DEPARTMENT OF RUBBER AND PLASTICS TECHNOLOGY
ANNA UNIVERSITY :: MIT CAMPUS

VISION

The Department of Rubber and Plastics Technology shall strive to be a renowned Department known for its academic excellence, professionalism and social responsibilities. We aim to impart high technical knowledge, practical skills, leadership qualities and foster creative entrepreneurial skills to become a demand based solution provider in the field of Rubber and Plastics Technology.

MISSION

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

- Equip its graduates to meet the fundamental expectations of Rubber and Plastics industries
- Enhance technical knowledge with respect to changing requirements, through collaboration with industries and research organisations
- Emphasize product design aspects to enable students to be innovators in the field of Rubber and Plastics Technology
- Motivate students to become job providers rather than job seekers
- Take up inter and multidisciplinary research and consultancy projects with industry and research establishments.

Attested

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Centre for Academic Courses
Anna University, Chennai-600 025

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UNIVERSITY DEPARTMENTS

REGULATIONS – 2019

M.TECH. RUBBER TECHNOLOGY

CHOICE BASED CREDIT SYSTEM (CBCS)

1. PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):

1. To equip graduates with appropriate scientific and engineering knowledge in Rubber Technology and allied areas
2. To help graduates analyze, design and create products based on rubber and rubber like materials for different applications
3. To train graduates for inter-disciplinary research involving Rubber Technology with other Engineering areas
4. To provide graduates with an academic environment, conducive for research and development in their life-long learning in various aspects of their profession
5. To enable graduates find gainful employment and grow up in their chosen profession with an ethical and social outlook

2. PROGRAMME OUTCOMES (POs):

On successful completion of the programme, the Post Graduates will

1. Have an ability to independently carry out research and development work to solve practical problems involving Rubber Technology
2. Use modern engineering tools, software and equipments for analysis, simulation and integrate multidisciplinary tasks pertaining to Rubber Technology
3. Demonstrate a degree of mastery on design, experiment, analysis and interpretation of research data and design new rubber components and processes
4. Be able to write and communicate a substantial research and technical document on scientific and technological aspects of rubber and allied products
5. Be able to provide technical and/or academic leadership for various organizations through life-long learning
6. Develop insights and necessary tools for forecasting sustainable development in Rubber and allied Industries .

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3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

PROGRAMME EDUCATIONAL OBJECIVES	PROGRAMME OUTCOMES					
	PO1	PO2	PO3	PO4	PO5	PO6
I	✓	✓		✓		✓
II	✓	✓	✓	✓		
III	✓	✓	✓	✓	✓	
IV	✓				✓	✓
V					✓	✓

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4. MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES

			PO1	PO2	PO3	PO4	PO5	PO6
YEAR 1	SEMESTER 1	**THEORY**						
		Advanced Mathematical Methods	3	3	2	2	1	-
		Concepts of Polymer Systems	3	3	2	1	1	1
		Rubber Materials and processing	3	-	2	2	-	2
		Program Elective I						
		Research Methodology and IPR	3	3	3	3	2	1
		Audit Course – I (one from list of Audit courses)						
		PRACTICAL						
		Rubber Science & Technology Lab	3	-	3	-	1	-
		Advanced CAD Lab	-	3	3	-	1	-
	SEMESTER 2	**THEORY**						
		Design of Rubber Compounds	3	2	2	2	-	2
		Rubber Products Design & Development	1	3	3	1	-	1
		Advanced Polymer Characterization Techniques	3	3	3	3	-	1
		Interfaces in Polymer systems	3	2	2	2	-	1
		Program Elective II						
		Program Elective III						
		Audit Course –II						
		PRACTICAL						
		Polymer Characterization Lab	3	3	3	2	-	-
		Product Design Lab	3	2	2	2	-	1
		Research Seminar	3	3	3	3	-	2
YEAR 2	SEMESTER 3	**THEORY**						
		Program Elective IV						
		Program Elective V						
		Open Elective						
		PRACTICAL						
		Project Phase I (Industry/ R&D/Department)	3	3	3	3	1	2
	SEMESTER 4	**PRACTICAL**						
		Project Phase II (Industry/ R&D/Department)	3	3	3	3	2	2

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

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M.TECH. RUBBER TECHNOLOGY
REGULATIONS – 2019
CHOICE BASED CREDIT SYSTEM
CURRICULUM AND SYLLABI FOR I TO IV SEMESTER

SEMESTER I

S. NO	CODE NO.	COURSETITLE	CATE GORY	PERIODSPE RWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA5152	Advanced Mathematical Methods	FCC	3	1	0	4	4
2.	RT5101	Concepts of Polymer Systems	PCC	3	0	0	3	3
3.	RT5102	Rubber Materials and Processing	PCC	4	0	0	4	4
4.		Program Elective I	PEC	3	0	0	3	3
5.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
6.		Audit Course – I	AC	2	0	0	2	0
PRACTICALS								
7.	RT5111	Rubber Science & Technology Lab	PCC	0	0	4	4	2
8.	RT5112	Advanced CAD Lab	PCC	0	0	4	4	2
			TOTAL	17	1	8	26	**20**

*Audit Course is Optional

SEMESTER II

S. NO.	CODE NO.	COURSETITLE	CATE GORY	PERIODSPER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	RT5201	Design of Rubber Compounds	PCC	3	1	0	4	4
2.	RT5202	Rubber Products Design & Development	PCC	3	0	0	3	3
3.	RT5203	Advanced Polymer Characterization Techniques	PCC	3	0	0	3	3
4.	RT5204	Interfaces in Polymer systems	PCC	3	0	0	3	3
5.		Program Elective II	PEC	3	0	0	3	3
6.		Program Elective III	PEC	3	0	0	3	3
7.		Audit Course –II		2	0	0	2	0
PRACTICALS								
8.	RT5211	Polymer Characterization Lab	PCC	0	0	4	4	2
9.	RT5212	Product Design Lab	PCC	0	0	4	4	2
10.	RT5213	Research Seminar	EEC	0	0	4	4	2
			TOTAL	20	1	12	33	**25**

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SEMESTER III

S. NO.	CODE NO.	COURSETITLE	CATE GORY	PERIODSPE RWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.		Program Elective IV	PEC	3	0	0	3	3
2.		Program Elective V	PEC	3	0	0	3	3
3.		Open Elective	OEC	3	0	0	3	3
PRACTICALS								
4.	RT5311	Project Phase I (Industry/ R&D/Department)	EEC	0	0	12	12	6
			TOTAL	9	0	12	21	**15**

SEMESTER IV

S. NO.	CODE NO.	COURSETITLE	CATE GORY	PERIODSPE RWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	RT5411	Project Phase II (Industry/ R&D/Department)	EEC	0	0	24	24	12
			TOTAL	0	0	24	24	**12**

Total Credits: (20 + 25 + 15 + 12) = 72

Foundation Courses(FC)

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	MA5152	Advanced Mathematical Methods	FCC	4	3	1	0	4

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Programme Core Courses (PCC)

Sl. No	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	RT5101	Concepts of Polymer Systems	PCC	3	3	0	0	3
2.	RT5102	Rubber Materials and Processing	PCC	4	4	0	0	4
3.	RT5111	Rubber Science & Technology Lab	PCC	4	0	0	4	2
4.	RT5112	Advanced CAD Lab	PCC	4	0	0	4	2
5.	RT5201	Design of Rubber Compounds	PCC	4	3	1	0	4
6.	RT5202	Rubber Products Design & Development	PCC	3	3	0	0	3
7.	RT5203	Advanced Polymer Characterization Techniques	PCC	3	3	0	0	3
8.	RT5204	Interfaces in Polymer systems	PCC	3	3	0	0	3
9.	RT5211	Polymer Characterization Lab	PCC	4	0	0	4	2
10.	RT5212	Product Design Lab	PCC	4	0	0	4	2

List of Professional Electives (PEC)

S. NO.	CODE NO.	COURSETITLE	CATEGORY	PERIODSPERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	RT5001	Engineering Design	PEC	3	0	0	3	3
2.	RT5002	Polymer Product Design	PEC	3	0	0	3	3
3.	RT5003	Theory of Rubber Elasticity& Viscoelasticity	PEC	3	0	0	3	3
4.	RT5004	Mould Design and Manufacture	PEC	3	0	0	3	3
5.	RT5005	Finite Element Analysis in Rubber Technology	PEC	3	0	0	3	3
6.	RT5006	Sustainable Technologies for Rubber Industry	PEC	3	0	0	3	3
7.	RT5007	Tyre Science and Technology	PEC	3	0	0	3	3
8.	RT5008	Polymer Composites	PEC	3	0	0	3	3
9.	RT5009	Polymer waste Management	PEC	3	0	0	3	3
10.	RT5010	Thermoplastic Elastomers	PEC	3	0	0	3	3

11.	RT5011	Polymer Nanocomposites	PEC	3	0	0	3	3
12.	RT5012	Adhesion Science and Technology	PEC	3	0	0	3	3
13.	RT5013	Polymer colloids and Latex Technology	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.	RM5151	Research Methodology and IPR	RMC	2	2	0	0	2

AUDIT COURSES (AC)

Registration for any of these courses is optional to students

S. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lectur	Tutorial	Practical		
1.	AX5091	English for Research Paper Writing	2	0	0	0	1/2
2.	AX5092	Disaster Management	2	0	0	0	
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0	
4.	AX5094	Value Education	2	0	0	0	
5.	AX5095	Constitution of India	2	0	0	0	
6.	AX5096	Pedagogy Studies	2	0	0	0	
7.	AX5097	Stress Management by Yoga	2	0	0	0	
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0	
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0	

OPEN ELECTIVE COURSES [OEC]*

*(Out of 6 Courses one Course must be selected)

S.NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			CREDITS	SEMESTER
			Lecture	Tutorial	Practical		
1.	OE5091	Business Data Analytics	3	0	0	3	3
2.	OE5092	Industrial Safety	3	0	0	3	3
3.	OE5093	Operations Research	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	3	0	0	3	3
5.	OE5095	Composite Materials	3	0	0	3	3
6.	OE5096	Waste to Energy	3	0	0	3	3

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EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	CONTACT PERIODS	L	T	P	C
THEORY								
1.	RT5213	Research Seminar	EEC	4	0	0	4	2
2.	RT5311	Project Phase I(Industry/ R&D/Department)	EEC	12	0	0	12	6
3.	RT5411	Project Phase II (Industry/ R&D/Department)	EEC	24	0	0	24	12

SUMMARY

S. No.	Subject Area	Credits per Semester				Credits Total
		I	II	III	IV	
1	PCC	11	17	-	-	28
2	PEC	3	6	6	-	15
3	OEC	-	-	3	-	3
4	EEC	-	2	6	12	20
5	RMC	2	-	-	-	2
6	FCC	4	-	-	-	4
	Total	20	25	15	12	**72**
	Audit courses (Non Credit)	*	*			

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SYLLABI
SEMESTER I

MA5152	ADVANCED MATHEMATICAL METHODS	L T P C 4 0 0 4

OBJECTIVES

- To familiarize the students in the field of differential equations.
- To enable them to solve boundary value problems associated with engineering applications using transform methods.
- To expose the students to the concepts of calculus of variations.
- To introduce conformal mappings and their applications to fluid flows and heat flows.
- To give the students a complete picture of tensor analysis.

UNIT I LAPLACE TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Laplace transform: Definitions, properties -Transform of error function, Bessel's function, Dirac Delta function, Unit Step functions – Convolution theorem – Inverse Laplace Transform: Complex inversion formula – Solutions to partial differential equations: Heat equation, Wave equation

UNIT II FOURIER TRANSFORM TECHNIQUES FOR PARTIAL DIFFERENTIAL EQUATIONS 12

Fourier transform: Definitions, properties – Transform of elementary functions, Dirac Delta function– Convolution theorem – Parseval's identity – Solutions to partial differential equations: Heat equation, Wave equation, Laplace and Poison's equations.

UNIT III CALCULUS OF VARIATIONS 12

Concept of variation and its properties – Euler's equation – Functionals dependant on first and higher order derivatives – Functionals dependant on functions of several independent variables – Variational problems with moving boundaries - Direct methods – Ritz and Kantorovich methods.

UNIT IV CONFORMAL MAPPING AND APPLICATIONS 12

Introduction to conformal mappings and bilinear transformations –Schwarz Christoffel transformation – Transformation of boundaries in parametric form – Physical applications : Fluid flow and heat flow problems.

UNIT V TENSOR ANALYSIS 12

Summation convention – Contravariant and covariant vectors – Contraction of tensors – Inner product – Quotient law – Metric tensor – Christoffel symbols – Covariant differentiation –Gradient, divergence and curl.

TOTAL: 60 PERIODS

OUTCOMES: On successful completion of the course, the students will be able to

CO1 Develop the mathematical methods of applied mathematics and mathematical physics
CO2 Solve boundary value problems using integral transform methods
CO3 Apply the concepts of calculus of variations in solving various boundary value problems
CO4 Apply conformal mappings in fluid flows and heat flow problems
CO5 Familiarize with the concepts of tensor analysis.

REFERENCES:

1. Andrew L.C. and Shivamoggi B.K., “Integral Transforms for Engineers”, Prentice Hall of India Pvt. Ltd., New Delhi, 2003.
2. Elsgolts L., “Differential Equations and the Calculus of Variations”, MIR Publishers, Moscow, 2003.
3. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 44th Edition, New Delhi, 2017.
4. Gupta A.S., “Calculus of Variations with Applications”, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
5. James G., “Advanced Modern Engineering Mathematics”, Pearson Education, 4th Edition, Horlow, 2016.
6. Mathews J.H. and Howell R.W., “Complex Analysis for Mathematics and Engineering”, Narosa Publishing House, 6th Edition, New Delhi, 2012.
7. O'Neil P.V., “Advanced Engineering Mathematics”, Thomson Asia Pvt. Ltd., 8th Edition, Singapore, 2017.
8. Ramanaiah, G.T., “Tensor Analysis”, S. Viswanathan Pvt. Ltd., Chennai, 1990.
9. Sankara Rao K., “Introduction to Partial Differential Equations”, Prentice Hall of India Pvt. Ltd., 3rd Edition, New Delhi, 2010.
10. Spiegel M.R., “Theory and Problems of Complex Variables and its Application” (Schaum’s Outline Series), McGraw Hill Book Co., Singapore, 2000.

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Develop the mathematical methods of applied mathematics and mathematical physics	3	3	1	1	1	-
CO2	Solve boundary value problems using integral transform methods	3	3	2	1	1	-
CO3	Apply the concepts of calculus of variations in solving various boundary value problems	3	3	1	2	1	-
CO4	Apply conformal mappings in fluid flows and heat flow problems	3	3	3	2	1	-
CO5	Familiarize with the concepts of tensor analysis.	3	3	3	2	1	-
Over all CO		**3**	**3**	**2**	**2**	**1**	**-**

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

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RT5101 **CONCEPTS 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.

UNITI 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

UNITII 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

UNITIII 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

UNITIV 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

UNITV 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 Understand different types and choices of polymer materials
CO2 Identify appropriate manufacturing technologies for making polymers
CO3 Relate Structure of Polymers with Performance properties
CO4 Choose appropriate polymers for specific applications

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 "Principlesof 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

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Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand different types and choices of polymer materials	3	2	1	1	-	1
CO2	Identify appropriate manufacturing technologies for making polymers	2	2	1	1	1	1
CO3	Relate Structure of Polymers with Performance properties	3	3	2	2	1	1
CO4	Choose appropriate polymers for specific applications	3	3	2	1	1	1
Over all CO		**3**	**3**	**2**	**1**	**1**	**1**

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

RT5102 RUBBER MATERIALS AND PROCESSING L T P C
4 0 0 4

OBJECTIVES

- To know about the properties and application of different rubbers.
- To understand the importance of special purpose rubbers and PEs
- To understand the importance of compounding and the techniques of rubber
- To get familiarized with various shaping operations and equipment for rubbers
- To understand the vulcanization methods other than moulding

UNIT I GENERAL PURPOSE RUBBERS 12

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

UNIT II SPECIAL PURPOSE RUBBERS 15

Need for, properties and uses of–IIR, EPRs, NBR,CR,HNBR,ACM, EMA, EVA, CSM, CM, epichlorohydrin rubbers – polysulphide rubbers - flurocarbon rubbers - silicones - PUs - TPEs

UNIT III MIXING OF RUBBERS 10

Need for compounding - Rubber mixing mechanism -mixing machinery- two roll mill- internal mixer–machine design -mixing in internal mixers &two roll mill, continuous mixers -mixing cycles and procedures, operating variables and mix quality

UNIT IV FORMING OPERATIONS 15

Rubber extrusion - single screw extruders - types, extruder screw designs - simulation and flow mechanism through dies, process optimization, extrudate defects; Calendaring of rubber, roll configurations, process simulation & flow analysis and troubleshooting - Compression, transfer and injection molding of rubbers, moulds, process optimization, simulation and flow analysis of molding process

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UNIT V VULCANISATION TECHNIQUES OTHER THAN MOULDING 8

Importance of vulcanization - vulcanization processes - batch processes - Continuous vulcanization – machinery & process - Reaction injection moulding of PU; silicone injection moulding.

TOTAL: 60 PERIODS

OUTCOMES:

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

CO1 Select an appropriate rubber for a given application.

CO2 Decide the processing parameters and techniques for a specific rubber product within Realistic constraints

REFERENCES

1 Dick.J.S., Rubber Technology Compounding and testing for performance, HanserPublisher,2001

2. Franta,I; Elastomers and Rubber Compounding materials, Elsevier,1989.

3. Kleemannand Weber, Elastomer Processing, Hanser,1998.

4. Richard F.Grossman,The Mixing of Rubber, Chapman &Hall,1997.

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Select an appropriate rubber for a given application.	3	-	2	2	-	2
CO2	Decide the processing parameters and techniques for a specific rubber product within Realistic constraints	3	-	2	2	-	2
Over all CO		**3**	**-**	**2**	**2**	**-**	**2**

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

RM5151 **RESEARCH METHODOLOGY AND IPR** **LT P C**
2 0 0 2

COURSE OBJECTIVES:

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

UNIT I RESEARCH PROBLEM FORMULATION 6

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

UNIT II LITERATURE REVIEW 6

Effective literature studies approaches, analysis, plagiarism, and research ethics.

UNIT III TECHNICALWRITING /PRESENTATION 6

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR) 6

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.
Traditional knowledge Case Studies, IPR and IITs.

TOTAL :30 PERIODS

COURCE OUTCOMES:

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓										
CO2	✓											
CO3	✓							✓				
CO4	✓				✓							
CO5	✓					✓						✓

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

REFERENCES:

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

RT5111 RUBBER SCIENCE AND TECHNOLOGY LAB L T P C
0 0 4 2

OBJECTIVS

- To enhance the skills of the students to design and prepare different rubber compounds
- To visualize / know the flow behaviour of various rubber compounds during mixing and forming stages.
- To learn the different rubber molding techniques and its problems with troubleshooting techniques.
- To evaluate the basic mechanical properties of the prepared rubber vulcanizates
- To study the Viscosity of raw rubber and compound
- To study the curing characteristics of the compound
- To know the working principles of various cure meters.

LIST OF EXPERIMENTS

IDENTIFICATION OF RAW RUBBERS

(i) RUBBER MIXING (6Exp)

- Mastication of natural rubber and mixing of rubber (gum and filled compounds) using two-roll mixing mill and Kneader.
- Mixing of synthetic rubbers (SBR, PBR, EPDM, NBR, CR) with various fillers (CB, Silica, Talc and others) using Two roll mixing mill and Kneader.

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(ii) RUBBER EXTRUSION (1Exp)

- Processing of Rubber compounds on a rubber extruder, trouble shooting in extrusion

(iii) MOULDING OF RUBBER COMPOUNDS (3Exp)

- Molding of rubber compounds by compression and transfer moulding.

(iv) LATEXCOMPOUNDING (2Exp)

- Preparation of dispersion in a ball mill
- Preparation of compounded latex.

(v) TESTS ON COMPOUNDS

- Viscosity of Raw and Compounded Rubber
- Cure Properties

(vi) TESTS ON VULCANISATES

- Determination of Hardness, Tensile properties, Tear Strength
- Compression Set Resistance, Rebound Resilience
- Abrasion Resistance, Cut-Growth resistance
- Fatigue to Failure, Heat Build-up study
- Swelling behaviour of rubbers

TOTAL: 60 PERIODS

OUTCOMES

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

CO1 Understand mixing and processing characteristics of Rubbers and latex
CO2 Evaluate appropriate rubber compounds for specific properties
CO3 Evaluate performance properties

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand mixing and processing characteristics of Rubbers and latex	3	-	3	-	1	-
CO2	Evaluate appropriate rubber compounds for specific properties	3	-	3	-	1	-
CO3	Evaluate performance properties	3	-	3	-	1	-
Over all CO		**3**	**-**	**3**	**-**	**1**	**-**

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

Attested

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RT5112 **ADVANCED CAD LAB** **L T P C**
0 0 4 2

OBJECTIVES

- To give an exposure in using Software tools for new product development, mould designing and to perform Analysis
- Introduction to mould, Dies & production drawing - classification of drawing - BIS conventions. Review 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:60PERIODS

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

CO1 To be able to apply advanced CAD / CAE in product and Mould Design
CO2 To perform simulation and analysis using software tools
CO3 To use concepts of non linear analysis of elastomers

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	To be able to apply advanced CAD / CAE in product and Mould Design	-	3	3	-	1	-
CO2	To perform simulation and analysis using software tools	-	3	3	-	1	-
CO3	To use concepts of non linear analysis of elastomers	1	3	3	-	1	-
Over all CO		**-**	**3**	**3**	**-**	**1**	**-**

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

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SEMESTER II

RT5201	DESIGN OF RUBBER COMPOUNDS	L T P C 3 1 0 4

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.

UNIT I RUBBER ADDITIVES 15

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 10

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

UNIT III DESIGNING COMPOUNDS FOR VARIOUS RUBBERS 15

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 15

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: 60 PERIODS

OUTCOMES

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

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

REFERENCES

1. Brendan Rodgers, Rubber Compounding- Chemistry and Applications (ed) Marcel Dekker Inc, 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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the line call out and analyze the compound design.	3	1	2	1	1	2
CO2	Design a cost effective formulation for a specific product requirement.	3	1	1	2	--	2
CO3	Maintain and improve the quality of the product consistently	3	2	--	2	-	2
Over all CO		**3**	**2**	**2**	**2**	**-**	**2**

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

RT5202 RUBBER PRODUCTS DESIGN & DEVELOPMENT 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 RUBBERS IN SEALING APPLICATIONS 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 selectionandcompounddesign-Design considerations - ConveyerBelts V-belts

UNITV 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 Demonstrate the ability to design
CO2 Conduct experiments
CO3 Analyze and interpret data for different 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	Demonstrate the ability to design	1	3	3	1	-	1
CO2	Conduct experiments	1	3	3	1	-	1
CO3	Analyze and interpret data for different rubber products	1	3	3	1	-	1
Over all CO		**1**	**3**	**3**	**1**	**-**	**1**

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

RT5203 ADVANCED POLYMER CHARACTERIZATION TECHNIQUES L T P C
3 0 0 3

OBJECTIVES

- To impart knowledge on various characterizations methods
- To make the students understand the importance of characterization 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

UNITII THERMALANALYSIS 9

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

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UNITIII 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.

UNITIV SPECTROSCOPY 9

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

UNITV 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 characterization techniques to characterize the given compound
CO2 Understand and apply sophisticated analytical techniques for problem solving
CO3 Interpret and analyze the given data of any compound.

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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Select suitable characterization techniques to characterize the given compound	3	3	3	3	-	1
CO2	Understand and apply sophisticated analytical techniques for problem solving	3	3	3	3	-	1
CO3	Interpret and analyze the given data of any compound.	3	3	3	3	-	1
Over all CO		**3**	**3**	**3**	**3**	**-**	**1**

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

RT5204 **INTERFACES IN POLYMER SYSTEMS** **L T P C**
3 0 0 3

OBJECTIVES

- The student appreciates the importance of interfaces in polymer products
- The student understands the segregation of polymers in solutions and mixture
- The student gets some insight into interfaces in block copolymers, composites of polymers 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

- Understand the surface phenomena and interfaces in polymer blends and solutions
- Understand the nature of interfaces forming in block copolymers and blends
- Get an insight into optimization of performance properties of polymer blends and composites

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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the surface phenomena and interfaces in polymer blends and solutions	3	1	1	1	1	--
CO2	Understand the nature of interfaces forming in block copolymers and blends	3	1	1	2	--	--
CO3	Get an insight into optimization of performance properties of polymer blends and composites	3	2	--	2	-	2
Over all CO		**3**	**2**	**2**	**2**	**--**	**1**

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

RT5211 **POLYMER CHARACTERIZATION LAB** **L T P C**
0 0 4 2

OBJECTIVES

Students will be exposed to the practical applications of all the below techniques with suitable demonstration, tutorials and interpretation.

LIST OF EXPERIMENTS

THERMAL ANALYSIS

- Differential scanning calorimetry
- Thermo Gravimetric Analysis / GC
- Dynamic Mechanical Analysis

RHEOLOGICAL STUDIES

- Capillary Rheometer
- Mooney Viscometer
- Moving Die Rheometer

MOLECULAR WEIGHT STUDIES

- Gel Permeation chromotography / HPLC
- Mass Spectroscopy

MICROSCOPIC TECHNIQUES

- Atomic Force Microscopy
- Scanning Electron Microscopy
- Transmission Electron Microscopy

SPECTROSCOPY (DEMO)

- FTIR Spectroscopy
- NMR Spectroscopy
- UV-visible Spectroscopy

Attested

TOTAL: 60PERIODS

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OUTCOMES:

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

- See the changes in polymer properties as a function of temperature
- Determine various thermal and Rheological properties of polymer
- Use various visualization and Spectroscopic techniques for polymer characterization

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	See the changes in polymer properties as a function of temperature	3	3	3	3	-	-
CO2	Determine various thermal and Rheological properties of polymer	3	3	3	3	-	-
CO3	Use various visualization and Spectroscopic techniques for polymer characterization	3	3	3	2	-	-
Over all CO		**3**	**3**	**3**	**2**	**-**	**-**

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

RT5212 **PRODUCT DESIGN LAB** **L T P C**
0 0 4 2

OBJECTIVES

- To expose students to Engineering design concepts for components design
- Introduction Review of the concepts of limits, tolerance, fits, surface roughness, and symbols. Terminology used in Production drawing

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.

1. Lathe Shaft subjected to various loading
2. Clamping rod deign in injection moulding
3. Calculation of Spur and helical gear dimensions in any polymer processing machinery.

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

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

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

V. Experiments based on any polymeric product design by using any software.

TOTAL:60 PERIODS

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

CO1 Use the concepts of design based on various loading and design criterions
CO2 Understand the importance of stress concentration factor
CO3 Understand various materials selection in engineering design

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Use the concepts of design based on various loading and design criterions	3	2	3	-	1	-
CO2	Understand the importance of stress concentration factor	3	3	3	-	1	-
CO3	Understand various materials selection in engineering design	3	2	2	-	1	-
Over all CO		**3**	**2**	**2**	**-**	**1**	**-**

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

RT5213 RESEARCH SEMINAR L T P C
0 0 4 2

The graduate students shall present seminars in a chosen area of their interest in the field of Rubber Technology and allied areas. They will be evaluated based on their presentation, comprehension and analysis. They need to use the outcome of such presentations to formulate innovative research concepts to be used in their project phases I and II. The main objective of this exercise is to train them for research assignments and careers.

SEMESTER III

RT5311 PROJECT PHASE I L T P C
- - 12 6

A PG student shall identify an appropriate area of research in the field of Rubber Technology and allied subjects and do extensive literature survey in the chosen field. They will have to focus on a specific research area based on their interest, literature survey and formulate an innovative research proposal, plan of action and its implementation with the guidance of a supervisor during Phase I. They will be evaluated by a panel of examiners at the end of Phase I according to prescribed norms.

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SEMESTER IV

RT5411	PROJECT PHASE II	L T P C - -24 12

Students will have to carry out an original independent research project in the field of Rubber Technology and allied subjects preferably as a continuation of Phase I. The work shall be carried out in the Department itself or in an Industry or in an R & D Institution. The research work should be based on new concepts, new designs, novel materials, new experimental techniques or a new process. The progress of the work will be assessed continuously in the form of reviews and final evaluation will be done by examiners at the end of Phase II according to prescribed norms.

ELECTIVES

RT5001	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

Stages in Design, Design criteria- Factor of safety - Selection of Materials - Standards and Codes – Economical and reliable design—Design equations for various loading and various sectional elements-Design for constant loading – Principal stresses, Failure criterions – stress concentration- Eccentric loading- Design for variable loading.

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 bearing sand rolling element bearings – Hydrostatic and aerostatic bearings.

UNIT III MECHANICAL VIBRATION 9

Single degree of freedom systems – Forced, damped vibrations – System response - time constant–Log dc – Vibration isolation – Torsional vibrations – Two rotor systems. case studies relevant to vibration in rubber product design.

UNIT IV DESIGN OF MACHINE ELEMENTS 9

Design of shafts, Couplings, Journal Bearings, springs, power screws- case studies based on design of elements in polymer processing machineries- Case studies relevant to polymer processing machineries.

UNITV DESIGN OF TRANSMISSION ELEMENTS 9

Belt and chain drives – Design of gear drives – Spur gear – Worm and worm wheel. Case studies based on design of elements in polymer processing machineries.

TOTAL:45 PERIODS

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

- Understand the design of machine components in rubber processing machineries
- Employ the concept of friction and vibration in machine elements
- Undertake the design task in real time Applications

REFERENCES

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

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the design of machine components in rubber processing machineries	3	3	2	-	-	2
CO2	Employ the concept of friction and vibration in machine elements	3	3	2	-	-	2
CO3	Undertake the design task in real time Applications	3	3	2	-	-	2
Over all CO		**3**	**3**	**2**	**-**	**-**	**2**

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

RT5002 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–Snap Fit 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

REFERENCES

1. Crawford R.J.,Plastics Engineering, 3rd Edition, Elsevier publications.
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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the various product design concepts and tools	2	3	3	2	1	-
CO2	Design, formulate, interpret and analyze data using CAD tools and software	2	3	3	2	1	-
CO3	Use modern engineering tools and solve the product design problems	2	3	3	2	1	-
Over all CO		**2**	**3**	**3**	**2**	**1**	**-**

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

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RT5003 THEORYOF RUBBER ELASTICITY AND VISCOELASTICITY L T P C
3 0 0 3

OBJECTIVES

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

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 linked polymers – 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

CO1 Adapt a suitable method 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.

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 Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Adapt a suitable method to study about the rheological behaviour and properties while processing the compound	3	2	2	3	-	-
CO2	Correlate and fix the external parameter to achieve desirable flow behaviour	2	3	3	3	-	-
CO3	Use the advantages and limitations of viscoelasticity	2	3	3	3	-	-
CO4	Relate the structure of rubber and their orientation with their physical behaviour.	2	3	3	3	-	-
Over all CO		**2**	**3**	**3**	**3**	**-**	**-**

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

Attested

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RT5004 **MOULD DESIGN AND MANUFACTURE** **L T P C**
3 0 0 3

OBJECTIVES

- To Learn Mould and Die design and their manufacturing Techniques
- To apply the recent concepts in mould manufacturing
- 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 - blow ratio – 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 Implement the various concepts of Mould design
CO2 Apply CAD in Mould design and Analysis
CO3 Study any mould design and drawing
CO4 Understand various recent trends in mould manufacturing

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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Implement the various concepts of Mould design	-	3	3	3	1	-
CO2	Apply CAD in Mould design and Analysis	-	3	3	2	2	-
CO3	Study any mould design and drawing	-	3	2	2	2	-
CO4	Understand various recent trends in mould manufacturing	-	3	3	2	2	-
Over all CO		**-**	**3**	**3**	**2**	**2**	**-**

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

RT5005 FINITE ELEMENT ANALYSIS FOR RUBBER TECHNOLOGY L T P C
3 0 0 3

OBJECTIVES

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

UNIT I INTRODUCTION 8

Review of various approximate methods – Rayleigh - RitZ, Galerkinand 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 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

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

CO1: Demonstrate the ability to FEM to a range of Engineering Problems

CO2: Use the modern engineering tools and analyze the problems within the domains of rubber and plastics as the members of multidisciplinary teams

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 Sons Inc., New Yors,1984.
3. Tirupathi R.Chandrupatla and Ashok D Belegundu, Introduction to Finite Elements in Engineering, PrinticeHall,2002
4. Bathe K.J.,and Wilson E.L.,"NumericalMethods infiniteElementsAnalysis",Prentice Hall 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
3. Krishnamurthy C.S.,"Finite Elements Analysis",Tata McGraw–Hill, 1987

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Demonstrate the ability to FEM to a range of Engineering Problems	3	3	3	2	-	2
CO2	Use the modern engineering tools and analyze the problems within the domains of rubber and plastics as the members of multidisciplinary teams	3	3	3	2	-	2
Over all CO		**3**	**3**	**3**	**2**	**-**	**2**

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

RT5006 SUSTAINABLE TECHNOLOGIES FOR RUBBER INDUSTRY **L T P C**
3 0 0 3

OBJECTIVES - To impart knowledge to students in the following:
Advantages and Limitations of Natural Rubber

- Advantages and Limitations of Thermoplastics elastomers
- Health hazards of rubber chemicals
- Sustainable use of Energy in Rubber Industries
- New Technologies for sustainable rubber 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

Approved

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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 house gas 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 Realize the shortcomings of petroleum based raw materials
CO4 Aware importance of energy efficiency in Rubber industries
CO5 Develop new applications based on recycled rubber

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Explore the possible alternatives for and modified forms of Natural Rubber	2	2	2	3	2	3
CO2	Substitute TPEs in place of conventional rubbers and plastics	3	3	3	2	2	3
CO3	Realize the shortcomings of petroleum based raw materials	3	2	2	2	2	2
CO4	Aware importance of energy efficiency in Rubber industries	3	2	3	2	2	2
CO5	Develop new applications based on recycled rubber	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

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RT5007 **TYRE SCIENCE AND TECHNOLOGY** **L T P C**
3 0 0 3

OBJECTIVS

- 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 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 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 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 pneumatic tyre
CO2 Understand various carcass materials and methods in tyre reinforcement
CO3 Design new tread patterns and evaluate its role in grip, life and safety
CO4 Explore new approaches for innovative tyre designs

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. TextileReinforcementofElastomers(ed)WCWake&DBWootton,AppliedScience PublishersLtd,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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Analyze the complex design of a high performance pneumatic tyre	3	3	3	2	2	3
CO2	Understand various carcass materials and methods in tyre reinforcement	3	2	3	2	2	3
CO3	Design new tread patterns and evaluate its role in grip, life and safety	3	2	3	2	2	3
CO4	Explore new approaches for innovative tyre designs	3	3	2	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

RT5008 **POLYMER COMPOSITES** **L T P C**
3 0 0 3

OBJECTIVES

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

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

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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 Design, analysis and test new composite materials

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	Statement	Programme Outcomes (POs)					
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	Use appropriate materials in suitable forms for making polymer composites	3	3	3	1	1	2
CO2	Design, analysis and test new composite materials	3	3	3	1	1	2
Over all CO		**3**	**3**	**3**	**1**	**1**	

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

RT5009 **POLYMER WASTE MANAGEMENT** **L T P C**
3 0 0 3

OBJECTIVS:

- To know various recycling methods of polymers
- To impart knowledge on degradation mechanisms in polymers

UNIT I SOURCESEGREGATION 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

CO1 Be able to design and implement appropriate recycling technologies for the management of Polymer wastes

CO2 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,Taylor and Francis Group, 2005

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Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Be able to design and implement appropriate recycling technologiesfor the management of Polymer wastes	3	3	2	1	1	3
CO2	Have professional and ethical responsibility to solve environmental issues related to polymers.	2	2	2	1	1	3
Over all 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

RT5010 THERMOPLASTIC ELASTOMERS L T P C
3 0 0 3

OBJECTIVES:

- To understand the need and approaches to development of TPEs
- To understand the morphology, properties and uses of block copolymer type TPEs
- To Understand blend type and ionomer type TPEs
- To get an idea about the new trends in research in TPEs

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

- Appreciate the differences between conventional and thermoplastic elastomers
- Select the raw polymer (TPE) for the given application
- Understand the design aspects of product manufacture with TPEs

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REFERENCE

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

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Appreciate the differences between conventional and thermoplastic elastomers	3	1	--	2	1	--
CO2	Select the raw polymer (TPE) for the given application	3	1	-	2	-	--
CO3	Understand the design aspects of product manufacture with TPEs	3	2	1	2	1	1
Over all CO		**3**	**1**	**1**	**2**	**1**	**1**

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

RT5011 POLYMER NANOCOMPOSITES L T P C
3 0 0 3

OBJECTIVES

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

UNIT I POLYMERSIN NANOSYNTHESIS 9

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

UNIT II NANOMATERIALS USED IN POLYMERS 9

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

UNIT III CARBON NANOTUBESAND THEIRAPPLICATION 9

Structure of carbon nanotubes, processing methods for nanotube based polymer nanocomposites, nano tube 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 applications

UNIT V APPLICATIONS OF POLYMER NANOCOMPOSITES 9

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

TOTAL: 45 PERIODS

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

- Understand the concepts in selecting nanofillers and its incorporation in polymer matrix

REFERENCES

1. Joseph H.Kao, "Polymer Nanocompsoites",McGraw-Hill Pub., 2006.
2. Klaus Friedrich,Stoyko Fakirov andZhong Zhang,"Polymer Composites from Nano to Macro", Springer2005
3. Rao C N R, A.Muller, & A.K.Cheetham,"The chemistry of Nanomaterials",Vol1 & Vol.Wiley-VCH,2005.
4. Yiu-Wing Maiand Zhong-Zhen Yu, "Polymer Nanocomposites", Woodhead Publishing Limited,2006

Course Articulation Matrix:

Course Outcomes	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Understand the concepts in selecting nanofillers and its incorporation in polymer matrix	3	-	--	-	1	1
Over all CO		**3**	**1**	**1**	**-**	**1**	**1**

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

RT5012 ADHESION SCIENCE AND TECHNOLOGY L T P C
3 0 0 3

OBJECTIVS:

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

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

UNITV 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.

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TOTAL :45 PERIODS

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

CO1 Select appropriate adhesives and adhesion process for specific applications

CO2 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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Select appropriate adhesives and adhesion process for specific applications	3	1	3	-	2	2
CO2	Design new adhesive formulations for emerging applications	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

RT5013 POLYMER COLLOIDS AND LATEXTECHNOLOGY 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

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 of latex.

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.

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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: Understand the principles behind latex processing and product manufacture
CO3: Ability to realize constraints concerning sustainability in latex technology

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	Statement	Programme Outcomes (POs)					
		PO1	PO2	PO3	PO4	PO5	PO6
CO1	Design latex formulations and products	3	1	3	1	1	3
CO2	Understand the principles behind latex processing and product manufacture	3	1	3	1	1	3
CO3	Ability to realize constraints concerning sustainability in latex technology	2	1	2	1	1	3
Over all CO		**3**	**1**	**3**	**1**	**1**	**3**

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

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OPEN ELECTIVE COURSES (OEC)

OE5091 BUSINESS DATA ANALYTICS L T P C
3 0 0 3

OBJECTIVES:

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

UNIT I OVERVIEW OF BUSINESS ANALYTICS 9

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

Suggested Activities:

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

Suggested Evaluation Methods:

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

UNIT II ESSENTIALS OF BUSINESS ANALYTICS 9

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

Suggested Activities:

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

Suggested Evaluation Methods:

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE 9

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

Suggested Activities:

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

Suggested Evaluation Methods:

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

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UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK 9

Introducing Hadoop– RDBMS versus Hadoop–Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop– Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

Suggested Activities:

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

Suggested Evaluation Methods:

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

UNIT V OTHER DATA ANALYTICAL FRAMEWORKS 9

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

Suggested Activities:

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

Suggested Evaluation Methods:

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

TOTAL: 45 PERIODS

OUTCOMES:

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

REFERENCES:

1. VigneshPrajapati, “Big Data Analytics with R and Hadoop”, Packt Publishing, 2013.
2. Umesh R Hodeghatta, UmeshaNayak, “Business Analytics Using R – A Practical Approach”, Apress, 2017.
3. AnandRajaraman, Jeffrey David Ullman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, “Essentials of Business Analytics”, Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, “Business Analytics: The Science of Data-Driven Decision Making”, Wiley, 2017.
6. A. Ohri, “R for Business Analytics”, Springer, 2012
7. Rui Miguel Forte, “Mastering Predictive Analytics with R”, Packt Publication, 2015.

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	1	1	1	2	3	1
CO2	2	1	1	2	1	1
CO3	1	1	2	3	3	1
CO4	2	2	1	2	1	1
CO5	1	1	2	2	1	1
CO6	1	1	1	3	2	1

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OE5092 **INDUSTRIAL SAFETY** **LT P C**
3 0 0 3

OBJECTIVES:

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

UNIT I INTRODUCTION 9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING 9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT III WEAR AND CORROSION AND THEIR PREVENTION 9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT IV FAULT TRACING 9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT V PERIODIC AND PREVENTIVE MAINTENANCE 9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

OUTCOMES:

CO1: Ability to summarize basics of industrial safety
CO2: Ability to describe fundamentals of maintenance engineering
CO3: Ability to explain wear and corrosion
CO4: Ability to illustrate fault tracing
CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P,Maintenance Engineering, S. Chand and Company,1987.
3. Hans F. Winterkorn , Foundation Engineering Handbook, Chapman & Hall London,2013.
4. Higgins & Morrow , Maintenance Engineering Handbook, Eighth Edition,2008

OE5093 OPERATIONS RESEARCH LT P C
3 0 0 3

OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation , assignment problems
- Solve project management problems
- Solve scheduling problems

UNIT I LINEAR PROGRAMMING 9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

UNIT II ADVANCES IN LINEAR PROGRAMMING 9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

UNIT III NETWORK ANALYSIS – I 9

Transportation problems -Northwest corner rule, least cost method,Voges's approximation method - Assignment problem -Hungarian algorithm

UNIT IV NETWORK ANALYSIS – II 9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

UNIT V NETWORK ANALYSIS – III 9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

TOTAL: 45 PERIODS

OUTCOMES:

CO1: To formulate linear programming problem and solve using graphical method.
CO2: To solve LPP using simplex method
CO3: To formulate and solve transportation, assignment problems
CO4: To solve project management problems
CO5: To solve scheduling problems

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	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerselvam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

OE5094 COST MANAGEMENTOF ENGINEERING PROJECTS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

UNIT I INTRODUCTION TO COSTING CONCEPTS 9

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member,Importance Project site: Data required with significance, Project contracts.

UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

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TOTAL: 45 PERIODS

OUTCOMES

CO1 – Understand the costing concepts and their role in decision making
CO2–Understand the project management concepts and their various aspects in selection
CO3–Interpret costing concepts with project execution
CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

OE5095 COMPOSITE MATERIALS L T P C
3 0 0 3

OBJECTIVES:

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identifythe various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

UNIT I INTRODUCTION 9

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

UNIT II REINFORCEMENTS 9

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES 9

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

UNIT V STRENGTH 9

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first play failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

TOTAL: 45 PERIODS

OUTCOMES:

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

REFERENCES:

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, WestGermany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

OE5096 **WASTE TO ENERGY** **L T P C**
3 0 0 3

OBJECTIVES:

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

UNITI INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNITIIBIOMASS PYROLYSIS 9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNITIII BIOMASS GASIFICATION 9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNITIV BIOMASS COMBUSTION 9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNITV BIO ENERGY 9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

OUTCOMES:

CO1 – Understand the various types of wastes from which energy can be generated
CO2 – Gain knowledge on biomass pyrolysis process and its applications
CO3 – Develop knowledge on various types of biomass gasifiers and their operations
CO4 – Gain knowledge on biomass combustors and its applications on generating energy
CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

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AUDIT COURSES (AC)

AX5091 ENGLISHFOR RESEARCHPAPERWRITING L T P C
2 0 0 0

OBJECTIVES

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

UNITI INTRODUCTION TO RESEARCH PAPER WRITING 6

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

UNIT II PRESENTATION SKILLS 6

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

UNIT III TITLE WRITING SKILLS 6

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

UNIT IV RESULT WRITING SKILLS 6

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

UNIT V VERIFICATION SKILLS 6

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

TOTAL: 30 PERIODS

OUTCOMES

CO1 –Understand that how to improve your writing skills and level of readability
CO2 –Learn about what to write in each section
CO3 –Understand the skills needed when writing a Title
CO4 – Understand the skills needed when writing the Conclusion
CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

REFERENCES

1. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011
2. Day R How to Write and Publish a Scientific Paper, Cambridge University Press 2006
3. Goldbort R Writing for Science, Yale University Press (available on Google Books) 2006
4. Highman N, Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book 1998.

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AX5092 **DISASTER MANAGEMENT** **L T P C**
2 0 0 0

OBJECTIVES

- Summarize basics of disaster
- Explain a critical understanding of key concepts in disaster risk reduction and humanitarian response.
- Illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
- Describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
- Develop the strengths and weaknesses of disaster management approaches

UNIT I INTRODUCTION **6**

Disaster: Definition, Factors and Significance; Difference between Hazard And Disaster; Natural and Manmade Disasters: Difference, Nature, Types and Magnitude.

UNIT II REPERCUSSIONS OF DISASTERS AND HAZARDS **6**

Economic Damage, Loss of Human and Animal Life, Destruction Of Ecosystem. Natural Disasters: Earthquakes, Volcanisms, Cyclones, Tsunamis, Floods, Droughts And Famines, Landslides And Avalanches, Man-made disaster: Nuclear Reactor Meltdown, Industrial Accidents, Oil Slicks And Spills, Outbreaks Of Disease And Epidemics, War And Conflicts.

UNIT III DISASTER PRONE AREAS IN INDIA **6**

Study of Seismic Zones; Areas Prone To Floods and Droughts, Landslides And Avalanches; Areas Prone To Cyclonic and Coastal Hazards with Special Reference To Tsunami; Post-Disaster Diseases and Epidemics

UNIT IV DISASTER PREPAREDNESS AND MANAGEMENT **6**

Preparedness: Monitoring Of Phenomena Triggering a Disaster or Hazard; Evaluation of Risk: Application of Remote Sensing, Data from Meteorological And Other Agencies, Media Reports: Governmental and Community Preparedness.

UNIT V RISK ASSESSMENT **6**

Disaster Risk: Concept and Elements, Disaster Risk Reduction, Global and National Disaster Risk Situation. Techniques of Risk Assessment, Global Co-Operation in Risk Assessment and Warning, People's Participation in Risk Assessment. Strategies for Survival

TOTAL : 30 PERIODS

OUTCOMES

CO1: Ability to summarize basics of disaster
CO2: Ability to explain critical understanding of key concepts in disaster risk reduction and humanitarian response.
CO3: Ability to illustrate disaster risk reduction and humanitarian response policy and practice from multiple perspectives.
CO4: Ability to describe an understanding of standards of humanitarian response and practical relevance in specific types of disasters and conflict situations.
CO5: Ability to develop the strengths and weaknesses of disaster management approaches

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

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REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies", Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. Nishitha Rai, Singh AK, "Disaster Management in India: Perspectives, issues and strategies "'New Royal book Company,2007.
3. Sahni, Pardeep Et.Al. ," Disaster Mitigation Experiences And Reflections", Prentice Hall Of India, New Delhi,2001.

AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE L T P C
2 0 0 0

OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

UNIT I ALPHABETS **6**

Alphabets in Sanskrit

UNIT II TENSES AND SENTENCES **6**

Past/Present/Future Tense - Simple Sentences

UNIT III ORDER AND ROOTS **6**

Order - Introduction of roots

UNIT IV SANSKRIT LITERATURE **6**

Technical information about Sanskrit Literature

UNIT V TECHNICAL CONCEPTS OF ENGINEERING **6**

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

TOTAL: 30

PERIODS

OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

REFERENCES

1. "Abhyaspustakam" – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. "Teach Yourself Sanskrit" Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. "India's Glorious Scientific Tradition" Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

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AX5094	VALUE EDUCATION	L T P C 2 0 0 0

OBJECTIVES

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

UNIT I

Values and self-development–Social values and individual attitudes. Workethics, Indianvision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

UNIT II

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love fornature, Discipline

UNIT III

Personality and Behavior Development-Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

UNIT IV

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the over all personality.

Suggested reading

1. Chakroborty, S.K."Values and Ethics for organizations Theory and practice", Oxford University Press, New Delhi

AX5095	CONSTITUTION OF INDIA	L T P C 2 0 0 0

OBJECTIVES

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals' constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:

History, Drafting Committee, (Composition &Working)

UNIT II PHILOSOPHYOFTHE INDIANCONSTITUTION:

Preamble, Salient Features

UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

UNIT IV ORGANS OF GOVERNANCE:

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

UNIT V LOCAL ADMINISTRATION:

District's Administration head: Role and Importance, Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy(Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

UNIT VI ELECTION COMMISSION:

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- DiscussthegrowthofthedemandforcivilrightsinIndiaforthebulkofIndiansbeforethe arrival of Gandhi in Indian politics.
- Discusstheintellectualoriginsoftheframeworkofargumentthatinformedtheconceptualization
- of social reform sliding to revolution in India.
- DiscussthecircumstancessurroundingthefoundationoftheCongressSocialistParty[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- DiscussthepassageoftheHinduCodeBillof1956.

Suggested reading

1. TheConstitutionofIndia,1950(BareAct), Government Publication.
2. Dr. S. N. Busi, Dr. B. R.AmbedkarframingofIndianConstitution,1st Edition,2015.
3. M.P. Jain,IndianConstitutionLaw,7th Edn.,Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis,2015.

Attested

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AX5096	PEDAGOGY STUDIES	L T P C 2 0 0 0

OBJECTIVES:

Students will be able to:

- Review existing evidence on there view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

UNIT I INTRODUCTION AND METHODOLOGY:

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

UNIT II THEMATIC OVERVIEW

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

UNIT III EVIDENCE ON THE EFFECTIVENESS OFPEDAGOGICALPRACTICES

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

UNIT IV PROFESSIONAL DEVELOPMENT

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

UNIT V RESEARCH GAPS AND FUTURE DIRECTIONS

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

TOTAL: 30 PERIODS

OUTCOMES:

Students will be able to understand:

- Whatpedagogicalpracticesarebeingusedbyteachersinformalandinformalclassrooms in developing countries?
- What is the evidence on the effectiveness soft he sepedagogical practices, in what conditions, and with what population of learners?
- How can teacher education(curriculum and practicum)and the school curriculum and guidance materials best support effective pedagogy?

Suggested reading

1. Ackers, HardmanF(2001)ClassroominteractioninKenyanprimaryschools,Compare,31(2): 245-261.
2. AgrawalM (2004)Curricular reform in schools: The importance of evaluation, JournalofCurriculumStudies,36(3):361-379.
3. AkyeampongK(2003)TeachertraininginGhana-doesitcount?Multi-siteteachereducationresearchproject(MUSTER) country report 1.London:DFID.
4. Akyeampong K,LussierK, PryorJ, WestbrookJ (2013) Improving teaching and learning of basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.
5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. ChavanM (2003) Read India: Amass scale, rapid, 'learningtoread 'campaign.
7. www.pratham.org/images/resource%20working%20paper%202.pdf

AX5097 **STRESS MANAGEMENT BY YOGA** **L T P C**
2 0 0 0

OBJECTIVES

- To achieve overall health of body and mind
- To overcome stress

UNIT I

Definitions of Eight parts of yoga.(Ashtanga)

UNIT II

Yam and Niyam - Do`s and Don't'sin life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

UNIT III

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

SUGGESTEDREADING

1. 'YogicAsanasforGroupTarining-Part-I":JanardanSwamiYogabhyasiMandal, Nagpur
2. "Rajayogaorconquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department),Kolkata

AX5098	PERSONALITY DEVELOPMENT THROUGH LIFE ENLIGHTENMENT SKILLS	L T P C 2 0 0 0

OBJECTIVES

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To a waken wisdom in students

UNIT I

Neetishatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

UNIT II

Approach to day to day work and duties - Shrimad BhagwadGeeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

UNIT III

Statements of basic knowledge - Shrimad BhagwadGeeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 -Personality of role model - shrimadbhagwadgeeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

TOTAL: 30 PERIODS

OUTCOMES

Students will be able to

- Study of Shrimad- Bhagwad- Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and man kind to peace and prosperity
- Study of Neetishatakam will help in developing versatile personality of students.

Suggested reading

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda , Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.