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.
ANNA UNIVERSITY::CHENNAI-600 025
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.
### 3. MAPPING OF PROGRAMME EDUCATIONAL OBJECTIVE WITH PROGRAMME OUTCOMES

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1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively.
# ANNA UNIVERSITY, CHENNAI
# UNIVERSITY DEPARTMENTS
# M.TECH. RUBBER TECHNOLOGY
# REGULATIONS – 2019
# CHOICE BASED CREDIT SYSTEM
# CURRICULUM AND SYLLABI FOR I TO IV SEMESTER

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

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### List of Professional Electives (PEC)

| S. NO. | CODE NO. | COURSE TITLE                                      | CATEGORY | PERIODS | P | C |
|--------|----------|---------------------------------------------------|----------|---------|---|
| 1.     | RT5001   | Engineering Design                                | PEC      | 3       | 3 |
| 2.     | RT5002   | Polymer Product Design                            | PEC      | 3       | 3 |
| 3.     | RT5003   | Theory of Rubber Elasticity & Viscoelasticity     | PEC      | 3       | 3 |
| 4.     | RT5004   | Mould Design and Manufacture                      | PEC      | 3       | 3 |
| 5.     | RT5005   | Finite Element Analysis in Rubber Technology      | PEC      | 3       | 3 |
| 6.     | RT5006   | Sustainable Technologies for Rubber Industry      | PEC      | 3       | 3 |
| 7.     | RT5007   | Tyre Science and Technology                       | PEC      | 3       | 3 |
| 8.     | RT5008   | Polymer Composites                                | PEC      | 3       | 3 |
| 9.     | RT5009   | Polymer Waste Management                          | PEC      | 3       | 3 |
| 10.    | RT5010   | Thermoplastic Elastomers                          | PEC      | 3       | 3 |
### RESEARCH METHODOLOGY AND IPR COURSES (RMC)

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### AUDIT COURSES (AC)

Registration for any of these courses is optional to students

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### OPEN ELECTIVE COURSES [OEC]*

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

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SUMMARY

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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

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

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:


Course Articulation Matrix:

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

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

UNIT I INTRODUCTION


UNIT II POLYMER FORMATION

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

UNIT III STATES OF AGGREGATION IN POLYMERS

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

UNIT IV STRUCTURE PROPERTY RELATIONSHIPS IN POLYMERS

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

UNIT V MECHANICAL PROPERTIES OF POLYMERS

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

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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

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

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

Course Articulation Matrix:

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

UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR)  6

COURSE 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.

TOTAL :30 PERIODS
1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively

REFERENCES:


OBJECTIVES

- 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.
(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

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

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 ANALYSIS SOFTWARES

IV. ANALYSIS OF SIMPLE PRODUCTS USING SOFTWARES
   a) O-rings; b) Seals c) Dampers/springs d) Rubber boot e) Engine mount

TOTAL: 60 PERIODS

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

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<tr>
<td>CO1</td>
<td>To be able to apply advanced CAD / CAE in product and Mould Design</td>
<td>-</td>
</tr>
<tr>
<td>CO2</td>
<td>To perform simulation and analysis using software tools</td>
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</tr>
<tr>
<td>CO3</td>
<td>To use concepts of non linear analysis of elastomers</td>
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<td>Over all CO</td>
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1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively
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


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.

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

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<tr>
<td>CO1</td>
<td>Understand the line call out and analyze the compound design.</td>
<td>3</td>
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<tr>
<td>CO2</td>
<td>Design a cost effective formulation for a specific product requirement.</td>
<td>3</td>
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<tr>
<td>CO3</td>
<td>Maintain and improve the quality of the product consistently</td>
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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


UNIT III RUBBER PRODUCTS UNDER DYNAMIC CONDITIONS  9


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 selection and compound design-Design considerations - ConveryerBelts V-belts
UNITV MOULD AND DIE DESIGN

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

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<tr>
<td>CO2</td>
<td>Conduct experiments</td>
<td>PO1 1  PO2 3  PO3 3  PO4 1  PO5 -  PO6 1</td>
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<tr>
<td>CO3</td>
<td>Analyze and interpret data for different rubber products</td>
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RT5203 ADVANCED POLYMER CHARACTERIZATION TECHNIQUES

OBJECTIVES
• To impart knowledge on various characterizations methods
• To make the students understand the importance of characterization techniques

UNIT I REVIEW ON CHARACTERIZATION METHODS

UNIT II THERMAL ANALYSIS
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

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<td>Interpret and analyze the given data of any compound</td>
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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

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

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

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

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

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

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<td>Understand the nature of interfaces forming in block copolymers and blends</td>
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<td>CO3</td>
<td>Get an insight into optimization of performance properties of polymer blends and composites</td>
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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 chromatography / HPLC
- Mass Spectroscopy

MICROSCOPIC TECHNIQUES
- Atomic Force Microscopy
- Scanning Electron Microscopy
- Transmission Electron Microscopy

SPECTROSCOPY (DEMO)
- FTIR Spectroscopy
- NMR Spectroscopy
- UV-visible Spectroscopy

TOTAL: 60PERIODS
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

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<td>CO2</td>
<td>Determine various thermal and Rheological properties of polymer</td>
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<td>CO3</td>
<td>Use various visualization and Spectroscopic techniques for polymer characterization</td>
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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.

**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

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<td>Understand the importance of stress concentration factor</td>
<td>3</td>
</tr>
<tr>
<td>CO3</td>
<td>Understand various materials selection in engineering design</td>
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**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.
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

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

UNIT I ENGINEERING DESIGN CONCEPTS

UNIT II FRICTION
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

UNIT IV DESIGN OF MACHINE ELEMENTS
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.

UNIT V DESIGN OF TRANSMISSION ELEMENTS
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

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<td>Understand the design of machine components in rubber processing machineries</td>
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<tr>
<td>CO2</td>
<td>Employ the concept of friction and vibration in machine elements</td>
<td>PO1 3 PO2 3 PO3 2 PO4 - PO5 - PO6 2</td>
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<tr>
<td>CO3</td>
<td>Undertake the design task in real time Applications</td>
<td>PO1 3 PO2 3 PO3 2 PO4 - PO5 - PO6 2</td>
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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

UNIT II PRODUCT DESIGN TOOLS AND STANDARDS 8

UNIT III COMPUTER AIDED PRODUCT DESIGN 9
UNIT IV PLASTICS PRODUCT DESIGN


UNIT V ADVANCES IN PRODUCT DESIGN

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

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<tr>
<td>CO2</td>
<td>Design, formulate, interpret and analyze data using CAD tools and software</td>
<td>PO1</td>
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<tr>
<td>CO3</td>
<td>Use modern engineering tools and solve the product design problems</td>
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1, 2 and 3 are correlation levels with weightings as Slight (Low), Moderate (Medium) and Substantial (High) respectively
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


UNIT II TIME-TEMPERATURE EFFECTS ON VISCOELASTICITY


UNIT III VISCOELASTICITY AND LONG TERM DEFORMATION

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

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

UNIT V MEASUREMENT OF VISCOELASTICITY

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:

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<td>Adapt a suitable method to study about the rheological behaviour and properties while processing the compound</td>
<td>PO1: 3, PO2: 2, PO3: 2, PO4: 3, PO5: -, PO6: -</td>
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<tr>
<td>CO2</td>
<td>Correlate and fix the external parameter to achieve desirable flow behaviour</td>
<td>PO1: 2, PO2: 3, PO3: 3, PO4: 3, PO5: -, PO6: -</td>
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<tr>
<td>CO3</td>
<td>Use the advantages and limitations of viscoelasticity</td>
<td>PO1: 2, PO2: 3, PO3: 3, PO4: 3, PO5: -, PO6: -</td>
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<td>CO4</td>
<td>Relate the structure of rubber and their orientation with their physical behaviour.</td>
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<td><strong>Over all CO</strong></td>
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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

UNIT II COMPRESSION, TRANSFER AND BLOW MOULD DESIGN 10
Types of compression moulds - clamping pressure - pressure pads - depth of loading chamber - heating systems - types of heaters - calculation of heat requirement and heater capacity - Types of transfer moulds - clamping pressure - transfer pot design - Types of blow moulds - blow ratio – blow pin and neck ring design - clamping force

UNIT III DESIGN OF INJECTION MOULDS 12

UNIT IV EXTRUSION DIE DESIGN 7
Extrusion die design - process characteristics of polymer melt - die geometry - Mechanical design of extrusion dies - Extrusion dies for elastomers - 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
4. Menges / Machaeli / Mohren, How to make Injection Moulds, 3rd edition, Hanser Publishers
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<td>Understand various recent trends in mould manufacturing</td>
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RT5005  FINITE ELEMENT ANALYSIS FOR RUBBER TECHNOLOGY  

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  

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

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

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

TOTAL:45 PERIODS
OUTCOMES
By the end of this course, students will be able to

CO1: 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:
3. Tirupathi R.Chandrupatla and Ashok D Belegundu, Introduction to Finite Elements in Engineering, PrinticeHall, 2002

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<td>CO2</td>
<td>Use the modern engineering tools and analyze the problems within the domains of rubber and plastics as the members of multidisciplinary teams</td>
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RT5006 SUSTAINABLE TECHNOLOGIES FOR RUBBER INDUSTRY L T P C

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
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
4. Martin Forrest, De Gruyter Recycling and Re-use of Waste Rubber, 2019

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

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

- 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


UNIT II  TYRE CORD REINFORCEMENTS  9


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

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## RT5008 POLYMER COMPOSITES

**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**
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

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

UNIT I SORCSESEGREGATION AND SORTING

UNIT II DEGRADATION MECHANISMS

UNIT III PLASTICS RECYCLING
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
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
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.

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<td>Have professional and ethical responsibility to solve environmental issues related to polymers.</td>
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RT5010 THERMOPLASTIC ELASTOMERS

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

UNIT V PRODUCT DESIGN ASPECTS OF TPES
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
REFERENCE

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RT5011 POLYMER NANOCOMPOSITES

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 POLYMERS IN NANOSYNTHESIS
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
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 NANOTUBES AND THEIR APPLICATION
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
Preparations of polymer nanocomposites - melt blending, solution blending, latex coagulation, in-situ polymerization, characterization, properties and applications

UNIT V APPLICATIONS OF POLYMER NANOCOMPOSITES
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
2. Klaus Friedrich, Stoyko Fakirov and Zhong Zhang, "Polymer Composites from Nano to Macro", Springer 2005

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RT5012 ADHESION SCIENCE AND TECHNOLOGY

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

UNIT II SURFACE PREPARATION 9

UNIT III NONREACTIVE ADHESIVES 12

UNIT IV REACTIVE ADHESIVES 7
Phenolics, epoxies, acrylics, anaerobics, cyanoacrylates – polyimides - bismaleimide and other high temperature adhesives-properties and applications

UNIT V ADHESION IN RUBBER PRODUCT MANUFACTURE 7
Rubber to metal bonding – rubber to fabric bonding – bonding systems available for manufacture of rubber to metal and rubber to fabric bonded products.

TOTAL :45 PERIODS
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

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RT5013  POLYMER COLLOIDS AND LATEX TECHNOLOGY  L T P C
3 0 0 3

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

UNIT I  LATEX– NATURE AND CHARACTERISTICS  9
General nature and characteristics of latex, classification of latex, comparison of polymer lattices and polymer solutions, colloidal stability and destabilization of lattices, flow properties of latex.

UNIT II  COMPOUNDING OF LATEX  9
Natural rubber latex tapping - chemical composition– preservation - concentration -stabilization -quality control test - Compounding of latex - selection of compounding ingredients & formulation design - maturation - prevulcanized and chemically modified latex

UNIT III  PROCESSING OF LATEX  9
Dipping process, types of dipping, dipping plant design, formers, process control; Foaming, extrusion, spraying and casting - process control; leaching, sterilization, chlorination, deprotenization - Manufacture and formulation of latex products - condom, gloves, balloons, catheters; Foam rubber, thread, tubing, toys

UNIT IV  SYNTHETIC LATTICES  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, polyvinylpyridine, butyl, fluro polymer, and CSM latex.
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", Vol 1, 2 & 3
2. Warson Hand Finch C.A, Applications of synthetic Resin latices, Vol.1,2,3, John Wiley& Sons Ltd. 2001

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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

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

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

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.
UNIT IV
ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK


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

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.

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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

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

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

TOTAL: 45 PERIODS
OE5093 OPERATIONS RESEARCH

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

REFERENCES:
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.
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

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2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988

OE5095 COMPOSITE MATERIALS

OBJECTIVES:
- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the 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
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
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

UNIT IV  MANUFACTURING OF POLYMER MATRIX COMPOSITES  9

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.

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REFERENCES:
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

UNIT I 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

UNIT II BIOMASS PYROLYSIS 9
Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT III BIOMASS GASIFICATION 9

UNIT IV 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.

UNIT V 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

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REFERENCES:
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

UNIT I  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

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

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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
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

UNIT III  DISASTER PRONE AREAS IN INDIA
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
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

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.

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AX5093 SANSKRIT FOR TECHNICAL KNOWLEDGE

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.

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1. “Abhyaspustakam” – Dr.Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
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, Indian vision of

UNIT II
Importance of cultivation of values. Sense of duty. Devotion, Self-reliance, Confidence,
Patriotism. Love for nature, 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 brotherhood and religious tolerance. True friendship. Happiness Vs suffering, love for
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

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
University Press, New Delhi
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 nationhood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolution in 1917 and 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  PHILOSOPHY OF THE INDIAN CONSTITUTION:
Preamble, Salient Features

UNIT III  CONTOURS OF CONSTITUTIONAL RIGHTS AND 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:

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.

OUTCOMES
Students will be able to:

- Discuss the growth of the demand for civil rights in India before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reform sliding to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party (CSP) under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

Suggested reading
1. The Constitution of India, 1950 (Bare Act), Government Publication.
OBJECTIVES:
Students will be able to:
- Review existing evidence on the view topic to inform programme design and policy
- Making undertaken 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 OF PEDAGOGICAL PRACTICES
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.

OUTCOMES:
Students will be able to understand:
- What pedagogical practices are being used by teachers in formal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical 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

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's in 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

SUGGESTED READING
1. "Yogic Asanas for Group Training - Part 1" - Janardan Swami Yogabhyasi Mandal, Nagpur
2. "Rajayoga or conquer the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata
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 (don't'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, Nitisringar-vairagya, New Delhi,2010