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### AUDIT COURSES - I (AC)

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MA4112  MATHEMATICS FOR PLASTIC TECHNOLOGY  L T P C
4 0 0 4

COURSE OBJECTIVES:

- To understand the basic concept of numerical methods in solving ordinary differential equations.
- To understand the basic concept of numerical methods in solving partial differential equations.
- To understand the basics of random variables with emphases on the standard discrete and continuous distributions.
- To introduce the basic concept of Markovian Queueing Systems.
- To apply small and large sample tests through tests of hypotheses.

UNIT I  NUMERICAL SOLUTION OF ORDINARY DIFFERENTIAL EQUATIONS  12
Solution of first order ordinary differential equation - Taylor's method - Euler's method - Runge-Kutta method of fourth order - Predictor – Corrector Methods - Milne’s and Adam’s – Bashforth methods - Introduction to numeric use of the above techniques in plastics engineering and calculations.

UNIT II  NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS  12

UNIT III  PROBABILITY AND STATISTICS  12
Probability – Addition theorem - Multiplication theorem - Conditional probability – Baye’s theorem - Distribution functions - Binomial distribution - Poisson distribution - Normal distribution - Uniform distribution - Curve fitting – Fitting a straight line and second degree curve - Fitting a non linear curve - Correlation and regression.

UNIT IV  QUEUEING MODELS  12
Poisson process – Markovian queues – Single and multiserver models – Little’s formula – Steady state analysis – Self service queue.

UNIT V  TESTING OF HYPOTHESIS  12
Sampling distribution – Large sample and small samples - Testing of null hypothesis - Type I and Type II errors - "t" test and Chi square test - Goodness of fit - Fisher’s "F" test.

TOTAL : 60 PERIODS

COURSE OUTCOMES:
At the end of the course, students will be able to
CO1  Develop a good understanding of the various methods used for the numerical solution of scientific problems.
CO2  Learn various numerical methods of solving partial differential equations.
CO3  Analyze the performance in terms of probabilities and distributions achieved by the determined solutions.
CO4  Formulate the various kinds of Non-Markovian, Markovian Queueing Models.
CO5  Apply the basic principles underlying statistical inference.(estimation and hypothesis testing)
REFERENCES:

PA4101 PLASTICS MATERIALS TECHNOLOGY L T P C 3 0 0 3

UNIT I POLYMER CHEMISTRY 9
Introduction to polymers- homopolymers, Copolymers. Different types of polymerizations -addition, condensation and stereoregular polymerization. Initiators, important steps involved, kinetics and mechanism of addition, condensation and stereoregular polymerizations. Copolymerization and its kinetics. Polymerization techniques- emulsion, bulk, solution and suspension, Molecular weight & its determination.

UNIT II COMMODITY THERMOPLASTICS 9
Introduction, source of raw materials, Manufacture, General Properties, processing and applications of Olefine Polymers such as Polyethylene - Polypropylene and their copolymers-Styrene Polymer such asPolystyrene and Copolymers (Styrene Acrylonitrile, Acrylonitrile Butadiene Styrene) -Vinyl polymers such as Poly Vinyl Chloride, Poly vinyl acetate- Acrylic and copolymers-Cellulose Polymers.

UNIT III ENGINEERING AND HIGH PERFORMANCE THERMOPLASTICS 9
Introduction, source of raw materials, Manufacture, General Properties, processing and applications of engineering thermoplastics such as-Acetal–Homopolymer & Co-polymer, polycarbonates, polyamides-Nylon 6, 66, 610, 11 and 12, Polyesters (Poly Ethylene Terephthalate & Poly Butylene Terephthalate) polyimides, Poly (benzimidazoles), polyphenylene oxide, Poly(aryl ether ketone), Poly(ether ketone), Poly(aryl ether sulfone), poly (phenylene sulfides), Polysulfones-Fluoropolymers (PolyVinyl Fluoride, Poly Vinylepene Fluoride, Poly Tetra Fluoro Ethylene,Polychloro TriFluoro Ethylene), Liquid crystalline polymers and Thermoplastic Polyurethane.

UNIT IV THERMOSETTING PLASTICS 9

UNIT V POLYMER BLENDS AND ALLOYS 9
Introduction to polymer blends and alloys- Definitions, compatibilization mechanism and methods, criteria for making polymer blends, Selection of polymer for blend, Types of polymer blends. Thermodynamics of polymer miscibility, Blend preparation techniques, Commercial polymer blends such as plastic-plastic, rubber-plastic, rubber-rubber blends, High performance polymer blends.

TOTAL: 45 PERIODS
REFERENCES:

**UNIT I**
**COMPOUNDING OF THERMOPLASTICS**
Compounding-Importance, ingredients, master batch, equipments- Twin screw extrusion, compression moulding and compounding lines -compounding of polyolefins, polystyrene and styrene copolymers, engineering polymers, natural fiber filled plastics, post compounding operations.

**UNIT II**
**INJECTION MOULDING AND EXTRUSION PROCESS**

**UNIT III**
**BLOW MOULDING, COMPRESSION & TRANSFER MOULDING PROCESS**
Basic principles of blow moulding—Injection Blow moulding, extrusion blow moulding, Parison programming, Advantage & disadvantage of blow moulding. Basic principles of compression and transfer moulding-Bulk factor-Curing time-Mould temperature and Pressure requirements-Preforms and preheating-Techniques of preheating- Machines used-Types of compression mould-Common moulding faults and their correction. Advantages of transfer moulding over compression moulding- Equipment used-Moulding faults—causes and remedies.

**UNIT IV**
**THERMOFORMING, CALENDERING AND ROTO MOULDING PROCESS**

**UNIT V**
**SELECTIVE LASER SINTERING (SLS) PROCESS**
Principle, process, Indirect and direct SLS- powder structures, materials, post processing, surface deviation and accuracy. Applications; Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications. Other Additive Manufacturing Systems: Shape Deposition Manufacturing (SDM), Ballastic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting;
REFERENCES:

8. Iyesew, A.I., Compression Molding
9. Bruins Basic Principle of Rotational Molding
10. Brycle, D.M, Basic Principle of Thermoforming

PA4103 POLYMER CHARACTERIZATION

UNIT I STANDARDS AND IDENTIFICATION OF PLASTICS 9

UNIT II MECHANICAL PROPERTIES 9

UNIT III THERMAL PROPERTIES 9

UNIT IV OPTICAL AND ELECTRICAL PROPERTIES 9

UNIT V PRODUCT TESTING 9
Testing of Pipe and fittings-film and sheets-container and FRP based products. Factors for designing tests for newer products, Factors affecting the quality of materials and products. Analysis of failure and
its measurements. Techniques of characterization-Principles, equipments and application of DSC, DMA, TGA and FTIR, Concepts of non-destructive testing.

TOTAL: 45 PERIODS

REFERENCES:

RM4151 RESEARCH METHODOLOGY AND IPR L T P C 2 0 0 2

UNIT I RESEARCH DESIGN 6
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys.

UNIT II DATA COLLECTION AND SOURCES 6
Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT III DATA ANALYSIS AND REPORTING 6
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT IV INTELLECTUAL PROPERTY RIGHTS 6

UNIT V PATENTS 6
REFERENCES

PA4111 POLYMER CHARACTERIZATION LABORATORY L T P C 0 0 4 2

LIST OF EXPERIMENTS:
1. Identification of Plastics materials.
2. Density determination.
3. Bulk polymerization - Preparation of polymethyl methacrylate.
4. Solution Polymerization - Preparation of polyacrylamide.
5. Preparation of Phenol-Formaldehyde, UF and MF resins.
8. End group analysis.
10. Study of Molecular weight distribution (GPC).
11. Determination of cure of a phenolic moulding (percentage acetone soluble matter).
13. Determination of K-value for PVC.
14. Viscosity and Molecular Weight Determination
15. Determination of Filler content

TOTAL: 60 PERIODS

EQUIPMENT REQUIRED:
Glassware for reactions and spot tests, Ostwald/Ubbelohde viscometer,

REFERENCES:
LIST OF EXPERIMENTS

1. Injection Moulding (Hand Operated, Semi-Automatic)
2. Microprocessor controlled Injection moulding operation
3. Extrusion Process
4. Compression Moulding
5. Blow Moulding
6. Vacuum Forming
7. Rotational Moulding
8. Coating of Plastics
9. Welding & Sealing of Plastics
10. Screen Printing
11. FRP – Hand layup process
12. Co-extrusion process
13. Machine Maintenance
14. Mould Study

TOTAL: 60 PERIODS

REFERENCES:

LABORATORY REQUIREMENTS

1. Injection moulding machine (conventional) - 2Nos.
2. Plastic tube extrusion machine - 1No.
4. Compression moulding machine - 1No.
5. Microprocessor controlled inj. moulding machine - 1 No.
7. Vacuum forming machine - 1 No.
8. Rotational moulding machine - 1 No.
10. Ultrasonic welding machine - 1 No.
12. Printing machine (on plastics) - 1 No.
15. Moulds for plastic products - 1 No.
16. FRP hand layup kit - 1 No.
17. Plastic co-extrusion film plant - 1 No.
SEMESTER II

PA4201 PLASTICS TESTING

UNIT I  STANDARDS AND SPECIFICATIONS  12

UNIT II  TESTING FOR MECHANICAL PROPERTIES  12

UNIT III  TESTING FOR ELECTRICAL AND OPTICAL PROPERTIES  12

UNIT IV  TESTING FOR THERMAL PROPERTIES  12

UNIT V  TESTING FOR CHEMICAL AND WEATHER RESISTANCE  12

REFERENCES:

TOTAL: 60 PERIODS
UNIT I  MATRIX AND REINFORCEMENT MATERIALS  12

UNIT II  ADDITIVES FOR COMPOSITES  12
Additives for composites, catalysts, room temperature and elevated temperature, accelerators, coupling agents, fillers, flame retardants, toughening agents, UV, stabilizers.

UNIT III  MECHANICAL PROPERTIES OF COMPOSITES  12
Theory of composite materials - calculation of composite properties- mechanism of load transfer, minimum and critical fibre content, critical fibre length- Rule of mixtures–Halpin - Tsai - equation.

UNIT IV  PROCESSING OF COMPOSITES  12
Processing of composites–Important processes like hand lay-up, spray-up, resin transfer moulding, vacuum bag, pressure bag moulding, centrifugal casting, pultrusion, filament winding, moulding compounds–SMC, DMC, BMC.

UNIT V  TESTING OF COMPOSITES  12

REFERENCES


TOTAL: 60 PERIODS
UNIT I  FUNDAMENTALS OF PLASTICS RECYCLING  9

UNIT II  RECYCLING OPERATIONS  9

UNIT III  RECYCLING OF MATERIALS- I  9

UNIT IV  RECYCLING OF MATERIALS- II  9

UNIT V  RUBBER RECYCLING  9

REFERENCES

UNIT I PRODUCT DESIGN

UNIT II INJECTION MOULD DESIGN

UNIT III EJECTION & COOLING SYSTEM DESIGN

UNIT IV DESIGN OF COMPRESSION & TRANSFER MOULD

UNIT V DESIGN OF OTHER MOULDS & DIES

REFERENCES
2. Peter Jones, the Mould Design Guide, Smithers Rapra Technology Limited, Shrewbury, Shropshire, SY4 4NR, UK, 2008,

UNIT I INTRODUCTION TO ADDITIVE MANUFACTURING
Introduction to Additive Manufacturing (AM): AM evolution, Distinction between AM & CNC machining, Advantages of AM; AM process chain: Conceptualization, CAD, conversion to STL, Transfer to AM, STL file manipulation, Machine setup, build, removal and clean up, post processing; Classification of AM processes: Liquid polymer system, molten material systems, discrete particle system, solid sheet system.

UNIT II TYPES OF ADDITIVE MANUFACTURING – I
Stereolithography Apparatus (SLA): Principle, pre-build process, part-building and post-build processes, photo polymerization of SL resins, Advantages, limitations and applications; Solid Ground Curing (SGC): Principle, process, Advantages, limitations, and applications; Fused deposition Modeling (FDM): Principle, details of processes Advantages, limitation, and applications; Laminated Object Manufacturing (LOM): Principles, details of processes, products, materials, advantages, limitations and applications;

UNIT III TYPES OF ADDITIVE MANUFACTURING – II
Selective Laser Sintering (SLS): Principle, process, Indirect and direct SLS, powder structures, materials, post processing, surface deviation and accuracy, Applications; Laser Engineered Net Shaping (LENS): Processes, materials, products, advantages, limitations and applications. Other Additive Manufacturing Systems: Shape Deposition Manufacturing (SDM), Ballistic Particle Manufacturing (BPM), Selective Laser Melting, Electron Beam Melting;

UNIT IV DESIGN FOR ADDITIVE MANUFACTURING
Design for AM: Motivation, DFMA concepts and objectives, AM unique capabilities, exploring design freedoms, Design tools for AM, Part Orientation, Removal of Supports, Hollowing out parts, Inclusion of Undercuts and Other Manufacturing Constraining Features, Interlocking Features, Reduction of Part Count in an Assembly, Identification of markings/numbers etc;

UNIT V APPLICATIONS OF ADDITIVE MANUFACTURING
AM Applications: Functional models, Pattern for investment and vacuum casting, Medical models, art models, Engineering analysis models, Rapid tooling (Direct and Indirect method), new materials development, Bi-metallic parts, Re-manufacturing. Application examples for Aerospace, defense, automobile, Bio-medical and general engineering industries; Post processing of AM parts: Support material removal, surface texture improvement, accuracy improvement, aesthetic improvement, preparation for use as a pattern, property enhancements using non-thermal and thermal techniques.

REFERENCES

PA4211 PLASTICS TESTING LABORATORY L T P C 0 0 4 2

LIST OF EXPERIMENTS
2. Physio-Mechanical properties of plastics : Tensile strength – Flexural strength – Compression strength – Tear strength - Impact strength – Hardness
3. Compounding, Blending using Two Roll Mill and Specimen
4. Determinations of Carbon Black Content
5. Determination of environmental stress cracking resistance for olefins
6. Testing of HDPE/RPVC Pipes
7. Testing of Water Storage Tanks/Containers
8. Testing of Films/Sheets
9. Testing of HDPE/PP Woven Sacks/Tapes
10. Testing of Bottles/Vanaspati, Ghee, Milk Packing

TOTAL: 60 PERIODS

LABORATORY REQUIREMENTS
1. Carbon black content tester - 1 No.
2. Environmental stress cracking resistance tester - 1 No.
3. Specimen Preparation Laboratory
4. Injection moulding machine - 1 No.
5. Compression moulding machine - 1 Nos.
6. Two roll mill - 1 No.
7. Contour cutter - 1 No.
8. Scrap grinder - 1 No.
10. Universal testing machine - 1 Nos.
11. Tear strength tester - 1 No.
12. Impact strength tester - 1 Nos.
15. Rockwell Hardness tester - 1 No.
17. Folding endurance tester - 1 No.
18. Burst strength tester - 1 No.
19. Humidity chamber - 1 No.
20. Gas permeability tester - 1 No.
22. Volume and Surface resistivity-1 No
23. Dielectric strength-1 No
24. Arc Resistance-1 No
25. Haze meter-1 No
REFERENCES

PA4212
PRODUCT DESIGN LABORATORY

LIST OF EXPERIMENTS

I. Plastics Product Design using CAD
   1. 2D and 3D modeling using CAD.
   2. Product drawing practice.

II. Mold Design using CAD/CAM
   4. Design of three plate Injection Mould
   5. Design of split type Injection Mould.
   8. Design of Extrusion Die.

III. Mold flow Analysis using CAE
   10. Optimization of Mould design and Process parameters using Mold flow Software

TOTAL: 60 PERIODS

REFERENCES
5. Design calculations for Compression moulds, Machinery publications, Yellow series, U.K.
PA4311  
PROJECT WORK I  
L T P C  
0 0 12 6

OBJECTIVES
The course aims to enable the students to
- identify the problem/process relevant to their field of interest that can be carried out
- search databases and journals to collect and analyze relevant data
- plan, learn and perform experiments to find the solution
- prepare project report

TOTAL : 180 PERIODS

Individual students will identify a problem relevant to his/her field of study, collect and analyze literature, design, and carryout experiment, collect data, interpret the result and prepare the project report.

OUTCOMES:
At the end of the course the students will be able to

CO1  Identify the research/industrial problems
CO2  Collect and analyze the relevant literature
CO3  Design, conduct experiment and analyse the data
CO4  Prepare project report

PA4411  
PROJECT WORK II  
L T P C  
0 0 24 12

OBJECTIVES
The course aims to
- train students to analyze the problem/ think innovatively to develop new methods/product /process
- make them understand how to find solutions/ create products economically and in an environmentally sustainable way
- enable them to acquire technical and experimental skills to conduct experiment, analyze the results and prepare project report
- enable them to effectively think about strategies to commercialize the product.

TOTAL : 360 PERIODS

Individual students will identify a problem relevant to his/her field of study, collect and analyze literature, design, and carryout experiment, collect data, interpret the result and prepare the project report.

COURSE OUTCOMES
At the end of the project the student will be able to

CO1  Formulate and analyze problems for developing new methods/solutions/processes.
CO2  Plan and conduct experiments to find solutions in a logical manner
CO3  Analyze the results, interpret and prepare project report/know the strategies for commercialization
UNIT I MOLECULAR CONFORMATION AND CONFIGURATION


UNIT II ELASTICITY

Thermoelasticity-Thermodynamics of rubbers–Flory construction- entropic and energetic contributions to the elastic force in rubbers–unentangled rubber elasticity-Affine network model- Phantom network model-entangled rubber elasticity-Edwards tube model-Mooney-Rivlin model

UNIT III SOLUTION PROPERTIES

Polymer solutions-theta condition-Thermodynamic view of miscibility-upper critical solution temperature (UCST)-lower critical solution temperature (LCST)-Concentration regimes in polymer solutions Viscoelasticity-elastic deformation-irrecoverable deformation-models of viscoelasticity-Voigt-kelvin-Maxwell-Burger models-WLF equation-TTS curve-Boltzman superposition principle, stress relaxation-creep and creep recovery-

UNIT IV FLOW BEHAVIOUR


UNIT V MELT RHEOLOGY AND RHEOMETRY


REFERENCES:


TOTAL: 45 PERIODS
UNIT I  PLASTICS MATERIALS FOR PACKAGING
Introduction to Packaging – Functions of packaging – Properties and Applications of major packaging materials viz. Polyolefins, Polystyrene, Polyvinyl Chloride, Polyesters, Polyamides (Nylons), Polycarbonate and Newer materials such as High Nitrile polymers, Polyethylene Naphthalate (PEN), Polyetherimide (PEI) and LCP.

UNIT II  PROCESSING OF PACKAGING MATERIALS
Adhesives, heat sealing types, sealing method, extrusion blown film and cast film and sheet co extrusion, surface treatment testing and evaluation of films, flexible packaging, pouches, bulk and heavy duty bags, thermoforming, thin sheet thermoforming, blow moulding, extrusion and injection blow moulding, foams, cushioning and distribution packaging.

UNIT III  BIO BASED PACKAGING MATERIALS

UNIT IV  APPLICATIONS OF PACKAGING

UNIT V  TESTING OF PACKAGING MATERIALS
Mechanical properties–Tensile properties, Impact properties, Tear strength, Burst strength, Stiffness, Crease or flex resistance, Co-efficient of friction, Blocking, Orientation and shrinkage. Optical Properties–Clarity, Haze and gloss Barrier Properties–Oxygen transmission, Water vapour transmission rate – Migration.

TOTAL: 45 PERIODS

REFERENCES:
4. Understanding Plastics Packaging Technology (Hanser Understanding Books) , Hanser; First edition (September 1, 1997).
UNIT I INTRODUCTION TO ADDITIVES

UNIT II ADDITIVES

UNIT III COMPOUNDING EQUIPMENTS

UNIT IV FORMULATIONS AND TECHNIQUES

UNIT V END USE MARKET FOR PLASTICS
Case studies on material suitability (e.g., Plastic Gears, Feeding Bottle, Bowels for microwave ovens). Survey and uses of plastics with reasons for their importance in major industries like Agriculture, Packaging, Building, Transport, Electrical, Electronics and Telecommunications, Medical and Furniture.

REFERENCES:

TOTAL: 45 PERIODS
UNIT II  NANOMATERIAL SYNTHESIS AND CHARACTERIZATION  
Preparation, Characterization of and functionalization of various nanomaterials such as C60, Carbon nanofiber, Carbon Nanotube, Graphene and Cellulose nanofibers. Characteristics of Polymer nanostructures materials. Processing of nanoparticles, binding mechanisms in nanoparticles, dispersion of nanoparticles, and stabilization of nanoparticles.

UNIT III  PREPARATION OF POLYMER NANOCOMPOSITES  
Processing and fabrication of polymer nanocomposites, Melt blending, solvent casting, In-situ polymerization, solution polymerization, template synthesis, high shear mixing. Homogeneous/heterogeneous nucleation, plasma promoted nucleation. Polymer nanocomposites with structural, gas barrier and flame retardant properties, carbon fibre reinforced polymer nanocomposites, elastomer and thermoplastic elastomer nanocomposites.

UNIT IV  CHARACTERIZATION OF POLYMER NANOCOMPOSITES  
Mechanical properties, X-ray diffraction, Small angle X-ray Scattering, Optical Microscopy, Scanning Electron Microscopy (SEM), Scanning Probe Microscopy (SPM), TEM and EDAX analysis, Scanning Tunneling Microscopy (STM), Atomic force Microscopy (AFM). Electrical properties of polymer nanocomposites. Thermal properties of polymer nanocomposites by using DTA, TGA, DSC.

UNIT V  APPLICATION OF POLYMER NANOCOMPOSITES
High temperature applications: fire retardant, flame retardant nanocomposite applications, Thermoset nanocomposites for rocket ablative materials, nanomodified carbon-carbon composites, Nanocomposites for carbon fiber reinforced polymer matrix composites, Thermoplastic Elastomer nanocomposites for propulsion systems. Biomedical implants, tissue engineering scaffolds, EMI shielding application.

REFERENCES:  
5. Properties and Applications of Polymer Nanocomposites-Clay and Carbon Based Polymer Nanocomposites- Kumar Tripathy, Deba, Prasad Sahoo, Bibhu (Eds.), Springer 2017.

TOTAL: 45 PERIODS

PA4005  SECONDARY PROCESSING OPERATIONS  
UNIT I  CALENDERING, THERMOFORMING AND ROTOMoulding  
UNIT II  FRP LAMINATES
Introduction, FRP processing methods – contact moulding – hand layup, spray up method– vacuum bag & pressure bag moulding, filament welding, centrifugal casting, pultrusion, matched die moulding – Laminates, definition of terms – high, pressure laminating process, types of machinery, impregnation systems – decorative and industrial laminates, continuous high pressure laminating process, application.

UNIT III  CELLULAR PLASTICS
Introduction–process to create foam in resins – mechanical foaming, chemical foaming, physical foaming–processes to shape and solidify foams–low pressure foam moulding, high pressure foam moulding, RIM extrusion foaming, casting foams, steam chest moulding structural foam moulding – applications.

UNIT IV  MACHINING & JOINING OF PLASTICS

UNIT V  CASTING PROCESSES AND ROTATIONAL MOULDING

REFERENCES


TOTAL: 45 PERIODS
UNIT I  NATURAL RUBBER PRODUCTION TECHNOLOGY  9
Various sources of natural rubber, Latex-physical nature and chemical composition, biosynthetic
pathway of natural rubber production, Tapping latex, Preservation of latex, Processing of Latex
(Centrifuging, creaming, etc), Dry rubber production (Smoked sheet, air dried sheet, ISNR, etc.)
Grading of rubbers - Modified forms of natural rubber.

UNIT II  SYNTHETIC ELASTOMERS  9
Manufacturing, structure, properties, compounding, curing and applications: Polyisoprene,
Polybutadiene, SBR, EPDM, Butyl rubber, Neoprene, Nitrile rubber, Silicone rubber, Fluoroelastomer,
Polysulphide rubber, polyurethane rubber, Acrylic rubber, EVA,

UNIT III  THERMOPLASTIC ELASTOMERS  9
Basic structure, Manufacture, Morphology, Commercial grades and Applications-Thermoplastic
styrene block copolymers, Polyester thermoplastic elastomers, polyamide thermoplastic elastomer,
Polyurethane thermoplastic elastomers.

UNIT IV  COMPOUNDING OF RUBBERS  9
Principles of rubber compounding. Compounding to meet processing and vulcanisate properties.
Introduction to dry rubber and latex compounding ingredients, Sulphur vulcanization and non-sulphur
vulcanization, vulcanization systems - accelerators, activators, promoters, antioxidants, antiozonants,
processing aids, extenders, fillers and effect of fillers, Blowing agents, etc. Equipments used rubber
processing, rubber Processability tests

UNIT V  RUBBER PRODUCT MANUFACTURING  9
Manufacturing of Dry rubber Products: Tyres, Belting, Hoses, Footwear, Rubber metal bonded items,
sports goods, cellular rubber. Manufacturing of Latex Products: Latex Gloves, Latex threads, Latex
foam rubber, latex adhesives

TOTAL: 45 PERIODS

REFERENCES
Research Institute, Kottayam, India

UNIT I  INTRODUCTION  9
Concepts & terminologies, Interfacial tension, Free energy changes, wetting, dispersion, adhesion,
Chemistry & Technology of Surfactants.

UNIT II  CONCEPT OF DYES & PIGMENTS  9
Theory of Color; Important Physico-Chemical Characteristics of Pigments, Analysis & testing of
pigments Inorganic Pigments; Chemistry, Properties and Applications of carbon black, metallic and
metal oxide pigments, Resinated pigments, Organic Pigments, High Performance Pigments & Special
Effect Pigments (IR Reflective, anticorrosive, thermo chromic, pearlescent etc), driers, additives,
solvents, plasticizers.
UNIT III CHEMISTRY AND TECHNOLOGY OF RESINS 9
Natural resins like rosin, shellac, Bitumen, Asphalts and Coal tar—Their modifications & uses Chemistry and Technology of Synthetic resins viz. Alkyds, Polyester, Phenolics, Amino, Acrylic & Vinyl resins: Raw materials for these resins, Chemistry of synthesis of these resins, processing techniques, properties & applications of these resins for surface coatings.

UNIT IV MANUFACTURE OF PAINTS & POWDER COATINGS 9
Powder Coatings, dry distempers, cement paints, oil based distempers and paints, other stiff paints, putties. Marking and labeling of packaged products, Solvent emission, recovery and disposal, environmental, health and safety issues

UNIT V VARIOUS SURFACE COATINGS 9
Preparation and characteristics of Coil Coating, UV cured coating, Waterborne PU Coatings, Non Stick coatings, Smart Coatings, super hydrophobic coatings, electro wetting, Hygienic Coatings, protective coatings, marine coatings, automotive and aerospace coatings Study of important characteristics of surface coating: Rheological properties, Optical Properties, Adhesion and Mechanical properties, Corrosion and Chemical resisting properties, Film thickness, Liquid Paint analysis according to ASTM, BIS and BS Standards, Characterization of Varnishes according to ASTM, BIS and BSS Standards.

TOTAL: 45 PERIODS

REFERENCES

PA4008 CAD/CAM/CAE APPLICATIONS IN MOULD / DIE DESIGNS

UNIT I COMPUTER GRAPHICS 9
Output primitives (Points, lines, curves, etc.,) - 2-D and 3D Transformations Homogeneous Coordinates- Windowing, Viewing and clipping transformation Hidden Line and Surface Removal Algorithms.

UNIT II COMPUTER AIDED DESIGN (CAD) 9
UNIT III  COMPUTER AIDED MANUFACTURING (CAM)  9
Introduction to NC machines, CNC machines, Direct Numerical Control (DNC), Advantages & Disadvantages, Working principle of CNC machines - Introduction to CAM software packages – G Codes & M Codes – Part programming for CNC Turning Centre and CNC Machining Centre.

UNIT IV  FINITE ELEMENT ANALYSIS (FEA)  9
Introduction to Finite Element Analysis (FEA), Types of analysis - Procedure for finite element analysis -Finite Element Analysis packages, and its application; Analysis of One Dimensional Bar elements-Derivation of Shape function and Stiffness matrix and force vector – Assembly of matrix – Field problems.

UNIT V  MOLD FLOW ANALYSIS  9
Introduction to Moldflow analysis- Design principles- Product design and Moldflow - Sequence of analysis- Moldflow concepts- Meshes used in Moldflow analysis- Types, Requirement- Geometry Creation- Importing Geometry; Shrinkages and Warpage- injection molding and shrinkage, basic cause of warpage and shrinkages ; Moldflow design procedure- Analysis steps framework, Evaluate an Initial design, optimized the design; Part defects.

REFERENCES

PA4009  REVERSE ENGINEERING  L T P C
3 0 0 3

UNIT I  INTRODUCTION  9

UNIT II  GEOMETRICAL FORM  9

UNIT III  MATERIAL CHARACTERISTICS AND ANALYSIS  9
Alloy Structure Equivalency-Phase Formation and Identification-Mechanical Strength-Hardness Part Durability and Life Limitation Part Failure Analysis-Fatigue-Creep and Stress Rupture-Environmentally Induced Failure
UNIT IV MATERIAL IDENTIFICATION & DATA PROCESS ANALYSIS 9
Material Specification-Composition-Determination-Microstructure Analysis-Manufacturing Process Verification

Data Process and Analysis
Statistical Analysis-Data Analysis-Reliability and the Theory of Interference-Weibull Analysis-Data Conformity and Acceptance.-Data Report

UNIT V PART PERFORMANCE AND ACCEPTANCE LEGALITY 9
Performance Criteria-Methodology of Performance Evaluation-System Compatibility

Acceptance and Legality

TOTAL: 45 PERIODS

REFERENCES

PA4010 MECHANICAL BEHAVIOR OF MATERIALS L T P C 3 0 0 3

UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR 10

UNIT II BEHAVIOUR UNDER DYNAMIC LOADS AND DESIGN APPROACHES 10
Stress intensity factor and fracture toughness – Fatigue, low and high cycle fatigue test, crack initiation and propagation mechanisms and Paris law.- Safe life, Stress life, strain-life and fail - safe design approaches -Effect of surface and metallurgical parameters on fatigue – Fracture of non metallic materials – Failure analysis, sources of failure, procedure of failure analysis.

UNIT III SELECTION OF MATERIALS 10
Motivation for selection, cost basis and service requirements–Selection for mechanical properties, strength, toughness, fatigue and creep – Selection for surface durability corrosion and wear resistance – Relationship between materials selection and processing – Case studies in materials selection with relevance to aero, auto, marine, machinery and nuclear applications – Computer aided materials selection.

UNIT IV MODERN METALLIC MATERIALS 8
UNIT V  NON METALLIC MATERIALS

Polymeric materials – Formation of polymer structure – Production techniques of fibers, foams, adhesives and coating – structure, properties and applications of engineering polymers – Advanced structural ceramics, WC, TiC, TaC, Al2O3, SiC, Si3N4 CBN and diamond – properties, processing and applications.

TOTAL: 45 PERIODS

REFERENCES:
REFERENCES
13. Schar, J., Press blowing option for tough to blow parts, SPE ANTEC April’87.

PA4012 FRACTURE MECHANISM & ANALYSIS IN POLYMERS

UNIT I ELEMENTS OF SOLID MECHANICS
The geometry of stress and strain, elastic deformation, plastic and elasto-plastic deformation – limit analysis–Airy’s function – field equation for stress intensity factor.

UNIT II STATIONARY CRACK UNDER STATIC LOADING

UNIT III ENERGY BALANCE AND CRACK GROWTH

UNIT IV FATIGUE CRACK GROWTH CURVE

UNIT V APPLICATIONS OF FRACTURE MECHANICS
Crack Initiation under large scale yielding – thickness as a design parameter – mixed mode fractures - crack instability in thermal and residual stress fields - numerical methods.

TOTAL: 45 PERIODS
REFERENCES:

PA4013 BIOMEDICAL PLASTICS L T P C 3 0 0 3

UNIT I MATERIALS USED IN MEDICINE 9
Introduction, Polymers, Silicone Biomaterials: History and Chemistry, Medical Fibers and Biotextiles, Hydrogels, Bioresorbable and Bioerodible Materials, Natural Materials, Metals, Ceramics, Glasses, and Glass-Ceramics, Composites, Textured and Porous Materials, Surface-Immobile Biomolecules

UNIT II BIOLOGICAL TESTING OF BIOMATERIALS 9
Introduction to Testing Biomaterials, In Vitro Assessment of Tissue Compatibility, In Vivo Assessment of Tissue Compatibility, Evaluation of Blood-Materials Interactions, Microscopy for Biomaterials Science

UNIT III DEGRADATION OF MATERIALS IN BIOLOGICAL ENVIRONMENT 9
Introduction: Degradation of Materials in the Biological Environment, Chemical and Biochemical Degradation of Polymers, Degradative Effects of the Biological Environment on Metals and Ceramics, Pathological Calcification of Biomaterials,

UNIT IV APPLICATION OF MATERIALS IN MEDICINE, BIOLOGY, AND ARTIFICIAL ORGANS 9
Introduction, Nonthrombogenic Treatments and Strategies, Cardiovascular Medical Devices, Implantable Cardiac Assist Devices, Extracorporeal Artificial Organs, Orthopedic Applications, Dental Implantation, Adhesives and Sealants, Ophthalmological Applications, Intraocular Lens Implants, Burn Dressings and Skin Substitutes, Sutures, Drug Delivery Systems, Cochlear Prostheses, Biomedical Sensors and Biosensors, Overview of Tissue Engineering, Synthetic Bioresorbable Polymer Scaffolds.

UNIT V PRACTICAL ASPECTS OF BIOMATERIALS 9
Introduction, Sterilization of Implants and Devices, Implant and Device Failure, Correlation, Surfaces and Biomaterials Science, Development and Regulation of Medical Products Using Biomaterials, Ethical Issues in the Development of New Biomaterials, Legal Aspects of Biomaterials

TOTAL: 45 PERIODS

REFERENCES

32
UNIT I  SMART MATERIALS

UNIT II  SUPER ALLOYS
Classification of Nanomaterials, fabrication of nanomaterials, Applications of Nanomaterials. Classification of super alloys, Development of different phases in super alloys, Ni-based super alloys, commercially available pure nickel alloys, Co-based super alloys, Fe-based super alloys, Ti alloys, Al-Li alloys.

UNIT III  BIOMATERIALS

UNIT IV  ULTRA-LIGHT MATERIALS
Bulk metallic glasses (BMG): Various methods for BMG production, Classification of BMG, Properties and behaviors of BMG, Thermodynamic aspects of stability, Potential applications of BMG. Aerogels, Aerographite, Metallic Foams, Polymeric Foams, Metallic Microlattices, their synthesis, properties and applications.

UNIT V  PLASMA SURFACE ENGINEERING
Plasma, plasma synthesis techniques, Energy associated with plasma, Kinetics in plasma, different types of plasma spraying, cold plasma, applications of plasma. Energy generation and energy storage: battery cell, Self-charging battery, Battery both generates and stores energy, Flow battery.

REFERENCES

UNIT I  ELECTROCHEMISTRY OF CONDUCTING POLYMERS  
Introduction to conducting polymers-discovery of polyacetylene-concept of doing and n-type -polaron and bipolarons-conduction mechanism-redox type polymers (electro - active polymers). Important properties of conjugated polymers-electrical conductivity, photoconductivity, charge storage capacity, photoluminescence, and electroluminescence.

UNIT II  GENERAL SYNTHESIS OF CONDUCTING POLYMERS  
Electrically conducting polymers-Chain growth polymerisation, step growth polymerization, electrochemical polymerization, Metathesis polymerization (Ring opening metathesis polymer (ROMP)). Advantages and disadvantages of conducting polymers, methods to enhance the processability of conducting polymers

UNIT III  SYNTHESIS OF DIFFERENT CONDUCTING POLYMERS  
Synthesis and properties of conducting polymers-Polyacetylene, Poly p-phenylene, Polyheterocyclic and polyaromatic conductive polymers like polythiophene, poly vinyl carbazole, polypyrene, polyaniline, Polypyrrole, Poly phenylene vinylene, Polypyridine.

UNIT IV  CHARACTERIZATION AND PROCESSABILITY OF CONDUCTING POLYMERS  
Characterization methods - elemental analysis for dopants - IR - UV (electro chemical) scanning electron microscopy (SEM)-electrochemical characterization-cyclic voltammetry- electrochemical quartz crystal microbalance (EQCM) - probe beam deflection (PBD) -Langmuir - blodgett technique. Concept of doping- Charge carriers: polaron, bipolarons and solitons. Types of dopants, oxidative dopants and reductive dopants, mechanism of doping, p-type doping and n-type doping, inorganic and organic dopants, effect of doping on the dielectric properties of conducting polymers

UNIT V  APPLICATIONS OF CONDUCTING POLYMERS  
Applications of conducting polymers- electro active applications Polymer rechargeable batteries, sensors, electrochemical actuators, electro luminescent applications. Conductivity applications - antistatic coatings, conducting adhesives, artificial nerves. Electronic applications- EMI shielding, Frequency selective surfaces, satellite communication links, Dielectric properties of conducting polymers in the high and very high frequency fields (a.c field ), ultra high frequency field (Microwave field). Recent trends in conducting polymer and conducting polymer nanocomposites

TOTAL: 45 PERIODS

REFERENCES
UNIT I    INTRODUCTION
Definition of LCP, Types of liquid crystalline polymer, Local order and classification, Chemistry and physics of liquid crystalline polymer, Synthesis of liquid crystalline polymer, Properties of liquid crystalline polymer.

UNIT II    STABILITY OF LIQUID CRYSTALLINE POLYMERS
Thermotropic liquid crystals-Rigid-rods to main-chain polymers, development of side chain liquid crystalline polymers, Stability of liquid crystalline polymers, Factors limiting liquid crystallinity in rigid rod-like molecules, Control of mesophase stability in main chain thermotropic liquid, crystalline polymers, Lyotropic rigid-rod polymers, Polymers with mesogenic side-chains, Liquid crystalline polymers with more complex molecular architectures.

UNIT III    THEORIES OF LIQUID CRYSTALLINITY IN POLYMERS

UNIT IV    PROCESSING OF STRUCTURAL LIQUID CRYSTALLINE POLYMERS
Processing of structural liquid crystalline polymers: Rheology, Processing and the consequences of flow alignment, Liquid crystalline polymers as structural materials, Liquid crystalline polymers in blends and composites, Identification of LCP by DSC, Microscopy and XRD.

UNIT V    APPLICATIONS OF FUNCTIONAL LIQUID CRYSTALLINE POLYMERS

REFERENCES

TOTAL: 45 PERIODS
AUDIT COURSES

AX4091 ENGLISH FOR RESEARCH PAPER WRITING L T P C
2 0 0 0

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

REFERENCES:
COURSE 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
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

COURSE OUTCOMES:
At the end of the course, students will be able to
- CO1 Ability to summarize basics of disaster
- CO2 Ability to explain a 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
REFERENCES:

AX4093 CONSTITUTION OF INDIA

COURSE 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.

TOTAL: 30 PERIODS
COURSE OUTCOMES:
Students will be able to:
- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization of social reforms leading 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.

AX4094

UNIT I

1. குறிச்சொல்லியமுள்ளதுச்சி - குறிச்சொல்லியமுள்ளதுச்சி
2. அட்டக்கம்பேற்றுச் சொல்லியமுள்ளது - குறிச்சொல்லியமுள்ளது
3. குறிச்சொல்லியமுள்ளதுச்சி - குறிச்சொல்லியமுள்ளது
4. குறிச்சொல்லியமுள்ளது - குறிச்சொல்லியமுள்ளது

UNIT II

1. அம்பாரின் குறிச்சொல்லியமுள்ளது - குறிச்சொல்லியமுள்ளது
2. புருவகேற்றுச் சொல்லியமுள்ளது - குறிச்சொல்லியமுள்ளது
3. குறிச்சொல்லியமுள்ளது - குறிச்சொல்லியமுள்ளது

UNIT III

1. குறிச்சொல்லியமுள்ளது குறிச்சொல்லியமுள்ளது
2. குறிச்சொல்லியமுள்ளது குறிச்சொல்லியமுள்ளது
UNIT IV

அருள்நநறித்தமிழ்

1. சிறுபொணொற்றுப்பகட
   - பபகன்மயிலுக்குப்பபொர்கவதகொடுத்தது,
   - அதியமொன்ஒளகவக்குதநல்லிக்கனிதகொடுத்தது,
   - பண்புகள்

2. பத்திரைகள
   - அகநொனூறு

3. திருமந்திரம் (617, 618)
   - இயமம்நியமம்விதிகள்

4. வள்ளலொர்

5. புறநொனூறு
   - சிறுபனவள்ளலொனொன்

6. அகநொனூறு (4)
   - மந்தன
   - கணிகம் (11)
   - பபகன், பொர்கவ
   - வள்ளலொர்
   - அகநொனூறு

UNIT V

தமிழ்இலக்கியம்

1. உகரநகடத்தமிழ்,
   - தமிழின்முதல்புதினம்
   - தமிழின்முதல்சிறுககத
   - கட்டுகரஇலக்கியம்
   - பயணஇலக்கியம்
   - நொடகம்
   - உகரநகடத்தமிழ்

2. முதொயவிடுத்தமிழ்இலக்கியமும்

3. விளிம்புநிகலயினரின்பஞ்சியமும்

4. அறிவியல்தமிழ்

5. இகணயத்தில்தமிழ்

6. சுற்றுசூழல்

TOTAL: 30 PERIODS

தமிழ்இலக்கியநெளியீடுகள் / புத்தகங்கள்

1. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
2. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
3. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
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21. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
22. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
23. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
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29. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org
30. தமிழ்விக்கிப்பீடியொ (Tamil Wikipedia) - https://ta.wikipedia.org