JSS MAHAVIDYAPEETHA

JSS Science and Technology University

(Sri Jayachamarajendra College of Engineering)

JSS Technical Institutions Campus, Mysuru-06

Scheme of Teaching and Examination for

M.Tech. in MATERIAL SCIENCE AND ENGINEERING

(Applicable for students admitting in 2017-18)

(I to IV semester Approved in BOS Meeting 2017)

CREDIT DETAILS

SEMESTER I	**28**
SEMESTER II	**28**
SEMESTER III	**18**
SEMESTER IV	**26**
Total	**100**

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Mysuru – 570 006

SCHEME OF TEACHING

I Semester M. Tech., Material Science and Engineering

Subject code	Name of the subject	Teaching Department	Credits				Contact hours	Marks			Exam duration in hrs
			L	T	P	Total		CIE	SEE	Total	
MSE110	Material Science and Engineering	PST	4	1	0	5	5	50	50	100	03
MSE120	Advanced Characterization Techniques	PST	4	0	1	5	5	50	50	100	03
MSE130	Materials Structure - Property Relations	PST	4	1	0	5	5	50	50	100	03
MSE14X	Elective 1	PST	5	0	0	5	5	50	50	100	03
MSE15X	Elective 2	PST	5	0	0	5	5	50	50	100	03
MSE16L	Material Synthesis and Characterization Lab	PST	-	-	1.5	1.5	3	50	-	50	-
MSE17S	Seminar	-	-	-	1.5	1.5	-	50	-	50	-
			Total Credits			**28**		**Total Marks**		**600**	

L=Lecture, T= Tutorial, P=Practical

Elective subjects:

Elective 1			Elective 2	
Subject code	**Course title**		**Subject code**	**Course title**
MSE141	Ceramic Science and Technology		MSE151	Computer Aided Design and Manufacturing
MSE142	Computational Material Science		MSE152	Technology of Paints and Surface Coating
MSE143	Material Failure Analysis		MSE153	Research Methodology
MSE144	Blends and Alloys		MSE154	Advanced Polymer Technology
MSE145	Applied Mathematics		MSE155	Semiconducting, Magnetic and Optoelectronic Materials
MSE146	Additive Manufacturing Technology			
MSE147	Statistical Quality Control			

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SCHEME OF TEACHING

II Semester M. Tech., Material Science and Engineering

Subject code	Name of the subject	Teaching Department	Credits				Contact hours	Marks			Exam duration in hrs
			L	T	P	Total		CIE	SEE	Total	
MSE210	Advanced Composite Technology	PST	5	0	0	5	5	50	50	100	03
MSE220	Nano Materials and Technology	PST	5	0	0	5	5	50	50	100	03
MSE230	Material Processing Technology	PST	5	0	0	5	5	50	50	100	03
MSE24X	Elective 3	PST	5	0	0	5	5	50	50	100	03
MSE25X	Elective 4	PST	5	0	0	5	5	50	50	100	03
MSE26L	Processing and Testing lab	PST	-	-	1.5	1.5	3	50	-	50	-
MSE27S	Seminar	-	-	-	1.5	1.5	-	50	-	50	-
			Total Credits			**28**		**Total Marks**		**600**	

L=Lecture, T= Tutorial, P=Practical

Elective subjects:

Elective 3		Elective 4	
Subject code	**Course title**	**Subject code**	**Course title**
MSE241	Smart Materials	MSE251	Non-Destructive Testing
MSE243	Finite Element Methods and Applications	MSE252	Renewable and Sustainable Materials
MSE242	Biomaterials	MSE253	Packaging Materials
MSE244	Project Engineering and Management	MSE254	Fiber Technology
MSE245	Heat Transfer in Material Engineering	MSE255	Advanced Rubber Technology

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SCHEME OF TEACHING

III Semester M. Tech., Material Science and Engineering

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	MSE31T	Training in Industry / Exploration Research	-	0	0	4	4	–	100	–	100	–
2.	MSE32P	Project Work (Phase-I)	-	0	0	14	14	–	100	–	100	–
				Total credits			**18**	**–**	**Total marks**		**200**	**–**

IV Semester M. Tech., Material Science and Engineering

Sl. No	Subject code	Course title	Teaching department	Credits				Contact hours	Marks			Exam duration in hrs
				L	T	P	Total		CIE	SEE	Total	
1	MSE41P	Project Work (Phase-II)	-	–	–	26	26	–	200	100	300	3
				Total credits			**26**	**–**	**Total marks**		**300**	**–**

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(Formerly SJCE) Mysuru – 570 006
M. Tech. Material Science and Engineering

Scheme of Evaluation for III and IV Semesters of M.Tech., Programme

Event	Normal Period	Credits	Expected Outcome	Remarks
III Semester				
Industrial Training	September 2nd Week	04	Report on industrial training / presentation	25% weightage for external evaluation 75% weightage for internal evaluation
CIE-I Synopsis Evaluation	October 1st Week	04	Synopsis presentation with Objectives / Scope / Literature Survey	By department committee
CIE-II Midterm Evaluation-I	December 1st Week	06	Comprehensive review of the progress	By department committee
CIE-III Verification of compliance	January 2nd Week	04	Verification of Compliance of midterm evaluation-I	By department committee
IV Semester				
CIE-IV Midterm Evaluation-II	April 2nd Week	08	Comprehensive review of the progress	By department committee
CIE-V Final Internal Seminar / Demonstration	June 2nd Week	08	Discussion with final results and conclusions	By department committee
Report Preparation and Submission	July 2nd Week	–	–	–
Thesis Evaluation and Viva-Voce	On or before 30th August	10	–	By the panel of examiners with HOD or his nominee as Chairman
Results	31st August	–	–	–

Note: 1. Marks awarded for Industrial Training and total marks awarded for CIE-I, CIE-II and CIE-III put together shall be sent to the controller of examination by the 3rd week of January.

2. Marks awarded for CIE-IV and CIE-V put together shall be sent to the controller of examination by the end of June.

Schedule of Events during the 2nd Year of M.Tech. Programme

- **Commencement of III Semester** : 13th July
  - Industrial Training (8 weeks) : 13th July – 5th September
  - Evaluation of Industrial Training : 2nd Week of September
- Reporting to Project work : 7th September
  - **CIE-I:** Evaluation of Synopsis : 1st Week of October
  - **CIE-II:** Mid-term Evaluation-I : 1st Week of December
  - **CIE-III:** Verification of Compliance of Mid-term Evaluation-I : 2nd Week of January
- **Commencement of IV Semester** : 16th January
  - **CIE-IV:** Mid-term Evaluation-II : 2nd Week of April
  - **CIE-V:** Final Internal Seminar / Demonstration of the Project Work : 2nd Week of June
  - Preparation of the M.Tech., Dissertation : 3rd Week of June-2nd Week of July
  - Submission of the M.Tech., Dissertation : 2nd Week of July
  - Viva-Voce : On or before 30th August
- **Announcement of the Results** : 31st August

Note: 1. If any day indicated is a holiday, then the event shall happen the next working day.

2. Marks awarded for Industrial Training and total marks awarded for CIE-I, CIE-II and CIE-III put together shall be sent to the controller of examination by the 3rd week of January.

3. Marks awarded for CIE-IV and CIE-V put together shall be sent to the controller of examination by the end of June.

I Semester

MSE110: MATERIAL SCIENCE AND ENGINEERING (4-1-0)		
Course Outcomes: Upon successful completion of this course, the students will be able to		
CO1: Analyze material atomic structure and bonding. **CO2:** Construct the phase diagrams for a given material systems. **CO3:** Explain mechanical behavior and the degradation mechanism of materials by corrosion and oxidation **CO4:** Explain magnetic and electrical properties of materials. **CO5:** Explain properties and applications of advanced materials.		
Course Content		
Unit 1	**Introduction to material science and engineering:** Importance of material science and engineering, Material evolution through ages, Criteria for selection of materials: properties, cost, manufacturing process, availability legal and safety factors. **Atomic structure:** Structure and bonding in materials. Crystal structure of materials, crystal systems, Concept of amorphous, single and polycrystalline structures and their effect on properties of materials. Imperfections in crystalline solids and their role in influencing properties, Crystal growth techniques, determination of structures of simple crystals by x-ray diffraction, packing geometry in metallic, ionic and covalent solids, numerical problems.	**10h**
Unit 2	**Solid solutions and alloys:** Types of Solid solutions, solubility limit, Gibbs phase rule, lever rule, binary phase diagrams, isomorphous and Eutectic phase diagrams, iron-iron carbide phase diagram, applications of phase diagrams, heat treatment of steels, cold and hot working of metals, micro-structural changes during solidification of alloys, theories of solid solution strengthening. Microstructure, properties and applications of important ferrous and non-ferrous alloys. Numerical problems.	**10h**
Unit 3	**Mechanical behavior of materials:** Stress-strain diagrams of metallic, ceramic and polymeric materials, introduction to long term and short term mechanical properties, factors influencing properties, determination of modulus of elasticity, elongation,	**10h**

	yield strength, tensile strength, impact strength, toughness, plastic deformation, visco-elasticity, hardness, creep, stress relaxation, fatigue, ductile and brittle fracture, numerical problems. **Degradation of materials by corrosion and oxidation** Corrosion: electrochemical principles, Electrode potential, Nernst equation. oxy-reduction potentials; general characteristics of electrochemical corrosion, overview of corrosion prevention methods.	
Unit 4	**Magnetic Properties -** Origin of magnetism in materials, concept of para-magnetism, diamagnetism, ferromagnetism, anti-ferromagnetism, ferrimagnetism, hard and soft magnets, applications of magnets, magnetic hysteresis. Numerical problems. **Electrical Properties -** Concept of energy band diagram for conductors, semiconductors and insulators, effect of temperature on conductivity, intrinsic and extrinsic semiconductors, dielectric properties, Hall effect, Numerical problems.	**10h**
Unit 5	**Advanced Materials -** Ferroelectric, piezoelectric, opto-electric, semiconducting materials, lasers, optical fibers, photoconducting materials, superconductors, Smart materials, biomaterials, super alloys, shape memory alloys, nano-materials – synthesis, properties and applications.	**10h**

References:

1. V Raghavan. Materials Science and Engineering, 5th Edition, PHI Learning Pvt. Ltd., New Delhi, 2011.
2. R. Balasubramaniam. Callister's Materials Science and Engineering, 2nd Edition, Wiley India Pvt. Ltd. New Delhi, 2014.
3. William D Callister. Materials Science and Engineering, John Wiley, New York, 2007.
4. A.K. Bhargava. Engineering Materials, Prentice-Hall of India Pvt. Ltd., 2005.
5. L.H. Van Vlack. Elements of Material Science and Engineering, 6th edition, Addison- Wesley Publishing Co., New York, 1989.

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MSE120: ADVANCED CHARACTERIZATION TECHNIQUES (4:0:1)		
Contact Hours: 5/week		
Course Outcomes: Upon successful completion of this course, the students will be able to **CO1:** Explain the theory and techniques of various modern analytical tools; **CO2:** Explain principles of various spectroscopic techniques **CO3:** Distinguish the type of material and Explain its structure / properties; **CO4:** Apply this knowledge to produce better engineering products; **CO5:** Apply this knowledge to distinguish quality of materials available commercially.		
Course Content:		
Unit 1	**Introduction to analytical instrumentation** - Calibration, accuracy, precision, reproducibility, standard deviation. **Spectroscopic Methods** Introduction, classification**,** Ultra-violet/Visible spectroscopy - Introduction, principle, Lambert law, Beer's law, theory, instrumentation, procedure, advantages, disadvantages, interpretation of spectrogram, applications-qualitative analysis, quantitative analysis; purity, cis- and trans- conformation. Numerical	**10h**
Unit 2	**Fourier transform infrared (FTIR) spectroscopy** Introduction, principle, theory, instrumentation, procedure, methods of sample preparation, advantages, disadvantages, interpretation of spectrogram, and applications-establishment of chemical structure of polymers, reaction kinetics, polymer linkage, hydrogen bond formation, purity, copolymerization, qualitative and quantitative results. **Chromatographic techniques** Principle of Gel permeation chromatography (GPC), mechanism of separation, theory/techniques, instrumentation, molecular weight determination and distribution (MWD), purity, composition, other applications.	**10h**
Unit 3	**Nuclear Magnetic spectroscopy (NMR)- (^{1}H NMR and ^{13}C NMR)** Introduction Principle, theory, Spin-spin coupling, coupling constant, instrumentation, procedure, method of sample preparation, advantages, disadvantages, applications – chemical structures, purity, tacticity.	**10h**

Unit 4	**Thermal Methods** Introduction, general classification, advantages of the TA methods; Differential scanning calorimetry (DSC and MDSC)- Introduction, theory, instrumentation, method of analysis, factors affecting on DSC results, advantage, disadvantage, interpretation of DSC thermograms, applications - T_g, T_m, determination of blends composition, purity, identification of unknown polymers, degree of crystallization, degree of cure and rate of cure studies/kinetics of curing, plasticizers effect, Thermo gravimetric analysis (TGA) - Introduction Principle, theory, instrumentation, procedure for analysis of sample, factors influence on studies, advantages, disadvantages, applications – Purity, fiber content, composition of compounded rubbers, identification of polymers/rubbers, thermal stability, thermal degradation, kinetics of thermal degradation and IPDT. Dynamic mechanical Analysis (DMA)- Introduction, principle, instrumentation, and its applications.	**10h**
Unit 5	**Microstructural analysis** X-ray diffractometry: X-ray diffraction analysis, experimental methods, applications-Chain conformations, chain packing, disorder in the crystal, degree of crystallinity, micro structural parameters, degree of orientations. Microscopic analysis: SEM, TEM, AFM; Morphology of polymers, Crystallization behavior, phase separation and other applications.	**10h**

References:

1. D.Campbell and J.R. White – Polymer Characterization – Physical Techniques (Chapman and Hall), 1989
2. F.W.Billmeyer-Text book of Polymer Science - 3rd ed. Wiley Interscience,1984.
3. K.J.Saunders-The Identification of Plastics and Rubber , Chapman and Hall, London 1970.
4. William C. Wake - Analysis of Rubber and Rubber like Polymers – Rev. ed. Wiley Interscience, New York 1969.
5. E.Turi -Thermal Characterization of Polymeric materials -Academic Press,New York 1981.

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MSE130: MATERIALS STRUCTURE PROPERTY RELATIONS (5-0-0)		
Course Outcomes: Upon successful completion of this course, the students will be able to		
CO1: Explain Structure Property Relations of Metals and Alloys **CO2:** Explain Structure Property Relations of Ceramics **CO3:** Explain Structure Property Relations of Polymers **CO4:** Explain Structure Property Relations of Composites **CO5:** Explain Structure Property Relations of Advanced Materials		
Course Content		
Unit 1	**Structure Property Relations of Metals and Alloys:** Solid Solutions and Alloys, Phase Transitions, Overview of Crystal Structures, Structure - Property Relations of ferrous and nonferrous alloys, Neumann's Principle, Thermal properties, Optical properties, Electrical properties, Dielectric properties, Magnetic properties and mechanical properties of metals. Effect of alloying, combinations of metals and nonmetals. Effect of processing conditions on properties, microstructure development. Prediction of structure and properties based on composition of the alloy. Numerical problems.	**10h**
Unit 2	**Structure Property Relations of Ceramics:** Crystal structure of ceramic materials, structure induced properties**,** thermal, chemical, mechanical, electrical, dielectric, magnetic and optical properties of ceramics. Toughened ceramics, Concept of various toughening mechanisms, structure property correlation in ceramics. Emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on the properties of ceramics.	**10h**
Unit 3	**Structure Property Relations of Polymers:** Inter-chain and intra-chain forces of interactions in polymers; determination of tacticity and crystallinity, strain induced morphology. The concept of polymer properties (fundamental, processing and product properties); Structural basis for polymers to be elastomers, fibers and plastics. Understanding polymer-solvent interactions, factors influencing T_g and T_m. Viscous flow, Kinetic theory of rubber elasticity, Visco-elasticity, mechanical damping, generalized stress-strain relationship for polymers. Effect of various additives on polymer behavior. Group contribution on	**10h**

	properties.	
Unit 4	**Structure Property Relations of Composites:** Metal and polymer composite properties, effect of interphase structure on composite properties, property prediction based on composition of constituent phases and additives, some case studies of metal and polymer composites/nanocomposites.	**10h**
Unit 5	**Structure Property Relations of Advanced Materials:** Types of advanced materials, advanced material structures and properties, influence of molecular structure to predict the properties of specialty polymers, nanomaterials, biomaterials, smart materials, superalloys, superconductors and shape memory alloys.	**10h**

References:

1. V. Krevelen. Properties of Polymers: Correlations with chemical structure, Elsevier Pub., New York, 1972.
2. R. B. Seymour. Structure-property relationships in polymers, Plenum Press, New York, 1984.
3. Patrick Meares. Polymers-structure and bulk properties, Van Nostrand Pub., New York, 1965.
4. A Russell, K L Lee. Structure-Property Relations in Nonferrous Metals. John Wiley and Sons, 2005.
5. R. E. Newnham, Structure-Property Relations. Springer Science and Business Media, 2012.
6. Tao Xu. The Structure-property Relation in Nanocrystalline Materials: A Computational Study on Nanocrystalline Copper by Monte Carlo and Molecular Dynamics Simulations, Georgia Institute of Technology, 2009.

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MSE141: CERAMIC SCIENCE AND TECHNOLOGY (5-0-0)

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

CO1: Explain the classification, bonding and structure of ceramics.

CO2: Correlate the structure with properties of ceramics.

CO3: Explain the conventional ceramic types, properties and applications.

CO4: Explain the advanced ceramic types, properties and applications.

CO5: Explain the concepts of ceramic fabrication and processing.

Course Content		
Unit 1	**Introduction:** Ceramics as a class of material, raw materials, bonding and structure of ceramic materials, crystal structure and defects, chronological developments, polymorphic transformations. Classification of ceramic materials conventional and advanced, Structural and functional, areas of applications. Ceramic Binary and ternary systems, ceramic phase equilibrium diagrams: Al_2O_3 - SiO_2 system, MgO-Al_2O_3-SiO_2 system, non-equilibrium phases. Development of microstructure in equilibrium and nonequilibrium phases, calcinations. Structural ceramics: oxides, carbides, nitrides and borides, characteristics of ceramic solids and ceramic microstructures.	**10h**
Unit 2	**Properties of Ceramics:** Thermal, chemical, mechanical, electrical, dielectric, magnetic and optical properties of ceramics. Brittle Failure: Statistical Design for Strength, Thermal Shock/Anisotropy-Induced Microcracking. Mechanical behavior of structural ceramics-Brittleness of ceramics, Concept of fracture toughness and different toughness and strength measurement techniques; Toughened ceramics, Concept of various toughening mechanisms; structure property correlation. Emphasis on the effects of composition, microstructure, processing, temperature and atmosphere on the properties of ceramics.	
Unit 3	**Conventional Ceramics: Refractories -** Classification of refractories, modern trends and developments, basic raw materials, elementary idea of manufacturing process, basic properties and areas of application. **Whitewares:** classification and type of whitewares, elementary idea of manufacturing process, basic properties and applications. **Ceramic Coatings:** Types of glazes and enamels, elementary ideas on compositions, process of enameling and glazing and their properties. **Glass:** Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, elementary concept of glass manufacturing process, types of glasses, application of glasses. **Cement and Concrete:** Concept of hydraulic materials, Basic raw materials, Manufacturing process and applications. Abrasives.	**10h**
Unit 4	**Advanced Ceramics:** Bio-ceramics, space ceramics, automotive ceramics,	**10h**

	electronic ceramics, superconducting ceramics, porous ceramics, piezo electric, pyroelectric, ferroelectric and electrooptic ceramics, elementary ideas of their preparation, properties and applications. Applications of electronic ceramics in devices and in optical communication. Ceramics for microwave applications, luminescent and photoconducting ceramics. Thin film techniques for electronic applications, cermets, ceramics for application in armored, aerospace and space vehicles.	
Unit 5	**Ceramic Fabrication and Processing:** selection of raw materials, control of microstructure, crushing, grinding and milling of ceramics. Characterization of ceramic powders – surface area, morphology, structure. Ceramic powders by co-precipitation, hydrothermal, flash pyrolysis, sol-gel processing, cryo-chemical and freeze drying techniques. Packing of powders, classification and scope of various fabrication methods. Dry and semi dry pressing, slip casting. Rapid prototyping, electrophoretic casting and electro-spinning. Drying and Firing of ceramics, elementary ideas of various furnaces used in ceramic industries. Sintering of ceramics- thermodynamic and process aspects. Ceramic coatings and their deposition; thick and thin film coatings – PVD and CVD techniques. Vapor infiltration techniques, fabrication of ceramic composites, ceramic membranes and ceramic nano-composites.	**10h**

References:

1. D. W. Richerson. Modern Ceramic Engineering - Properties Processing and Use in Design. 3rd Edition, CRC Press, 2006.
2. S. Somiya. Handbook of Advanced Ceramics: Materials, Applications, Processing and Properties. Vol. II, Elsevier Academic Press, 2013.
3. F. H. Norton. Elements of Ceramics. 2nd Edition, Addison Wesley, 1974.
4. W. D. Kingery, H. K. Bowen, D. R. Uhlhmen. Introduction to Ceramics, 2nd Edition, John Wiley, 1976.
5. J. B. Watchman. Mechanical properties of ceramics. John Wiley, New York, 1996.
6. Y. M. Chiang, D. P. Birnie, W.D. Kingery. Physical Ceramics: Principles for Ceramic Science and Engineering. John Wiley, 1997.

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MSE142: COMPUTATIONAL MATERIAL SCIENCE (4-1-0)		
Course Outcomes: Upon successful completion of this course, the students will be able to		
CO1: Explain the basic concepts of computational material science **CO2:** Explain Time reversal and inversion symmetries **CO3:** Explain Functional for exchange and correlation **CO4:** Determine electronic structure of materials using computational tools **CO5:** Solve material science problems using the molecular dynamics and first principle methods.		
Course Content		
Unit 1	**Introduction and Basic concepts:** Fundamentals of atomic level modeling of the structure and properties of materials. Theoretical Background, basic equations for interacting electrons and nuclei, Coulomb interaction in condensed matter, Independent electron approximations, Exchange and correlation, Periodic solids and electron bands, structures of crystals, The reciprocal lattice and Brillouin zone, Excitations and the Bloch theorem. Basics of the density functional theory and approximations in terms of pair potentials, embedded atom method and tight-binding.	**10h**
Unit 2	**Time reversal and inversion symmetries:** Integration over the Brillouin zone and special points, Density of states uniform electron gas and simple metals. Non-interacting and Hartree-Fock approximation, The correlation hole and energy. Density functional theory: foundations, Thomas-Fermi-Dirac approximations: example of a functional. The Hohenberg-Kohn theorems, constrained search formulation of density functional theory, Extensions of Hohenberg-Kohn theorems, The Kohn-Sham ansatz. Replacing one problem with another: The Kohn-Sham variational equations Exc, Vxc and the exchange correlation hole meaning of the eigenvalue. Intricacies of exact Kohn-Sham theory.	**10h**
Unit 3	**Functionals for exchange and correlation:** The local spin density approximation (LSDA), Generalized-gradient approximation (GGAs), LDA and GGA expressions for the potential Vxc(r), Non-collinear spin density, Non-local density formulations: ADA and WDA, Orbital dependent functionals I: SIC and LDA+U. Orbital	**10h**

	dependent functional II: OEP and EXX, Hybrid functionals, Tests of functionals Solving Kohn-Sham equations – Self-consistent coupled Kohn. Sham equations - Total energy functionals, Achieving self-consistency – Numerical mixing schemes, Force and stress.	
Unit 4	**Determination of electronic structure**: Atomic sphere approximation in solids, Plane waves and grids: basics - The independent particle Schrodinger equation in a plane wave basis. The Bloch theorem and electron bands - Nearly free-electron-approximation - Form factors and structure factors. Plane-wave method - 'Ab initio' pseudopotential method - Projector augmented waves (PAWs) - Simple crystals: structures, bands - Supercells: surfaces, interfaces, phonons, defects - Clusters and molecules. Localized orbitals: tight-binding – Tight-binding bands: illustrative examples - Square lattice and CuO_2 planes - Examples of bands: semiconductors and transition metals - Electronic states of nanotubes. Localized orbitals: full calculations – Solution of Kohn-Sham equations in localized bases. Analytic basis functions: gassians - Gassian methods: ground state and excitation energies - Numerical orbitals - Localized orbitals: total energy, force and stress - Applications of numerical local orbitals - Green's function and recursion methods - Mixed basis.	**10h**
Unit 5	Augmented plane waves (APW's) and 'muffin-tins' – Solving APW equations: examples Muffin-tin orbitals (MTOs). Linearized augmented plane waves (LAPWs) - Applications of the LAPW method - Linear muffin-tin orbital (LMTO) method - Applications of the LMTO method - Full potential in augmented methods - Molecular dynamics (MD): forces from the electrons - Lattice dynamics from electronic structure theory - Phonons and density response functions - Periodic perturbations and phonon dispersion curves - Dielectric response functions, effective charges - Electron-phonon interactions and superconductivity.	**10h**

References:

1. J. G. Lee. Computational Material Science - An Introduction. Second edition, CRC Press, 2016.
2. H. Skriver. The LMTO Methods, Springer, 1984.
3. E. Kaxiras, Atomic and Electronic Structure of Solids, Cambridge University Press, 2003.

4. R.M. Martin. Electronic Structure Basic Theory and Practical Methods, Cambridge University Press, 2004.
5. R. Dronskowski. Computational Chemistry of Solid State Materials, Wiley VCH, 2005.
6. E. B. Tadmor. Modeling Materials Continuum, Atomistic and Multiscale Techniques, Cambridge University Press, 2012.

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MSE 143: MATERIAL FAILURE ANALYSIS (5-0-0)		
Contact Hours: 5/week		
Course Content:		
Unit 1	The perspective on failure and direction of approach, isotropic base lines: failure characterization, stress versus strain, failure theory for isotropic materials and their failure behavior	**10h**
Unit 2	Experimental and theoretical evaluation	**10h**
Unit 3	Failure theory applications, ductile /brittle transition for isotropic materials. Defining yield and failure stress.	**10h**
Unit 4	Fracture mechanics, anisotropic unidirectional fibre composite failure. Anisotropic fibre composite laminate's failure.	**10h**
Unit 5	Micro mechanics failure analysis. Nanomechanics failure analysis. Damage, cumulative damage, creep and fatigue failure, probabilistic failure and life prediction.	**10h**

Reference

1. Christensen, The theory of materials failure**,** Oxford University Press, UK, 2010.

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MSE144: BLENDS AND ALLOYS

Course Outcomes:

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

CO1: Explain the basic and fundamental concepts of blends and alloys

CO2: Explain the fundamental concepts and importance of polymer miscibility

CO3: Describe the preparation of blends using different methods.

CO4: Analyze the properties of blends by different characterization techniques.

CO5: Acquire the knowledge on engineering and commodity polymer blends		
Course Content:		
Unit 1	**Introduction:** Alloying and blending, historical outline of industrial development of polymer blends and alloys, definitions, the reasons for and methods of blending, how to select blend components, fundamental principles for development of polymer alloys and blends. How to design a polymer blend.	**10h**
Unit 2	**Polymer-polymer miscibility:** General principles of phase equilibria calculation, theories of liquid mixtures containing polymer: Huggins-Flory theory, Mechanisms of phase separation, general types of polymer blends, polymer crystallization, morphology of blends, compatibilzed blends, interpenetrating polymer network in polymer blends	**10h**
Unit 3	**Blend preparation equipment:** Mixers and their various types like banbury, hot and cold mixers, twin screw compounders, and two- roll mills, etc. Design features of these equipments like rotor types, screws and their various types; flow behavior of the plastic material in the mixing equipments and theory of mixing.	**10h**
Unit 4	**Characterization of Blends:** Phase equilibria methods- turbidity, light scattering, SAXS, measurement of polymer/polymer interaction parameter by direct methods and ternary system containing solvent; Indirect methods - T_g (DSC, DMA), IR and Microscopy.	**10h**
Unit 5	**Commercial polymer blends /alloys and applications:** Blends of engineering and commodity plastics like PVC/ABS, PVC/SAN, PVC/NBR, PC/PET, PC/PBT, PC/ABS; PPO/HIPS - Study in detail along with properties and applications; Applications of polymer blends and alloys in adhesives, molded products, footwear, films, fibers, tyres and tubes, surface coatings, wire and cable compounds, belting and hoses, miscellaneous uses, current trends in polymer blends and alloys technology.	**10h**

References

1. Utracki, Polymer blends and alloys, Hanser Publication.
2. Paul and Newman, Polymer blends : Academic press
3. Lloyd M. Robeson, Polymer blends– A comprehensive review, Hanser publishers.
4. John A Manson and Lesliw H Sperling, Polymer blends and composites, Plenum Press, New York.

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MSE145: APPLIED MATHEMATICS (4:1:0)		
Course Outcome: Upon successful completion of this course, the students will be able to- **CO1**: Recognize ODEs / PDEs and apply suitable numerical methods to solve them. **CO2:** Solve systems of linear equations by exact / approximate methods, determine eigen values. **CO3:** Recognize suitable techniques to handle the given data and adopt correct method for curve fitting. **CO4:** Determine values of functions by applying proper algorithms. **CO5:** Handle and interpret large data and compute measures of central tendency and deviations from measures of central tendency.		
Course Content:		
Unit 1	**Ordinary and partial differential equations:** basic definitions and classification; examples from physical world – mass-spring system ODE, heat equation, wave equation and diffusion equation. **Systems of linear equations and matrix computations:** basic terminology – consistency, over determined systems; exact and approximate solutions of systems of linear equations – Gauss / Gauss-Jordan elimination, LU-factorisation, Gauss / Gauss-Seidel iterative method; eigenvalues / eigenvectors – characteristics equation, power method of determining the dominant eigenvalue; inverses of square matrices.	**10h**
Unit 2	**Curve fitting:** Polynomial interpolation – Newton difference formulas, Lagrange interpolation, Bezier curves; least square fitting lines / quadratic curves. **Root finding:** Method of bisection, Chord method, Newton-Raphson's method and combinations of these methods; **Statistics:** measures of central tendencies, measures of deviations from central tendencies; correlation; basic sampling theory.	**10h**
Unit 3	**Introduction to machine computation:** Number representation on a machine – min / max representable numbers, machine epsilon; errors arising out of approximations and propagation of errors – absolute / relative errors, error propagation during addition / multiplication of numbers, catastrophic addition	**10h**
Unit 4	**Computational Softwares:** Numerical packages (Matlab / Scilab / Bench Calculator),	**20h**

	symbolic Algebra packages (Maple/Mathematica) and statistical packages (DataMelt/ R/SciPy). The practical will consists of using some of the above softwares to solve problems from the topics dealt with in the first part of the course.	

Reference:

1. Applied numerical methods for Engineers using MATLAB. 1st edition, R J Schilling and S L Harris. Brooks/Cole Publishing Co. USA, 1999.

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MSE146: ADDITIVE MANUFACTURING TECHNOLOGY (5:0:0)

Contact Hours: 5/week

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

CO 1: Explain development and growth of additive manufacturing methods and its applications.

CO 2: Explain suitability of different types of materials for additive manufacturing and will be able design the process for making simple and complex geometries

CO 3: Explain principles behind various layer manufacturing techniques with special emphasis to Powder Bed Fusion, STL, Digital Light Processing, Micro Stereolithography, Vat Photo polymerization Processes.

CO 4: Explain principles behind various layer manufacturing techniques with special emphasis to Fused Layer Modeling, Sheet Lamination, Powder-Binder Bonding and Three dimensional printing.

CO 5: Explain principles behind various layer manufacturing techniques with special emphasis to jetting, directed energy deposition processes, direct write technologies and the machines used for these processes.

Course Content:

Unit 1	**Introduction:** Terminologies (Additive manufacturing, Layer-Based Manufacturing, rapid prototyping, Stereolithography, 3D printing, selective laser sintering, direct metal laser sintering), History of additive manufacturing, benefits of additive manufacturing, The generic AM process, additive manufacturing vs CNC machining, classification of AM Processes, Application levels. Applications of AM, challenges in AM	**10h**

Unit 2	**Materials, Design, and Quality Aspects for Additive Manufacturing:** Materials for AM (Anisotropic Properties, Basic Isentropic Materials: Plastics, metals, ceramics, composites), Engineering Design Rules for AM, Additive Manufacturing Design and Strategies; AM Unique Capabilities, Complex Geometries, Integrated Geometry, Integrated Functionalities, Multi-Material Parts and Graded Materials.	**10h**
Unit 3	**Layer Manufacturing Processes: (Principle, classification, materials, process parameters, merits and demerits of)** Powder Bed Fusion Processes, Polymerization (Laser-Stereolithography, Polymer Printing and Jetting, Digital Light Processing, Micro Stereolithography, Vat Photopolymerization Processes)	**10h**
Unit 4	**Layer Manufacturing Processes: (Principle, classification, materials, process parameters, merits and demerits)** Extrusion-Based Systems (Fused Layer Modeling), Sheet Lamination Processes, Powder-Binder Bonding – Three Dimensional Printing.	**10h**
Unit 5	**Layer Manufacturing Processes: (Principle, classification, materials, process parameters, merits and demerits of)** Material Jetting, Binder Jetting, Directed Energy Deposition Processes, Direct Write Technologies, Other Processes: Aerosolprinting, Bioplotter, Multifunctional printing, Guidelines for Process Selection, Machines for Additive Manufacturing, Post processing techniques.	**10h**

References:

1. Ian Gibson, David Rosen and Brent Stucker (Ed), Additive Manufacturing Technologies; 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing (2nd edition), Springer, New York, 2015.
2. Amit Bandyopadhyay and Susmita Bose (Ed.), Additive Manufacturing, Boca Raton, London, 2016.
3. Andreas Gebhardt (Ed), Understanding Additive Manufacturing; Rapid Prototyping, Rapid Tooling, Rapid Manufacturing, Hanser Publishers, Munich, 2011.
4. ASTM F2792 − 12a: Standard Terminology for Additive Manufacturing Technologies

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MSE147: STATISTICAL QUALITY CONTROL
Contact Hours: 5/week

Course Content:		
Unit 1	**Quality improvement in the modern business environment:** The Meaning of Quality and Quality Improvement Dimensions of Quality, Quality Engineering Terminology, A Brief History of Quality Control and Improvement, Statistical Methods for Quality Control and Improvement	**10h**
Unit 2	**Statistics and Sampling Distributions:** Sampling from a Normal Distribution, Sampling from a Bernoulli Distribution ,Sampling from a Poisson Distribution, Point Estimation of Process Parameters , Statistical Inference for a Single Sample ,Inference on the Mean of a Population, Variance Known , The Use of P-Values for Hypothesis Testing, Inference on the Mean of a Normal Distribution, Variance Unknown, Inference on the Variance of a Normal Distribution , Inference on a Population Proportion, The Probability of Type II Error and Sample Size Decisions, Statistical Inference for Two Samples , Inference for a Difference in Means, Variances Known, Inference for a difference in means of two normal distributions, variances unknown, inference on the variances of two normal distributions, linear regression models, estimation of the parameters in linear regression models	**10h**
Unit 3	**Methods and philosophy of statistical process control:** Introduction, Chance and Assignable Causes of Quality Variation , Statistical Basis of the Control Chart ,Basic Principles, Choice of Control Limits, Sample Size and Sampling Frequency, Rational Subgroups , Analysis of Patterns on Control Charts, Discussion of Sensitizing Rules for Control Charts, Phase I and Phase II of Control Chart Application, The Rest of the Magnificent Seven, Implementing SPC in a Quality Improvement Program, An Application of SPC, applications of statistical process control and quality improvement tools in transactional and service businesses	**10h**
Unit 4	**Control charts for variables:** Introduction control Charts for –x and R , Statistical Basis of the Charts, Development and Use of –x and R Charts, Charts Based on Standard Values Interpretation of –x and R Charts, The Effect of Nonnormality on –x and R Charts, The Operating-Characteristic Function, The Average Run Length for the –x Chart, Control Charts for –x and s, Construction and Operation of –x and s Charts, The –x and s Control Charts with Variable Sample Size	**10h**

Unit 5	**Control Charts For Attributes:** Introduction, The Control Chart for Fraction Nonconforming, Development and Operation of the Control Chart Variable Sample Size Applications in Transactional and Service Businesses, The Operating-Characteristic Function and Average Run Length Calculations , Control Charts for Nonconformities (Defects) Procedures with Constant Sample Size, Procedures with Variable Sample Size ,Demerit Systems The Operating-Characteristic Function Dealing with Low Defect Levels, Nonmanufacturing Applications , Choice Between Attributes and Variables Control Charts Lot-By-Lot Acceptance Sampling For: The Acceptance-Sampling Problem Advantages and Disadvantages of Sampling Types of Sampling Plans Lot Formation Random Sampling Guidelines for Using Acceptance Sampling Single-Sampling Plans for Attributes Definition of a Single-Sampling Plan The OC Curve Designing a Single-Sampling Plan with a Specified OC Curve Rectifying Inspection Double, Multiple, and Sequential Sampling Double-Sampling Plans Multiple-Sampling Plans Sequential-Sampling Plans; IATF; Latest softwares like mini tab.	**10h**

Reference:

1. Introduction to Statistical Quality Control, Sixth Edition, DOUGLAS C. MONTGOMERY, John Wiley and Sons, Inc,

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MSE151: COMPUTER AIDED DESIGN AND MANUFACTURING (5-0-0)

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

CO1: Explain the fundamentals of CAD

CO2: Explain solid modeling and its construction

CO3: Explain concepts of NC and extensions of NC

CO4: Explain the Concepts of GT, FMS, AGV's, AS / RS systems

CO5: Explain Various planning systems and process monitoring

Course Content:

Unit 1	**Introduction ;**Product Life Cycle, Design Process, Application of Computers for Design, Benefits of CAD, Computer configuration for CAD Applications, Grover's Model of Product life Cycle for Selection of CAD/CAM. Configuration of graphics	**10h**

	workstations, Fundamentals of 2D graphics, Menu design and Graphical User Interface (GUI), Parametric Programming, Vector representation of geometric entities, Homogeneous coordinate systems, Geometric transformations.	
Unit 2	**Solid Modeling Fundamentals:** Topology of Closed Paths, Piecewise flat surfaces, topology of closed curved surfaces, Generalized Concept of boundary, Set theory, Boolean operators, Set-membership Classification, Euler operators, Formal Modeling Criteria. **Solid Model Construction:** Graph Based methods, Boolean models, Instances and Parameterized Shapes, Cell Decomposition and spatial-Occupancy Enumeration, Sweep Representation, Constructive Solid Geometry, Boundary Representation **Transformations:** Translation, Rotation, Scaling Symmetry and Reflection, Homogeneous Transformations.	**10h**
Unit 3	**CAM:** Introduction to manufacturing systems and their performance analysis automation, computer integrated manufacturing (CIM). **Numerical Control (NC):** Introduction, numerical control – its growth and development, components of NC system, input devices, control systems – point to point, straight cut, and continuous path NC, open loop and closed loop NC systems, NC interpolations – linear, circular, helical, parabolic and cubic interpolation, applications of NC systems, merits and demerits. **Extensions of NC:** Concepts of computer numerical control (CNC), machining center and direct numerical control (DNC) and their advantages.	**10h**
Unit 4	**Material Handling and Storage:** Overview of material handling equipments, automated material handling equipments – AGVs, conveyor systems, performance analysis of material handling systems, automated material storage systems – ASRS and carousel storage, analysis of automated storage systems. Group Technology and FMS : Part families – Part classification and coding systems – production flow analysis– Machine cell design – Benefits of GT –FMS- Concept	**10h**
Unit 5	**Computer Aided Inspection:** Coordinate Measuring Machine - Components of CMM- Construction-types measuring head-types of probe- measuring accuracy-calibration of CMM performance of CMM- Non contact CMM –Basics of machine	**10h**

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Manufacturing Planning Systems and Process Control:

CAPP - Computer Integrated production planning systems –MRP- Capacity planning- Shop Floor control -factory Data collection systems – process monitoring, supervisory computer control.

References:

1. Zeid Ibrahim, CAD/CAM theory and practices, McGraw Hill international edition. 2009.
2. K. Lalit Narayan, K. Mallikarjuna Rao, M.M.M. Sarcar, "Computer Aided Design and Manufacturing", Prentice Hall of India, 2008.
3. Groover, M. P, Automation, Production systems and Computer Integrated Manufacturing, Prentice-Hall. 2008
4. Singh, N., Systems Approach to Computer Integrated Design and Manufacturing, John Wiley and Sons Wiley, 1996
5. Chang, T.-C., Wysk, R.A. and Wang, H.P, Computer Aided Manufacturing, Prentice Hall.1991
6. Besant, C. B. and Lui, C. W. K., Computer Aided Design and Manufacture, E. Horwood, 1986
7. P. N., Tiwari, N. K. and Kundra, T.K., Computer Aided Manufacturing, Rao, Tata McGraw-Hill Education, 1993.

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MSE152: TECHNOLOGY OF PAINTS AND SURFACE COATING

Course Outcomes:

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

CO 1: Explain the components of paints, paint making and methods of paint application.

CO 2: Describe the equipments used for the preparation of pigment dispersion.

CO 3: Identify different surface preparation and paint application methods

CO4: Test and evaluate the important properties of surface coatings.

CO 5: Select and formulate different surface coating for different application.

Course Content:

Unit 1	**Paint composition and application – A general Introduction:** Components of paint, paint making, methods of application, Organic film formers, pigments, solvents, thinners, diluents and other additives for paint	**10h**
Unit 2	**Paint preparation: Pigment dispersion:** Factors affecting pigment dispersion, Preparation of pigment dispersion: grinding equipment, additives for pigment dispersion	**10h**
Unit 3	**Surface preparation and paint application:** Surface cleaning methods: mechanical cleaning, solvent cleaning, alkali cleaning and acid pickling, Chemical conversion treatments: Phosphating and chromating, Paint application methods: brushing, dip coating and flow coating, curtain coating, roller coating and spray painting, electro deposition, chemiphoretic deposition.	**10h**
Unit 4	**Paint properties and Evaluation:** Mechanism of film formation, Factors affecting coating properties, methods used for film formation. Evaluation of mechanical, optical, ageing, rheological, corrosion, adhesion properties of coatings and Pigment to binder ratio calculation (PBR)	**10h**
Unit 5	**Types of coatings:** Appliance finishes, automotive finishes, coil coating, can coating, marine coating and aircraft coating, industrial protective coatings, Water borne coatings, radiation curable coatings, powder coatings, High solids coatings, Smart Paint Technology, Trouble shooting, Colour Science/Technology	**10h**
	References: 1. Swaraj Paul, Surface coatings; Science and Technology,2nd edition, John Wiley and Sons, Inc., 1995. 2. R Lambourne and T R Strivens, Paint and Surface Coatings. Theory and practice, 2nd edition, Woodhead Publishing Limited, 1999.	

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MSE153: RESEARCH METHODOLOGY (4:1:0)
Course Outcome: Upon successful completion of this course, the students will have an ability to- **CO1:** Explain literature survey, indentify the gap and undertake research. **CO2:** Critically evaluate current research and propose possible alternate directions for further work. **CO3:** Explain hypothesis and methodology for research.

CO4: Apply basic statistics in research and document research results. **CO5:** Comprehend and communicate their scientific results clearly for peer review.		
Course Content		
Unit 1	**Objectives and types of research:** Motivation and objectives – Research methods vs Methodology. Types of research – Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, Conceptual vs. Empirical. Literature survey tools/ search engines (Thomson Innovation, Scifinder, web of science).	**10h**
Unit 2	**Research Formulation:** Defining and formulating the research problem - Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem – Literature review – Primary and secondary sources – reviews, treatise, monographs-patents – web as a source – searching the web - Critical literature review – Identifying gap areas from literature review - Development of working hypothesis.	**10h**
Unit 3	**Research design and methods:** Research design – Basic Principles- Need of research design — Features of good design – Important concepts relating to research design – Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction, Development of Models. Developing a research plan - Exploration, Description, Diagnosis, Experimentation. Determining experimental and sample designs.	**10h**
Unit 4	**Data Collection and analysis:** Execution of the research - Observation and Collection of data - Methods of data collection – Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-testing - Generalization and Interpretation.	**10h**
Unit 5	**Reporting and thesis writing:** Structure and components of scientific reports - Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes - Oral presentation – Planning – Preparation –Practice – Making presentation – Use of visual aids - Importance of effective communication - Application of results and ethics -— Reproduction of published material, Plagiarism - Citation and acknowledgement - Reproducibility and	**10h**

	accountability. **Intellectual Property Rights:** IPRs- Invention and Creativity- Intellectual Property- Importance and Protection of Intellectual Property Rights (IPRs)- A brief summary of: Patents, Copyrights, Trademarks, Industrial Designs- Integrated Circuits-Geographical Indications-Establishment of WIPO-Application and Procedures.	

References:

1. Garg, B.L., Karadia, R., and Agarwal, An introduction to Research Methodology, RBSA Publishers, UK, 2002.
2. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International, 1990.
3. Sinha, S.C. and Dhiman, A.K., Research Methodology, Ess Ess, 2002.
4. Trochim, W.M.K., Research Methods: the concise knowledge base, Atomic Dog Publishing. 2005.
5. Anthony, M., Graziano, A.M. and Raulin, M.L., Research Methods: A Process of Inquiry, Allyn and Bacon. 2009.
6. Day, R.A., How to Write and Publish a Scientific Paper, Cambridge University Press. 1992.
7. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper, Sage Publications. 2009.
8. Coley, S.M. and Scheinberg, C. A., "Proposal Writing", Sage Publications. 1990,
9. K.Eugene Maskus, Intellectual Property Rights in the Global Economy, Washington, DC, 2000
10. Subbarau N R, Handbook on Intellectual Property Law and Practice-S Viswanathan Printers and Publishing Private Limited.1998.

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MSE154: Advanced Polymer Technology (5:0:0)	
Contact Hours: 5/week	
Course Outcomes: Upon successful completion of this course, the students will be able to	
CO1	Explain the synthesis, structure-property relationships and applications of engineering polymers
CO2	Explain miscibility of blends and select the polymers for high-performance applications
CO3	Discuss the performance of polymers as bio-materials, LCPs & membranes.

Course Content:		
Unit 1	Manufacturing (in brief), process-ability, structure-property relationships and the end use (applications) are to be discussed for the following engineering/ highperformance polymers with case studies: Polyamides, PET, PBT, PTFE, PC, PCTFE, PVDF, Polyarylate, Polyaramid, Polyimides, Polyamide imides, Polyphenelene Sulphide, Polysulphone.	**10h**
Unit 2	Manufacturing (in brief), process-ability, structure-property relationships and the end use (applications) are to be discussed for the following engineering/ high performance polymers with case studies: Polyacetals, Poly phenylene oxide (PPO), Polyphenylene ether (PPE), Polyketones (PEK, PEEK), Ultra High Molecular Weight Poly Ethylene, Acrylonitrile butadiene styrene.	**10h**
Unit 3	**Polymer Blends:** Fundamentals of polymer blends and alloys, Designing a polymer blend, Mixers, Thermodynamic aspects of blending, Factors affecting miscibility of polymer blends- Thermodynamics, compatibility, solubility parameter, interaction parameter, composition, molecular weight, transition temperature, mechanism of blending, etc. Properties of miscible and immiscible blends. Morphology and Phase behaviours.	**10h**
Unit 4	**Designing of Blends:** Compatibilization (Alloying) Methods- types and role of compatibilizer, compatibilization methods, IPNs, mechanism and properties of compatibilized blends. Degree of compatibilization. Mechanism and theory of toughening, Toughening of thermoplastics and thermosets; Thermoplastic elastomers (TPEs). Blends of engineering polymers- based on PC, Polyamides, Polyesters [Case study including properties and applications].	**10h**
Unit 5	**Biomaterials, Liquid Crystalline Polymers, Membranes** Biomaterials: polymeric implant materials (Polyolefins, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetals). Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Biocompatibility & toxicological screening of biomaterials. Polymeric Membranes: Synthetic polymeric membranes and their applications. Liquid Crystalline Polymers: Requirements, classification, examples, properties,	**10h**

	applications.	

References:

1. Michael L Berins. Plastic Engineering handbook of the society of plastics industry Inc, 5^{th} Ed, Van Nostrand Reinhold, 1991.
2. Jacqueline I Kroschwitz. Concise Encyclopedia of Polymer Science and Engineering, Wiley, 1990.
3. James M Margolis. Engineering Thermoplastics properties and application, Marcel Dekker Inc, New York, 1985.
4. Paul and Newman. Polymer blends, Academic press, NewYork, 1978.
5. Lloyd M Robeson. Polymer blends– A comprehensive review, Hanser publishers, 2007.
6. John Mason and Leslie H Sperling. Polymer blends and composites, Plenum Press, New York, 1976.
7. J B Park, Biomaterials - Science and Engineering, Plenum Press, 1984.
8. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
9. Jonathan Black, Biological Performance of materials, Marcel Decker, 1981
10. C.P.Sharma & M.Szycher, Blood compatible materials and devices, Technomic Publishing Co. Ltd., 1991
11. Piskin and A.S. Hoffmann, Polymeric Biomaterials (Eds), Martinus Nijhoff Publishers. (Dordrecht. 1986)
12. Eugene D. Goldbera , Biomedical Polymers, Akio Nakajima
13. A . Rembaum & M. Shen, Biomedical Polymers, Mercer Dekkar Inc. 1971
14. L. Hench & E. C. Ethridge, Biomaterials - An Interfacial approach

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MSE155: SEMICONDUCTING, MAGNETIC AND OPTOELECTRONIC MATERIALS (5-0-0)

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

CO1: Understand electronic, magnetic and optical properties of materials **CO2:** Explain types and characteristics of semiconducting materials **CO3:** Explain types and characteristics of magnetic Materials **CO4:** Explain types and characteristics of optoelectronic Materials **CO5:** Choose suitable semiconducting, magnetic and optoelectronic materials for given applications.		
Course Content		
Unit 1	**Electronic, magnetic and optical properties of materials:** Review of free electron and band theories of solids, Hall effect, Temperature dependence of electrical conductivity. Thermoelectric properties of metals and semiconductors, electron transport in amorphous solids, ionic conductivity, super conductivity, piezo-electricity, pyro-electricity and Ferro-electricity. Dielectric constants of solids and liquids, dielectric dispersion and losses. **Optical Properties:** Refraction, Absorption, Absorption in Dielectrics, Photographic images and Luminescence. Optical constants, atomistic theory of optical properties, quantum mechanical treatment, band transitions, dispersion, plasma oscillations. **Magnetic Properties:** Dia, Para and Ferromagnetism, Anti ferromagnetism, Helimagnetism, Superparamagnetism, surface magnetism and Ferrimagnetism. Ferromagnetic anisotropy and magnetostriction. Magnetic energy and Domain structure, Hysteresis loop, Demagnetization factor and Magnetoresistance - Gaint magnetoresistance, Tunneling magnetoresistance, Colossal magnetoresistance.	**10h**
Unit 2	**Semiconducting Materials:** Nature of chemical bonds and their relation to crystal structure of semiconductors, preparation and doping techniques of elemental and compound semiconductors and their characterization; narrow and wide band gap semiconductors. Direct and indirect band gap semiconductors, intrinsic and extrinsic (doped) semiconductors; rapid thermal processing of Si and compound semiconductors. Organic semiconductors - Fermi level - variation of conductivity, mobility with temperature – law of mass action, Hall coefficients for intrinsic and extrinsic semiconductors. Polycrystalline and amorphous Si, CdS/CdTe, CIGS,	**10h**

	Ge/GaAs/InGaP tandem structure materials.	
Unit 3	**Magnetic Materials:** Weiss molecular field theory, Heisenberg's theory and Magnetic Domains, Ferrimagnetic order, ferrites and garnets, hard and soft magnets, single domain magnets, Magnetism in Rare Earths and Antiferromagnetic Alloys, spin waves, Spin Glasses, Single Domain Particles, Coercivity in fine particles, Spintronics. Dia, Para, Ferromagnetic and Anti ferromagnetic materials. Magnetic data storage materials.	**10h**
Unit 4	**Optoelectronic Materials:** Photoconducting and non-photoconducting materials, Photonic crystals. Non-linear optic materials, fibre-optic systems, Organic optoelectronic materials and devices. Optical properties of semiconductors: absorption and emission processes; Kramers-Kronig and Van Roosbroeck-Shockley relations; radiative and non-radiative transitions, Photoluminescence. Optical emission from semiconductors, conditions for laser action, types of lasers. Quantum Confinement: 2-D, 1-D and O-D systems, Quantum well and quantum dot lasers, Quantum Cascade Laser (QCL), Quantum Well Infrared Photodetectors (QWIP).	**10h**
Unit 5	**Applications of Semiconducting, Magnetic and Optoelectronic Materials:** Different types of semiconductors and their application in commercial devices: Ge, Si, GaAs, InP, PbS, HgxCd1-xTe. The III-V, II-VI and IV-VI semiconductors and nanostructures for optoelectronic applications. Photo-detectors: photoconducting, photovoltaic, PIN, Avalanche photodiode (APD). Quantum dot solar cell, anti-reflection coating. Principles of semiconductor devices. Applications of magnetic materials.	**10h**

References:

1. P. Fulay, J-K Lee. Electronic, Magnetic and Optical Materials. CRC Press, 2016.
2. B. D. Cullity. Introduction to Magnetic Materials. Addison-Wesley Publications, California, London, 1972.
3. D. Jiles. Introduction to Magnetism and Magnetic Materials. Chapman and Hall, 1991.
4. J. P. Jakubovics. Magnetism and Magnetic Materials, 2nd edition, Publisher-Institute of Materials, London, 1994.

5. D. K. Schroder. Semiconductor Material and Device Characterization, 3rd edition, John Wiley and Sons, 2006.
6. R. E. Hummel. Electronic Properties of Materials, 3rd edition, Springer 2012.
7. Y. Aoyagi and K Kajikawa, Optical Properties of Advanced Materials, Springer, Berlin Heidelberg, 2015.

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MSE16L: MATERIAL SYNTHESIS AND CHARACTERIZATION LAB	
Course outcome: Upon successful completion of this course, the students will be able to-	
CO1:	Apply the theoretical knowledge to prepare and characterize the polymers.
CO2:	Qualitatively analyze the prepared polymers.

List of experiments:

1. Bulk polymerization of styrene.
2. Emulsion polymerization of methylacrylate.
3. Solution polymerization of acrylonitrile.
4. Preparation of poly acrylamide by free radical polymerization.
5. Determination of molecular weight by end-group analysis.
6. TGA studies of polymer samples.
7. DSC studies of polymer samples.
8. FTIR studies of polymer sample
9. Synthesis and characterization of nanomaterials bysol-gel synthesis
10. Synthesis and characterization of nanomaterials: Graphene by Hammer's method
11. Determination of kinetics of spherulite growth using polarized optical microscope
12. Diffusion and gas permeability measurement of polymer films
13. Powder synthesis: XRD characterisation, particle size, surface area analysis
14. Preparation and study of microstructures of cast iron

References:

1. Practicals in Polymer Science - Synthesis and Qualitative and Quantitative Analysis of Macromolecules
2. Dr. Siddaramaiah. Practicals in Polymer Science, CBS publishers. New Delhi, 2007.

3. S. Zhang, Lin Li, A. Kumar, Materials Characterization Techniques, CRC press, 2008.
4. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley and Sons (Asia), 2008.
5. D.A. Skoog, F.J. Holler, S. R. Crouch, Instrumental Analysis, Cengage Learning, 2007.
6. W. Kemp, Organic Spectroscopy, 3rd ed., Pagrave, 2007.
7. H.Lee and K. Neville in Encyclopedia of polymer Science and Technology, Vol. 6 Interscience, New York (1967)
8. Experiments in polymer Science – Collins, Bares and Billmeyer, John Willey and Sons.
9. Experimental Methods in Polymer Chemistry – Jan F.Rabek, John-Wiley.
10. R.M. Silverstein, Spectrometric identification of organic compounds, 7th ed., John Wiley and Sons, 2007

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II SEMESTER

MSE210: ADVANCED COMPOSITE TECHNOLOGY (5:0:0)		
Course Outcomes: Upon successful completion of this course, the students will be able to **CO1:**Explain the basics of composites and select a suitable matrix material **CO2:**Select a suitable reinforcement to meet the end product requirement. **CO3:** Explain composite processing techniques. **CO4:** Discuss the performance of polymer composites and failure mechanisms. **CO5:** Explain designing aspects of polymer composites.		
Course Content:		
Unit 1	**Introduction:** Definition, reason for composites, classifications of composites, advantages and disadvantages of composites. **Metals as matrix materials:** raw materials, physical and chemical properties, thermal and mechanical properties **Thermoplastic Matrix:** Functions of matrix, raw materials, physical and chemical properties, thermal and mechanical properties. **Thermoset Matrix:** Epoxy; Curing reactions, hardener, gel time, viscosity modifications, Prepeg making. Unsaturated polyester resin; Catalyst, curing reactions, viscosity modifier. Alkyd resin, vinyl ester, cyanate ester, polyimides, physical and chemical properties, thermal behaviour, mechanical properties and uses.	**10h**
Unit 2	**Reinforcements:** Introduction, Functions of fillers, types, properties, chemistry and applications of fillers such as silica, titanium oxide, talc, mica, silicon carbide, graphite. Flakes - Both and natural and synthetic should be considered. Fibers-Natural (silk, jute, sisal, cotton, linen) and synthetic, short and long fibers, general purpose and high performance fibers, organic and inorganic fibers - Properties, structure and uses; Glass fiber-classifications, chemistry, manufacturing process. Properties and uses of Nylons, Carbon, Aramid, Boron, aluminum-carbide. **Coupling agents:** Function, chemistry, methods of applications, advantages and disadvantages.	**10h**

Unit 3	**Processing of thermoplastic composites:** Types of processing methods, matched die molding, solution, film, lamination, sandwich. Processing conditions, advantages and disadvantages. **Fabrications of thermoset composites:** Hand layup method, match die molding, compression and transfer molding, pressure and vacuum bag process, filament winding, pultrusion, RIM, RRIM, VARTM and VERTM, Injection moulding of thermosets, SMC and DMC, Advantages and disadvantages of each method. **Fabrications of metal composites:** liquid-phase processes, solid–liquid processes, deposition techniques and in situ processes and two- phase (solid–liquid) processes	**10h**
Unit 4	**Factors influencing on performance of the composites:** Aspect ratio, void content, length of the fiber, nature of the fiber, structure property relationship between fiber and matrix, modifications of the fiber surface, degree of interaction between and fiber and matrix, wetting behavior, degree of cross linking. **Testing of composites:** Destructive and non-destructive tests; Destructive-tensile, compression, flexural, ILSS, impact strength and HDT. The basic concepts of fracture mechanisms.	**10h**
Unit 5	**Composite product design:** Introductions, Design fundamentals, definitions, structure-material-design relationships, design values and design constraints, uncertainty in product design, constitutes of composite product, design process, decision making in design, design methodologies, material considerations in composite design, numerical problems.	**10h**

References:

1. George Lubin , Hand book of composites, Van Nostrand Reinhold Company Inc, New York 1982
2. Nikhilesh Chawla, Krishan K. Chawla, Metal Matrix Composites, Springer Science and Business Media, 2013L.
3. C. Hollaway, Polymers and Polymer Composites in Construction, Thomos Telford Ltd., London, UK, 1990.
4. John C. Bittence, Fran Cavern, Engineering Plastics and Composites, Materials data series, 2nd

edition, ASM International, 1990

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7. Leif A. Carlssen and Joahn W. Hillispie, Delwane Composite design Encyclopedia (Vol 3) Processing and Fabrication / Technology, Technomic Publishing Ah. Lancaster, U.S.A.
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12. Vishu Shah, Hand Book of Plastics Testing Technology, 2nd edition, John Wiley and Sons, Inc NY. 1998

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<table>
<tr><td colspan="3">MSE220: NANO MATERIALS AND TECHNOLOGY</td></tr>
<tr><td colspan="3">Contact Hours: 5/week</td></tr>
<tr><td colspan="3">Course Outcome: At the end of the course, the students will be able to
CO 1: Explain the fundamentals of nanostructured materials,
CO 2: Synthesize and characterize the nanostructured materials.
CO 3: Prepare polymer nanocomposites for tailor made applications.
CO 4: Solve the problems related to health issues</td></tr>
<tr><td colspan="3">Course Content:</td></tr>
<tr><td>Unit 1</td><td>Nanostructured materials: Introduction, basic of Nanoparticles, Nanowires, Nanorods, Nanoplatelets, Nanoclusters, Solid solutions.
Classification, synthetic routes for nanoparticles production- super critical fluid based particle production, droplet and aerosol techniques, gas atomization</td><td>10h</td></tr>
</table>

	approaches, dendrimers, block copolymers,self-assembly, block copolymer phase diagram, Block copolymer thin films,hyper branched polymers or star polymers, molecular imprint polymers, nano oxides, nanowires, nanotubes and nanofibres, polymer nanofilm, applications of polymeric nanoparticles. Bottom up and top down approaches, nanofabrication.	
Unit 2	**Polymer-inorganic nanocomposites:** Introduction of nanotechnology and polymer nanocomposites, the difference between nanocomposites and traditional filler enhanced polymers, the structure and classification of polymer nanocomposites, different types of nanofillers, One dimensional, Two dimensional and Three dimensional nanostructured materials, nanoclay- introduction, structure, chemistry, and its modification with surfactants, preparative methods and structure of polymer/clay nanocomposites, types of polymers used for polymer/clay nanocomosites preparation, material properties of polymer/clay nanocomposites, melt rheology and processing operations of nanocomposites, characterization of nanocomposites. Nanocomposites of polymers and inorganic particles, synthesis and properties. Major progress over the past one and half decades.	**10h**
Unit 3	**Carbon nanomaterials:** CNTs- Structural aspects, single walled and multi walled nanotubes, preparation of nano tubes: carbon arc process, catalytic assisted pyrolysis, laser technique, electro chemical method, purification of carbon nano tube, properties of nano tubes, surface modification of CNTs, application of nanotubes. Graphite nanofibre, Graphene oxide- chemistry, types, preparation and surface modification and properties. Applications of Nanomaterials: Catalysis, Electronic, Aerospace, Automotive, Surface coatings, Magnetic, Optical, Medicine etc.	**10h**
Unit 4	**Nanocomposites of carbon nanotubes:** Introduction, carbon nanotube-metal matrix composites, carbon nanotube –ceramic-matrix composites – properties and uses. CNT-polymer-matrix composites – methods of fabrication, characterization, and their uses. Factors affects on the performances of nanocomposites. Graphene oxide – polymer composites - fabrication, characterization and their uses. **Conducting polymeric nanomaterials:** Introduction to conducting polymers, mechanism of conduction in nanocomposite, effect of dopants on conductivity,	**10h**

	methods of synthesis of polymeric nanomaterials, structure-property relationship, polymeric nanomaterials for electrical and electronic applications.	
Unit 5	**Application of Nanotechnology:** Nanotechnology for waste reduction and improved energy efficiency, nanotechnology based water treatment strategies. Nanoporous polymers and their applications in water purification, Nanotoxicology. Use of nanoparticles for environmental remediation and water treatment. Case studies and Regulatory needs. **Polymeric nanoparticles for drug and gene delivery:** Introduction, transport phenomenon and mechanism, features of polymeric materials, preparation and characterization of nanoparticles, recent developments in nanoparticles technology, nanoparticles for drug and gene delivery applications.	**10h**

References:

1. H.S.Nalwa (ed). Encyclopedia of nanoscience and nanotechnology, American Scientific Publisher, USA, Vols- 1-10, 2004.
2. Tapas Kuilla, Sambu Bhadra Dahu Yao, Nam Hoon Kim, Saswata Bose, Joong Hee Lee, Recent advances in graphene based polymer composites - Progress in Polymer Science, 35(2010) 1350-1375.
3. Editors: S. Thomas, G.E. Zaikov and S.V. Valsaraj, Recent advances in polymer nanocomposites, Leiden, Boston, 2009.
4. Editors: S.Thomas, G.E.Zaikov, Progress in Polymers Nanocomposites Research , Nova publishers, USA, 2008. web site address: novapublishers.com
5. Y.C.Ke, P.Stroeve, F.S.Wang, Polymer layered silicate and silica nano composites, Elsevier, 2005.
6. B.K.G. Theng. Formation and properties of clay-polymer complexes. 2nd ed., Elsevier, Amsterdam, 2012.
7. B.K.G. Theng, Chemistry of clay-organic reactions, Adam Hilger, London, 1974.
8. V.Chirala, G.Marginean, W.Brandl and T.Iclanzan, Vapour grown carbon nanofibres-polypropylene composites and their properties in carbon nanotubes, edited by V.N. Popov and P.Lambin, p.227, Springer, Netherlands, 2006.

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MSE230: MATERIAL PROCESSING TECHNOLOGY (5:0:0)		
Course Outcomes: Upon successful completion of this course, the students will be able to- **CO1:** Explain the different metal processing techniques. **CO2:** Explain polymer processing techniques and derive polymer melt constitutive equations from first principle **CO3:** Explain mix quality and the mixing mechanism. **CO4:** Explain the design and control the process steps/parameters of reactive processing. **CO5:** Explain mold filling, simulation and reaction injection moulding		
Course Content:		
Unit 1	**Introduction to processing** **Principles of Metal fabrication Processes:** Smelting and refining of metal ores and scrap, casting molten metals into a given shape (foundry), hammering or pressing metals into the shape of a die (hot or cold forging), welding and cutting sheet metal, sintering and shaping metals on a lathe. **Techniques are used to finish metals:** Grinding and polishing, abrasive blasting and many surface finishing and coating techniques (electroplating, galvanizing, heat treatment, anodizing, powder coating. Metal reclamation.	**10h**
Unit 2	**Principles of polymer fabrication:** Current polymer processing practice, analysis of polymer processing in terms of elementary steps and shaping methods. polymer processing techniques- principle, design, typical applications and case studies of extrusion, injection molding, blow moulding thermoforming, compression and transfer moulding process. The balance equations and Newtonian fluid mechanics. Non-Newtonian Fluid mechanics, polymer melt constitutive equations. Numerical.	**10h**
Unit 3	**Single screw extrusion:** General features, Mechanism of flow, Analysis of flow in extruder and extruder volumetric efficiency. General features of twin screw extruders **Mixing:** Introduction, distributive and dispersive mixing, mix quality evaluation, residence time and strain distributions. Mixing equipments, mixing elements, mixing mechanisms, motionless mixers, mixing in a stirred tank and practical aspects of mixing	**10h**

Unit 4	**Reactive Polymer processing and compounding:** Classes of polymer chain modification reactions carried out in reactive polymer processing equipment, strategy of reactive extrusion. Reactor classifications, reactive compatibilization, grafting techniques, functionalization of end groups, compatibilization by additives, Polymer compounding.	**10h**
Unit 5	**Injection molding:** Introduction, feed system, hot and cold runners, balanced runner system, flow in an idealized runner system, theoretical aspects of mold filling and simulation, molding window diagram, practical aspects of injection molding, applications and trouble shooting. **Reaction Injection Moulding**: Principle, operation, advantages, applications **Thin film making technology**	**10h**

References:

1. Zehev Tadmor and Costa G. Gogos, Principles of polymer processing, 2nd edition, Jhon wiley and sons Inc. Publication, New Jersey, 2006.
2. Beddoes and M. Bibby, Principles of Metal Manufacturing Processes, Butterworth-Heinemann, 2003.
3. Donald G. Baird and Dimitris I. Collias, Polymer processing, principles and design, John Wiley and Sons Inc, NY, 2001.
4. J K Fink. Reactive polymers fundamentals and applications- A concise guide to industrial polymers ,William Andrew Publishing, Newyork, USA, 2005.
5. Stanley Middleman, Fundamentals of polymer processing. McGraw-Hill Inc. USA, 1977.
6. Manas- Zloczower and Z Tadmor, Mixing and Compounding-Theory and Practice. Carl Hanser Verlag, 1994.
7. Crawford R.J., Plastics Engineering, Pergamon Press, 2nd Edition, 1987.
8. Billmeyer, Text Book of Polymer Science, John Wiley and Sons (Asia) Pvt. Ltd., 1994.
9. Charles A Harper, Handbook of Plastic Processes, Jhon wiley and sons Inc. Publication, Newjersey, 2006

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MSE241: SMART MATERIALS (5-0-0)		
Course Outcomes: Upon successful completion of this course, the students will be able to-		
CO1:	Explain physical principles underlying the behavior of smart materials.	
CO2:	Explain fundamentals of nanomaterials and their role	
CO3:	Explain physical principles underlying the behavior of electro-active organic compounds	
CO4:	Explain nanofabrication and plastic electronics	
CO5:	Explain engineering design, principle and production of smart materials for different applications	
Course Content:		
Unit 1	**Introduction to materials-** Classes of materials – Smart/intelligent materials – Overview of Smart Materials, Functional materials – Diverse areas of intelligent materials – primitive functions of intelligent materials – Examples of intelligent materials – Materials responsive to thermal, electrical, magnetic, optic, stress fields, Biocompatible materials and bio-Mimitics (stimuli-responsive materials). Principles of Piezoelectricty, Piezoelectric Materials, Principles of Magnetostriction, Introduction to Electro-active Materials, Ionic Polymer Matrix Composite (IPMC), Shape Memory materials.	**10h**
Unit 2	**Fabrication and Applications of smart materials:** Overview of the materials synthesis techniques. Established Deposition Methods - Spin-Coating; Physical Vapour Deposition; Chemical Vapour Deposition; Electrochemical Methods, Sol–Gel Processing Molecular Architectures - Langmuir–Blodgett Technique; Chemical Self-Assembly; Electrostatic Layer-by-Layer Deposition. Importance of the relationship between the microstructure on nanoscale and the functional properties. Smart composites, Self-healing materials, Self-cleaning materials, Thin Film Processing and Device Fabrication.	**10h**
Unit 3	Electroactive Organic Compounds - Acids and Bases; Ions; Solvents; Functional Groups; Aromatic Compounds; Conductive Polymers; Buckyballs and Nanotubes; Fullerenes; Carbon Nanotubes, Optical and electrical properties of	**10h**

	nano tubes and nano wires – quantum wires and quantum dots. Basic Principles and Compounds - Organic Piezoelectric, Pyroelectric and Ferroelectric	
Unit 4	Nanofabrication – Photolithography; Soft Lithography Techniques; Scanning Probe Manipulation; Dip-Pen Nanolithography; Miniature designs, microfluidic devices, switchable surfaces. Plastic Electronics – Introduction; Organic Diodes - Schottky Diode; Ohmic Contacts. Metal–Insulator–Semiconductor Structures - Idealized MIS Devices; Organic MIS Structures.	**10h**
Unit 5	Organic Light-Emitting Displays - Device Efficiency; Methods of Efficiency Improvement; Full-Colour Displays; Electronic Paper Photovoltaic Cells - Organic Semiconductor Solar Cell, Dye-Sensitized Solar Cell; Luminescent Concentrator. Chemical Sensors and Actuators - Sensing Systems; Chemical Sensors- Calorimetric Gas Sensors, Electrochemical Cells; Gas Sensors; Acoustic Devices; Optical Sensors. Physical Sensors and Actuators - Touch Sensors; Polymer Actuators; Lab-on-a-Chip; Smart Textiles and Clothing.	**10h**

References:

1. V. Mukesh and B.S. Thompson, Smart materials and structures, Chapman and Hall, London, 1992.
2. M.V. Gandhi, B.D. Thompson, Smart Materials and Structures Springer Science and Business Media, 1992,
3. T.W.Duerig, K.N.Melton, D.Stockel and C.M.Wayman, Engineering aspects of shape memory Alloys, Butterworth-Heinemann,1990
4. Sorab K. Gandhi, Fabrication Principles of VLSI, John Wiley, 1996
5. Charles P.Poole and F.J. Owens, Introduction to nano technology, Wiley Interscience, 2003.
6. T. Chatterji, Colossal magneto resistive manganites, Kluwer Academic Publishers, 2004
7. Malcolm E.Lines and Alastair M.Glass, Principles and applications of Ferroelectrics and Related materials, Oxford University Press, 2001.

MSE242: BIOMATERIALS (5:0:0)		
Contact Hours: 5/week		
Course outcomes: Upon successful completion of this course, the students will be able to **CO1:** Define the basic terms and explain the structure and properties of metals commonly used for making biomedical implants and devices**.** **CO2:** Explain the classification, properties, manufacturing techniques and applications of bioceramics. **CO3:** Explain different types, properties, manufacturing techniques and applications of polymeric biomaterials. **CO4:** Explain different surface modification techniques commonly used to engineer biomaterial surfaces and types and importance of sterilization methods. **CO5:** Explain the applications of biomaterials.		
Course Content		
Unit 1	**Introduction:** Terminologies (Biomaterials, biocompatibility, biomedical devices, Implant, Prosthesis, Artificial organ, Hybrid artificial organ, Bioprosthesis, Graft, Tissue engineering, regenerative medicine, nanomedicine), History of biomaterials, Classification of biomaterials, typical requirements of biomaterials, applications of biomaterials, Regulatory bodies: Food and Drug Administration (FDA), Center for Drug Evaluation and Research (CDER), Center for Devices and Radiological Health (CDRH); Center for Biologics Evaluation and Research (CBER). **Metallic Biomaterials:** Classification, structure – properties and applications of: Titanium and its alloys, Stainless steel, Cobalt–chromium alloys, Nitinol, Tantalum, Magnesium, Shape–memory alloys, Corrosion of metallic implants, manufacturing of metallic implants.	**10h**
Unit 2	**Bioceramics:** Nearly bioinert oxide-based ceramics (Alumina, Zirconia and Carbons (low-temperature isotropic (LTI) and the ultralow-temperature isotropic (ULTI) pyrolytic carbons), Bioactive ceramics **(**Bioactive glass, glass-ceramics, hydroxyl apatite), Biodegradable/Resorbable ceramics **(**Calcium phosphates, Hydroxyapatite, Tricalcium phosphate), Glass-ionomers**,** Nanoceramics, characteristics and manufacturing techniques.	**10h**
Unit 3	**Polymeric and composite biomaterials:** Classification, structure – properties and	**10h**

	applications of; Polyvinylchloride, Polyethylene, Polypropylene, Polymethyl methacrylate, PS and its copolymers, Polyesters, Polyamides (Nylons), Fluorocarbon polymers, Silicone rubber, Polyurethanes, Polyacetal, Polysulfone, and Polycarbonate, Thermoplsatic elastomers, Natural polymers, Biodegradable Polymers, Shape-memory polymers, Conducting polymers, Hydrogels, FRPs	
Unit 4	**Surface modification and sterilization:** Need for surface modification and sterilization, Principle, merits and demerits of surface modification techniques (Abrasive blasting, Plasma glow discharge treatments, Thermal spraying, Physical and chemical vapor deposition, Grafting, Self-assembled monolayer, Layer-by-layer assembly. Sterilization techniques; Steam sterilization, Ethylene oxide sterilization, Gamma radiation sterilization, Dry heat sterilization, Electron beam sterilization, Recently developed methods such as Low temperature gas plasma treatment, Gaseous chlorine dioxide treatment	**10h**
Unit 5	**Applications of biomaterials:** Cardiovascular medical devices (stents, grafts and etc.), Orthopedic and dental applications (implants, tissue engineered scaffolds and etc.), Ophthalmologic applications (contact lenses, retinal prostheses and etc.), Bioelectrodes, Bioinformatics and Biosensors, Burn dressings and skin substitutes, Sutures, Drug delivery systems.	**10h**

References:

1. Véronique Migonney (Ed.), Biomaterials, John Wiley and Sons, Inc., USA, 2014.
2. C. Mauli Agrawal, Joo L. Ong, Mark R. Appleford and Gopinath Introduction to Biomaterials; Basic theory with engineering applications, Cambridge university press, UK, 2014.
3. Jyoce Y. Wong and Joseph D Bronzino, Biomaterials, CRC press, New York, 2007.
4. Joyce Y. Wong, Joseph D. Bronzino and Donald R. Peterson, Biomaterials principles and practices, CRC press, New York, 2013.
5. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemons, Biomaterials Science; An Introduction to Materials in Medicine (3rd edition), Academic Press, UK, 2014.
6. Hamid Reza Rezaie, Leila Bakhtiari and Andreas Öchsne, Biomaterials and Their

Applications, Springer International Publishing AG, Switzerland, 2015.	

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MSE243: FINITE ELEMENT METHODS AND APPLICATIONS		
Contact Hours: 5/week		
Course Content:		
Unit 1	Recap of Mathematical Concepts Introduction to Fundamentals of Elasticity Introduction to Fundamentals of Plasticity Introduction to FEM or FEA, MATLAB Program for Tapered Cylinder Problem: (i) Without the idea of assembly, only discretization (ii) With the idea of assembly, Formulation of problem using FEM - Discrete Body Truss Problem (i) Main MATLAB File, (ii) Stiffness function, (iii) Stress and strain function	**10h**
Unit 2	Formulation of problems using FEM - Continuous Body MATLAB Program for 1-D General ODE Problem with 2-node Elements: Example problem: General 2nd order homogeneous ODE, MATLAB Program for 1-D Heat Transfer Problem with 2-node Elements (i) Constant Cross Section Bimetallic rod with 2-node elements; MATLAB Program for 1-D Heat Transfer Problem with 2-node Elements (ii) Tapered Cross Section Bimetallic rod with 2-node elements Formulations of Interpolation Function for Generic Finite Elements	**10h**
Unit 3	Application of FEM in Heat Transfer MATLAB Program for 1-D Heat Transfer Problem with 3-node Elements (1) Bimetallic rod with 3-node elements; MATLAB Program for 1-D Heat Transfer Problem with 3-node Elements (2) Tapered Cross Section Bimetallic rod with 3-node elements; MATLAB Program for 2-D Heat Transfer Problem with 4-node Elements: A Square Leaf with Convection Boundary Condition with 4-node elements MATLAB Program for 1-D Transient Heat Transfer Problem with 2-node Elements: FEM file MATLAB Program for 1-D Transient Heat Transfer Problem using Finite Difference	**10h**

	Method: FDM file	
Unit 4	Application of FEM in Solid Mechanics Error Estimation and Convergence **ANSYS Tutorials** Tutorial 01: Introduction to ANSYS and a Truss/Bridge Problem Tutorial 02: Bar and Beam Problems Using ANSYS Tutorial 03: Effect of Plasticity Using ANSYS Tutorial 04: Elastic and Elasto-Plastic Fracture Mechanics Using ANSYS	**10h**
Unit 5	Tutorial 05: Heat Transfer 2-D, 3-D and Transient Problems Using ANSYS Tutorial 06a: 2-D Contact Problems Using ANSYS Tutorial 06b: A 2-D Transient Indentation Problem Tutorial 6b: Movies (play using windows media player) animating: (i) Displacement in Z-direction and (ii) von Mises Stress near indentation zone Tutorial 07: Fatigue Analysis with ANSYS Tutorial 08: Explicit Dynamics using ANSYS	**10h**

Reference:

1. Seshu P., Text book of Finite element analysis, Prentice Hall India Learning Pvt. Ltd., 2003

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MSE244: PROJECT ENGINEERING AND MANAGEMENT (5-0-0)		
Contact Hours: 5/week		
Course Content:		
Unit 1	Project Planning and Phases: Need and importance, phases of capital budgeting, project Analysis facts, resource allocation framework (investment strategies, portfolio planning tools, and interface between strategic planning and capital budgeting), Generation and Screening of Project Ideas	**10h**
Unit 2	Generation of ideas, monitoring, scouting for project ideas, preliminary screening, project rating index, sources of net present value. Market and demand analysis, technical analysis, financial estimates and projections.	**10h**
Unit 3	Time value of money, investment criteria, project cash flows, cost of capital, project risk analysis, numerical.	**10h**

Unit 4	Project rate of return, social cost benefit analysis, financing of projects, venture and private capital	**10h**
Unit 5	Implementation: project management, network techniques for project management	**10h**

References:

1. Project Planning, Analysis, Selection, Implementation and Review", seventh edition, Prasanna Chandra. New Delhi, Tata McGraw Hill Publications, 2009.
2. P. Gopalkrishnan and E. Rama Moorthy. "Text book of Project Management". New Delhi, McGraw Hill Publications, 2000
3. Harold Kerzner, "Project Management: A Systems Approach to Planning, Scheduling and Controlling", New Delhi, CBS Publications, 1994.
4. Rajive Anand, "Project Profiles with Model Franchise Agency and Joint Venture Agreement", New Delhi, Bharat Publications.

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MSE245: HEAT TRANSFER IN MATERIAL ENGINEERING (5-0-0)

Contact Hours: 5/week

Course Content:

Unit 1	Review of Fourier's Law – Thermal Conductivity of gases, solids, liquids and bulk materials – Numerical Problems. Heat Transfer and Energy Equation – Heat transfer with forced convection in a tube, Heat transfer with laminar forced convection over a flat plane, Heat transfer with natural convection, Heat conduction - Numerical Problems	**10h**
Unit 2	Correlations and Data for Heat Transfer Coefficients, Heat Transfer Coefficients for forced convection in tubes, Dimensional analysis, Correlation for forced convection in tubes and past submerged objects - Numerical Problems.	**10h**
Unit 3	Heat Transfer Coefficients for natural convection Quenching Heat Transfer Coefficients, Heat Transfer Coefficients in fluidized beds, packed beds, forging - Numerical Problems.	**10h**
Unit 4	Conduction of Heat in Solids – The energy equation for conduction, Steady-state one-dimensional systems, Transient systems, finite dimensions, Transient conditions, infinite and semi-infinite solids, Simple multidimensional problems, Moving sources -	**10h**

	Numerical Problems.	
Unit 5	Solidification of Metals - Solidification in sand molds, Solidification in metal molds, Continuous casting, Crystal growth - Numerical Problems.	**10h**

Reference

1. D R Poirer and G H Geiger, Transport phenomena in materials processing, The minerals, metals and materials Society, Pennsylvania, 1994.

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MSE251: NON-DESTRUCTIVE TESTING (5-0-0)

Course Outcomes: Upon successful completion of this course, the students will be able to-

CO1: Explain visual and liquid penetrants methods

CO2: Explain Ultra sonic testing methods

CO3: Explain Radiography testing methods

CO4: Explain Eddy current testing and Thermography methods

CO5: Explain Magnetic particle testing methods

Course Content:

Unit 1	**Visual Inspection**- tools, applications and limitations. **Liquid Penetrant Inspection** -principles, types and properties of penetrants and developers. Advantages and limitations of various methods of LPI.	**10h**
Unit 2	**Ultra sonic testing(UT)** - Nature of sound waves, wave propagation - modes of sound wave generation - Various methods of ultrasonic wave generation, types of UT Principles, applications, advantages, limitations, A, B and C scan - Time of Flight Diffraction (TOFD)	**10h**
Unit 3	**Radiography testing (RT)** – Principles, applications, advantages and limitations of RT. Types and characteristics of X ray and gamma radiation sources, Principles and applications of Fluoroscopy/Real-time radioscopy - advantages and limitations - recent advances.	**10h**
Unit 4	**Eddy current testing** - Principles, types, applications, advantages and limitations of eddy current testing. **Thermography** - Principles, types, applications, advantages and limitations. Optical	**10h**

	and Acoustical holography- Principles, types, applications, advantages and limitations.	
Unit 5	**Magnetic particle testing -** principles, magnets and magnetic field, discontinuity and defects, circular and longitudinal fields, induces magnetic fields, selection of magnetizing methods, MT improvements, remote magnetic particle inspection, applications, advantages and limitations, magnetic rubber inspection and under water MRI.	**10h**

References:

1. Paul E. Mix, Introduction to Nondestructive Testing: A Training Guide, 2nd edition, John Wiley and Sons, 2005
2. Baldev Raj, T. Jayakumar, M. Thavasimuthu, Practical Non – Destructive Testing, Woodhead Publishing, 2002
3. B. Hull and V. John, Non-Destructive Testing, Macmillan,1988
4. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, 3rd Edition, New York, Springer-Verlag, 1983.

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MSE252: RENEWABLE AND SUSTAINABLE MATERIALS (5:0:0)		
Contact Hours: 5/week		
Course Content		
Unit 1	**Chemicals/Monomers from renewable resources or Green Chemistry: (Sources, synthesis, properties and applications of):** Glucose, xylose, arabinose, Furfural, Lactic Acid, Gluconic Acid, Furans, Xylitol, Sorbitol, Mannitol, Terpenes, Oligomers such as rosins, tannins, vegetable oils, Surfactants, Triglycerides, Levulinic Acid, Levoglucosan, Hydroxyacetaldehyde	**10h**
Unit 2	**Fibers from renewable resources: (Sources, synthesis, properties and applications of):** Nratural fibers (Cellulosic fibres; Cotton, viscose, acetate, triacetate, flax, linen, hemp, jute, sisal, abaca, cabuya, Coconut Fibres and henequen. Protein fibers; Silk, Wool, Synthetic fibers from biorenewable resources	**10h**
Unit 3	**Fuels from renewable resources / Green fuels: (Sources, synthesis, properties and applications of):** First generation, second generation and third generation biofuels. Bioethanol (From sugar, starch cellulose and algae), Biodiesel (from Trans-	**10h**

	esterefication, Hydrotreated Vegetable Oil, Gasification + Fischer-Tropsch, Microalgae) and Biogas (biomethane, biohydrogen)	
Unit 4	**Polymers from renewable resources: (Sources, synthesis, properties and applications): Polymers from biomass/Natural Polymers:** Proteins; (Gelatin/ Collagen, Casein, Whey, Albumin). Polysaccharides (Starch, Cellulose, Lignin, Carboxymethylcellulose, Chitosan hyaluronic acid, Alginate, Soy), Natural rubber, Gauyle rubber, Polymers from vegetable oils/lipids, Polymers from microorganisms (Polylactic acid, Polyhydroxybutyrate (microbial polyester), Polyhydroxyvalerate) and Nucleic acid polymers.	**10h**
Unit 5	Green composites for advanced applications	**10h**

References:

1. Mohamed Naceur Belgacem and Alessandro Gandini (Edrs), Monomers, Polymers and Composites from Renewable Resources, Elsevier, UK, 2008.
2. James h. Clark and Fabien e. I. Deswarte (Edr), Introduction to Chemicals from Biomass, A John Wiley and Sons, Ltd, Publication, UK, 2008.
3. Ashok Pandey, Christian Larroche, Steven C Ricke, Claude-Gilles Dussap and Edgard Gnansounou, Biofuels; Alternative Feedstocks and Conversion Processes, Academic Press, USA, 2011.
4. Joseph J. Bozell, Chemicals and Materials from Renewable Resources, American Chemical Society, Washington, DC, 2001.
5. Ryszard M. Kozłowski (Edr.), Handbook of Natural Fibres, Volume 2: Processing and Applications, Woodhead Publishing Limited, New Delhi, 2012.

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MSE 254: PACKAGING MATERIALS (5-0-0)

Contact Hours: 5/week

Course Content:

Unit 1	Introduction to packaging, Definition, roles and functions of packaging, Classification of packaging: Primary, secondary and tertiary packaging, Packaging design, Protection against handling, transportation and storage hazards, Packaging supply chain, Labeling, coding and marking, Packaging aesthetics and graphic	**10h**

	design, Packaging legislation.	
Unit 2	Packaging materials and their properties: Glass, Paper and paperboard, Types of Glass, Corrugated fiber board (CFB), Metal containers: Tin Plate and Aluminum, plastics, Composite containers, Collapsible tubes, Mono and multi layer plastic Films, Laminated films, Metalized films, Principles for choice of packaging materials, Testing of packaging material.	**10h**
Unit 3	Manufacturing process of packaging materials, Mechanical operations for the manufacturing of paper and paperboard, Production of packaging from papers and boards, Production of paper based semi rigid packaging, Corrugated containers – classifications, components, flutes and stages in preparation in corrugated boards, Glass Manufacturing techniques, Metal based packaging, Can manufacturing, Aluminium foil containing packaging, Film casting and extrusion of plastic films, Blow moulding for bottles, Packaging closures. Packaging from combined materials.	**10h**
Unit 4	Advanced Packaging Technologies: Electrostatic discharge (ESD) protective packaging, Modified and controlled atmosphere packaging, Smart , Active and Intelligent Packaging, cold chain packaging technology, Gas flush and vacuum packaging, Skin packaging, Shrink films, Vacuum packaging, Time-temperature indicators, RFID tags, Bar Codes, Nanotechnology in packaging.	**10h**
Unit 5	Packaging Laws and regulations, Safety aspects of packaging materials, migration of additives into food materials; Packaging material residues in food products, Environmental issues, recycling and waste disposal of packaging, biodegradable and biopolymers for packaging.	**10h**

References:

1. Food packaging technology, Editors: Coles, McDowell and Kirwan, Vol. 5. CRC Press, 2003, ISBN 1841272213
2. Fundamentals of Packaging Technology, Editors: Natarajan S, Govindarajan M, Kumar B. PHI Learning Pvt. Ltd.; 2014, ISBN 9788120350540.
3. Packaging Technology, Fundamentals, Materials and Processes, Editors: Anne and Henry Emblem, , Woodhead Publishing, 2012, ISBN: 9781845696658

4. Handbook of Package Engineering. Third Edition. Editors: Hanlon, Kelsey and Forcinio, CRC Press, USA, 1998, ISBN 9781498731935.
5. Materials for advanced packaging, Editors: Lu and Wong, Vol. 181, Springer, New York, 2009, ISBN: 978-0-387-78218-8.
6. Food Packaging: Principles and Practice, Third Edition. Editor: Gordon L. Robertson, CRC Press , 2012, ISBN 9781439862414

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MSE254: FIBER TECHNOLOGY

Contact Hours: 5/week

Course Outcomes: Upon successful completion of this course, the students will be able to-

CO1: Explain the production, properties and applications of natural and synthetic fibers.

CO2: Describe the requirements and characterization of fiber forming polymers.

CO3: Select suitable spinning techniques and modification methods

CO4: Discuss the applications of fibers.

CO5: Explain recent developments in the advanced fiber technology

Course Content:

Unit 1	**Introduction:** Definition of fibers and various textile terms, Production, chemical composition, properties and applications. **Synthetic fibers**: Rayon, cellulose acetate, nylon 6, nylon 66, polyesters, acrylics, spandex fibers, high performance fibers – aramid, carbon, flame resistant fibers. **Natural fibers**: cotton, coir, flax, wool, silk, asbestos and glass.	**10h**
Unit 2	**Requirements and characterization Fiber forming polymers** Crystallinity and orientation. X-ray diffraction measurement of Crystallinity. orientation, crystal size, small angle X-ray scattering. Measurement of density of fibres, Infrared spectroscopy for determination of orientation, Crystallinity, etc. Optical microscopy for measurement of birefringence. Internal and surface structure by electron microscopy. Thermal methods DSC, TGA and TMA for structural investigation.	**10h**
Unit 3	**Production and Testing of fibers:** Principle, technology, advantages and disadvantages of the following techniques; Melt spinning, Dry spinning, wet spinning	**10h**

	process, Electro spinning techniques. processing, dyeing and finishing of man-made fibers, Fiber – matrix adhesion, improvement of bonding – bonding agents / coupling agents, modification of fibers like bleaching, grafting, chemical treatments. Principles of finishing and dyeing of man-made fibers. identification, analysis and testing of fibers.	
Unit 4	**Application of fibres:** Textiles: Protective clothing, Design principles and evaluation of protective clothing. Medical Textiles, Sportswear, Stimuli sensitive intelligent textiles, Agriculture, biomedical applications.	**10h**
Unit 5	**Advanced fiber technology:** Bi- and multi-component fibers, hollow fibers, hard elastic fibers, geotextile fibers and structural applications .Recent developments in fiber technology	**10h**

References:

1. Kostikov, V. I. Fibre science and technology; Chapman and Hall: London, 1995.
2. R.W.Moncrieff, Man made fibres, Newnes-Butterworths, London 1975
3. Jasper Graham-Jones, John Summer scales, Marine Applications of Advanced Fibre-reinforced Composites, Woodhead Publishing, 2015.
4. V.K. Kothari, Manufactured Fibre Technology, Springer Science and Business Media, 2012
5. L.C. Hollaway, Advanced fibre-reinforced polymer composites for structural applications, Elsevier Inc. Chapters, 2013
6. Mark, H. F., Atlas, S. M., Man-made fibers; Science and Technology, Interscience Publishers: New York, 1967.
7. S.P Mishra, A text book of Fiber Science and Technology, New age International Publishers, New Delhi, 2005.
8. Dorothy Lyle, Modern Textiles, 2nd edition Macmillan Publishing Co., 1982
9. Bernard P Corbman., Textiles: Fiber to Fabric- McGraw-Hill, New York 1999.

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MSE255: ADVANCED RUBBER TECHNOLOGY (5:0:0)
Contact Hours: 5/week
Course Outcomes: Upon successful completion of this course, the students will be able to- CO1: Explain the additives, processing and characterization of rubber compound

CO2: Design/develop rubber compounds to meet specific criteria. CO3: Explain and interpret the effect of mixing process parameters. CO4: Explain different vulcanization techniques CO5: Characterize, analyze and interpret the results of rubber compound testing		
Course Content:		
Unit 1	Mechanistic understanding of rubber processing (chemistry behind each process). Mechanism of curing (for different types of curing). Function of different rubber additives. Characterization of rubber compound – methods most prevalent in industry.	**10h**
Unit 2	Compounding and Compounding Ingredients: Overview of the science of compounding, Review of the properties and applications of natural and synthetic rubbers, Major classes of additives i.e., fillers, oils, plasticizers, processing aids, anti-degradents, and curative systems, Examples of how compounds are designed to meet the requirements of various end applications will be given. Compounding and Mixing for Specific Applications: Mixing procedures for specific compounds, illustrating the variations that follow from the nature of the ingredients, Application and the equipment available, Relationship between compounding and successful mixing is emphasized. Compounding and Mixing of Tire Compounds: An outline of the various tire components, required properties in the finished tire, Resultant compositions and mixing procedures. The Effect of Various Compounding Ingredients on Processing Behavior of the Rubber Compound: The effect of various elastomers, fillers, plasticizers and process aids.	**10h**
Unit 3	The Mixing Process: An account of the mixing process from raw material acceptance to packaging of the mixed compound, raw material specification and testing, weighing and feeding of ingredients, the mixing process (incorporation, distribution, and dispersion), flow behavior in mixers, modeling the mixing process, process variables (e.g. temperature control, basic mixing procedures, natural rubber mastication, and dump criteria), operating variables (e.g. rotor speed, ram pressure, chamber loading), control of the mixing process, discharge, shaping and cooling.	**10h**

	Mixing Cycles and Procedures: Cost of internal mixing, Unit operations in mixing, Single-pass versus multiple-pass mixing, Types of mix cycle, Mill mixing. Rubber Mixing Equipment: Basic mixer design, Review of developments in rotor design. Continuous Mixing of Rubber: An outline of developments in extruder mixing.	
Unit 4	Vulcanization: Equipment, Compounding, Desired flow properties and cure rates, for the batch processes of molding and autoclave vulcanization, for continuous vulcanization of hose, profiles, wire coverings and calendared products.	**10h**
Unit 5	Physical Testing of Rubber: Tensile, Hardness, Thermal, Dynamic mechanical, Electrical testing of vulcanizates, Tests for dispersion and contamination, Tests to identify surface exudation. Processibility Testing of Rubber Compounds: Review the tests and testing equipment used to assess the processibility of mixed compounds i.e. the Mooney test, capillary rheometer, torque rheometer, oscillating disc cure meters, rotor less cure meters, dynamic mechanical rheological testers (especially the RPA 2000), and stress relaxation instruments, Correlation (or its lack) between ODR and MDR Cure Times will be discussed, IISRP, Comparative Evaluation of Processibility Tests, 'Which is the Best Processibility Tester?' will be addressed.	**10h**

References:

1. Rodgers, B. Rubber compounding: chemistry and applications; Marcel Dekker: New York, 2004
2. Gent, A. N. Engineering with rubber how to design rubber components; 2nd ed.; Hanser; Munich, 2001.
3. Morton, M., Rubber technology, 2d ed.; Van Nostrand Reinhold: New York, 1973.
4. Freakley, P. K., Rubber processing and production organization; Plenum Press: New York, 1985.
5. Brydson, J. A., Rubbery materials and their compounds; Elsevier Applied Science, London, 1988.
6. Barlow, F. W., Rubber compounding: principles, materials, and techniques; M. Dekker: New York, 1988.

7. J.E. Mark and Erman.F.R. Eirich, Science and Technology of Rubber, Elsevier Academic Press, UK, Third Edition, 2005.
8. N.R. Legge, G.Holden and H.E. Schroeder, Thermoplastic elastomers, 2nd edition, Hanser Verlag, Munich, 1996.
9. Blow, C. M.; Hepburn, C. Rubber technology and manufacture; 2nd ed.; Butterworth Scientific: London, 1982.
10. Alliger, G. and Sjothun, I.J., Vulcanization of elastomers: Principles and practice of vulcanization of commercial rubbers; Reinhold Pub. Corp.: New York, 1964.

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MSE26L: POLYMER PROCESSING AND TESTING LAB

Course Outcomes: Upon successful completion of this course, the students will be able to-

CO1: Explain the experimental procedures and optimize the cycle time to make defect free products

CO2: Operate and practice processing equipments

CO3: Explain the significance of the test, detailed procedure to conduct the test and interpretation of results

CO4: Explain the importance of ISO and ASTM standards for polymer testing.

PART A- PROCESSING

1. Hand operated injection molding machine: Different materials, molds and optimization of cycle time
2. Hand operated blow molding machine: Different materials and optimization of cycle time
3. Pneumatic injection molding: Different materials, molds and optimization of cycle time
4. Pneumatic blow molding machine: Different materials, molds and optimization of cycle time
5. Semi-automatic injection molding machine: Different materials, molds and optimization of cycle time
6. Fully automatic injection molding machine: Different materials, molds and optimization of cycle time
7. Extrusion of strands and pelletization
8. Blown film extrusion
9. Determination of melt flow index for different polymers
10. Rubber compounding for at least two specific products
11. Effect of mastication level on natural rubber compounds: Masticate the rubber for different times (5, 10, 15 and 20 minutes) and find out the variation of solution viscosity. Plot solution viscosity Vs time.
12. Rubber compounding using Haake batch mixer
13. Blending of two polymer using Haake twin screw extruder

PART B: TESTING

1. Tensile tests (A) Plastics and (B) Rubbers
2. Flexural test (Plastics)
3. Specific gravity of rubbers
4. Durometer hardness tests (A) Plastics and (B) Rubbers
5. Abrasion resistance (A) Plastics and (B) Rubbers
6. Izod impact strength (Plastics)
7. Flex-fatigue strength (Rubbers)
8. Thermal properties (Plastics) (i) heat distortion temperature (HDT) and (ii) Vicat softening temperature (VST)
9. Electrical properties (Plastics) (i) Break down voltage and (ii) Dielectric strength

10. Resilience studies of rubbers
11. Mooney viscosity, Mooney scorch and curing characteristics of rubber compounds
12. Rubber swelling and compression set studies

References:

1. Vishu Shah, Handbook of plastics testing technology, John Wiley, New York, 2007
2. Processing Technology Laboratory Manual (Department of PST).
3. Isayev, Injection molding and compression molding fundamentals, Marcel Dekker, 2010
4. Alan Griff ,Plastics Extrusion Technology, Krieger Publishing Company,1996
5. Rosato and Rosato. Injection Molding Handbook, Hanser Publishers, 2010
6. Rosato and Rosato, Blow Molding Handbook, Hanser Publishers, 2010.
7. Ed.Corish, Concise Encyclopedia of Plastics Processing and applications, Pergamon Press, 1996
8. Relevant ASTM standards for testing methods.

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