HKE Society's PDA College of Engineering, Gulbarga Karnataka

Revised Scheme of Teaching and Examination for M.Tech. Degree (Materials Science and Technology):2019-2020

Second Sem. : M.Tech. Materials Science and Technology

Code No.	Course	Hours/Week				Maximum Marks		
		Lecture	Tutorial	Practical	Credits	CIE	SEE	Total
19MST21	Characterization of Materials	4	--	--	4	50	50	100
19MST22	Mechanical Properties & Testing of Materials	4	--	--	4	50	50	100
19MST23	Research Methodology	4	--	--	4	50	50	100
19MST24X	Elective – IV	4	--	--	4	50	50	100
19MST25X	Elective – V	4	--	--	4	50	50	100
19MST26X	Elective-VI	4	--	--	3	50	50	100
PRACTICAL								
19MSTL27	Materials Testing Lab.	--	--	4	2	50	50	100
					26	350	350	700

Electives					
19MST24X	**Elective-IV**	**19MST25X**	**Elective-V**	**19MST26X**	**Elective-VI**
19MST241	Engineering Composites	**19MST251**	**Electrical and Magnetic Materials**	**19MST261**	**Biomaterials**
19MST242	Colloids and Interfacial Engineering	19MST252	Production and Operation Management	19MST262	High Temperature Materials
19MST243	**Non-Traditional Machining**	19MST253	Smart Materials	19MST263	Sustainable solid electrolytes

Course Title: Characterization of Materials				
Subject Code	19MST21			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				

Course Objective: To impart knowledge and enable students to understand

1. Symmetry elements, Point groups and Space groups
2. X-ray diffraction technique and X-ray diffractometer and phase determination by XRD
3. SEM, TEM and their utilization to study the microstructure and morphology
4. Thermal analysis techniques and spectroscopic techniques and Instruments

Modules	**Contents**	**Teaching Hours**
I	Crystallography: Overviews in bonding, crystal systems, Bravais lattices, Miller indices. Symmetries in crystals; rotational (2, 3, 4, 6, fold etc), reflection(mirror), inversion and roto-reflection symmetries in crystals. Point groups; stereographic presentations and symmetry diagram of 32 point group. Centro-symmetric and non Centro-symmetric point groups. Space groups; Notation conventions of all symmetry elements translation symmetry (glide planes and screw axis). Conversion of space groups into point groups. Derivation of equivalent points for given space groups, describing of space group notation of all 230 space groups, drawing of stereographic diagram and symmetry element diagrams for space groups of triclinic, monoclinic and orthorhombic crystal systems reciprocal lattice, morphology.	**12 Hours**
II	X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, photon scattering, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. modern diffractometers, diffractometer measurements, determination of crystal structure of powder sample, small angle scattering, line broadening, particle size, crystallite size, residual stress measurement, plane indexing, precise parameter measurement, phase identification, phase quantification, phase diagram determination, significant information analysis from peak broadening, peak intensity, peak splitting, peak shifting of XRD pattern. stereographic projection, pole figure, preferred orientation (texture analysis) and chemical analysis, profile fitting and Rietveld analysis. Systematic absences of planes (hkl) in XRD pattern due to symmetry.	**10 Hours**

III	Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes, application of microscopy in metallurgical studies (qualitative and quantitative), morphology and symmetry, grain boundaries and dislocations, phase contrast microscopy, polarised light microscopy, hot-stage microscopy, sample preparation. Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. geometry of electron microscopes, specimen handling and preparation, secondary electron image, backscattered electron image, image processing, analysis of electron micro-graphs and fractography studies, transmission electron microscopy (TEM). Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunnelling microscope, atomic force microscope, magnetic force microscopy, topography studies, nanoindentation and its probing.	**10 Hours**
IV	Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetery, thermomechanical analysis and their applications. VSM , mossbauer spectroscopy	**10 Hours**
V	Solid State and Surface Spectroscopies: Electron Energy Loss Spectroscopy (EELS), Reflection_Absorption Infra-red Spectroscopy (RAIRS), Transmission IR, Raman, Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), Xray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), Extended X-ray Absorption Fine Structure (EXAFS).	**10 Hours**

Question paper pattern:

Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

Reference Books:

1.C.Giacovazzo Editor "Fundamentals of Crystallography" International Union of Crystallography Oxford University Press 1994

2. Cullity B. D. "Elements of X-ray Diffraction" Addison-Wesley Publishing Co.

3. C.Suryanarayana "X-ray Diffraction:A Practical Approach" M.Grant Norton Plenum Press NewYork 1998

4.P.J. Goodhew, F.J. Humphreys Electron Microscopy and Analysis, , 2nd edition Taylor & Francis publications

5. Antony R. West "Solid state chemistry and its Applications" Wiley Student Edition. 2008

6. Colin N. Banwell and Elaine M. McCash "Fundamentals of Molecular spectroscopy" Tata McGraw Hill Publishing Co. Ltd., Fourth edition.

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	CO #	Course Outcome (CO)

19MST21	**CO1**	Explain the construction and working of SEM, TEM, XRD and other characterization techniques
	CO2	Analysis and Interpretation of the data obtained from different characterization techniques
	CO3	Execute the schematic diagrams of points groups and space groups of crystal systems
	CO4	Computation crystalloid size by using the XRD data
	CO5	Evaluation of materials with application of appropriate characterization techniques

Course Title: Mechanical Behvaior and Testing of Materials				
Subject Code	19MST22			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	5			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: To impart elementary knowledge about structure-property correlations and investigations of the mechanical behavior and testing of materials				

Modules	**Contents**	**Teaching Hours**
I	Characteristic properties of metals, bonding in solids, crystal system of materials, crystal imperfections and metallic solid solutions. Solidification of pure metals, homogenous and heterogeneous nucleation processes, Iron-Carbide phase diagram. Introduction to mechanical Properties; Tensile strength, compressive strength, ductility, malleability, stiffness, toughness, creep strength, hardness, impact and fatigue strength	**10 Hours**
II	Introduction of Engineering Materials; Steel, Cast Irons, Aluminum and its alloy, Copper and its alloy, Nickel and its alloy, Cobalt and its alloy, Ceramic and Polymeric materials. Elastic and Plastic deformation in metals, slip planes and direction in crystals, critically resolved shear stress. Plastic deformation in metals: Strain hardening, structural changes in cold worked polycrystalline metals and alloys, annealing of cold worked metals, mechanism of annihilation and rearrangement of point imperfections/dislocations, recrystallization and grain growth. Deformation by twinning, Deformation behavior in ceramics and polymers	**12 Hours**
III	Strengthening mechanism of metals and alloys; Grain boundary strengthening, solid solution strengthening, second phase particle strengthening, martensitic strengthening. Engineering Composites; Mechanical properties of different types of fibres and fibre-reinforced composites, dispersion strengthened composites. Strengthening of plastics, strengthening of ceramics, mechanical properties of metals, ceramics and polymer based matrix composites. Transformation toughening in ceramics; Partially stabilized zirconia, Zirconia toughened alumina.	**10 Hours**
IV	Tensile behaviors; Tension test and stress-strain curves, tensile properties. Scratch and Indentation hardness, Brinell hardness test and its limitation, Vickers hardness test and its limitation, Rockwell hardness test and its limitations, Microhardness test. Ductile-brittle transition behavior and Behavior of polymers under impact loading	**10 Hours**
V	Ductile fracture, brittle fracture, mechanism of brittle fracture. Fracture toughness test, fracture stress test, hardness indentation	

	method. Fatigue behavior of materials, Fatigue test, Mechanism of fatigue. Creep behavior of materials, creep curves, mechanism of creep deformation	**10 Hours**

Course outcomes:

After studying this course, students will be able to:

1. Explain crystal structure, imperfection, solid solutions and mechanical properties of materials
2. Distinguish elastic and plastic deformation mechanisms and its impact on strain hardening and cold working of metals and alloys
3. Design and analysis of microstructure-property correlations for enhancement of materials strengthening
4. Analysis and Interpretation of experimental results of mechanical properties
5. Analysis of causes for materials failure and set threshold values for sustainability

Question paper pattern:

Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

A.K. Bhargava and C. P. Sharma "Mechanical Behaviour and Testing of Materials PHI Learning Private Limited New Delhi 2011

Reference Books:

1.Williams F Smith, Javad Hashemi and Ravi Prakash, "Materials Science and Engineering" 5th Edition, McGraw Hill Education (India) Pvt. Limited New Delhi
2. V. Raghavan ,"Physical Metallurgy" Prentice Hall of India Pvt. Ltd New Delhi

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST22	**CO1**	Explain crystal structure, imperfection, solid solutions and mechanical properties of materials	**L2**
	CO2	Distinguish elastic and plastic deformation mechanisms and its impact on strain hardening and cold working of metals and alloys	**L4**
	CO3	Design and analysis of microstructure-property correlations to enhance strengthening of materials	**L4**
	CO4	Analysis and Interpretation of experimental results of mechanical properties of materials	**L4**
	CO5	Analysis of causes for materials failure and set threshold values for sustainability	**L4**

Course Title: Research Methodology				
Subject Code	19MST23			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	5			SEE Hours: 03
Common with M.Tech. Production Engg, Thermal Power Engg., Power Electronics, Biomedical Electronics and Industrial Instrumentation				

Elective IV: 20MST24X

19MST241

Course Title: Engineering Composites				
Subject Code	19MST241			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: To impart knowledge on Types of composites, their fabrication methods, matrix materials and mechanics of composites				

Modules	**Content**	**Teaching Hours**
I	Classification and characteristics of composites, Advantages and limitations, Salient applications in various fields. Fibres preparation and Properties: Natural fibres, Introduction. To synthetic fibres, Synthetic organic fibres, Synthetic inorganic fibres, particulate and whisker reinforcement, reinforcement matrix interface.	**10 Hours**
II	Matrix materials: Processing and Properties of polymers, metals and ceramic matrix materials. Interfaces – wettability and bonding, interface in composites, interactions at the interface, types of bonding at the interface. Test for measuring interfacial strength. Discussion on few examples of commercial composites.	**12 Hours**
III	Determining fibre volume fraction, properties of matrix and reinforcement materials. Micromechanics of unidirectional composites; Longitudinal stiffness, Transverse stiffness, shear	

	modulus, Poission's ratio. Longitudinal tensile and compressive, transverse tensile strength, thermal and moisture effects	**10 Hours**
IV	Short fibre composites; Significance, fibre length and orientation, stress and strain distribution at fibres, critical fibre length and average fibre stress, stiffness and strength	**10 Hours**
V	Parameters for failure of composites; Crack opening displacement, fracture initiation, impact, slow crack growth and crack opening mode. Toughening mechanism of composites: Crack bowing, crack deflection, debonding, pullout, wake toughening, mircocrack toughening, Transformation toughening	**10 Hours**

Course outcomes:
After studying this course, students will be able to:

Question paper pattern:
Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:
1)F. L. Matthews and R. D. Rawlings "Composite Materials: Engineering and Science" Chapman and Hill publication London 1993
2) Krishan K. Chawla "Composite Materials- Science and Engineering, Springer-Verlag New York Inc., 1987

Reference Books:
1) Robert Millard Jones " Mechanics of Composite materials" Published by Taylor & Francis, 1999 -
2) Ever J. Barbero Introduction to Composite Materials Design CRC Press 1998
3)John Wanberg Composite Materials: Fabrication Handbook Wolfgang Publications, Incorporated - Technology & Engineering 2009

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**
19MST241	**CO1**	Distinguish various kinds of fibres and fibre reinforced composites
	CO2	Design and development of composition, processing parameters and correlation of composite properties
	CO3	Computation of matrix and reinforcement volume fractions and its influence composite properties
	CO4	Interpretation of microstructure-property correlations with stiffness and strength of composites
	CO5	Analysis of failure mechanism of composites and toughening mechanism of composites.

19MST242

Course Title: Colloids and Interfacial Engineering				
Subject Code	19MST242			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: To impart knowledge to the students regarding 1. Colloids of interfacial phenomena and engineering applications 2. Explain theories proposed for interatomic, intermolecular and surface forces of materials 3. Experimental methods adopted regarding surface and interfacial forces 4. Evaluation and analysis of adsorption of solid- solid and solid-liquid interaction				

Modules	**Contents**	**Teaching Hours**
I	**Introduction to engineering of interfaces:** Definition and examples of interfaces, industrial applications of interfacial phenomena. Colloidal materials: Properties and characterization of colloidal systems. Applications of interfaces in crystallization, ceramics, catalysts, electronic products and nanomaterials	**10 Hours**
II	Theoretical methods for the calculation of surface and interfacial tension. Introduction to intermolecular and surface forces: van der Waals forces, Electrostatic double layer force, Disjoining pressure, DLVO theory, Non-DLVO forces.	**10 Hours**
III	**Surface and interfacial tension:**; Experimental techniques for the determination of equilibrium and dynamic tension; Shape of the surfaces: curvature and radius of curvature; Young-Laplace equation; Kelvin equation; Pendant and sessile drops; Adams-Bashforth equation. Characterization of fluid-solid interfaces for Contact angle and wetting phenomena, Measurement of equilibrium and dynamic contact angles. Deposition of thin films: Mechanism of film nucleation-Chemical vapor deposition, molecular beam epitaxy, sputtering and atomic layer deposition techniques;	**11 Hours**
IV	**Adsorption at fluid-fluid and fluid-solid interfaces:** Adsorption of surfactants; Gibbs and Langmuir monolayers, Gibbs adsorption equation, Surface equation of state, Surface pressure isotherm. Langmuir-Blodgett films and their applications, radiotracer and neutron reflection techniques for studying adsorption at fluid-fluid interfaces. Adsorption isotherms, Adsorption hysteresis, Characterization of adsorption at fluid-solid interfaces by vacuum and non-vacuum techniques. Adsorption of proteins at interfaces, Biomembranes.	**11 Hours**
V	**Interfacial rheology and transport processes:** Surface shear viscosity, Surface dilatational viscosity, Boussinesq number,	

	Interfacial tension gradient and Marangoni effect, Gibbs and Marangoni elasticity, Boussinesq-Scriven model, Black films. Interfacial forces at biointerfaces, Adhesion and fusion phenomena	**10 Hours**

Course outcomes: After studying this course, students will be able to:

1. Distinguish significant forces between colloidal systems, its measurement and computation.
2. Explain interatomic forces and DLVO theory proposed
3. Differentiate elastic and plastic deformation mechanisms in metals and alloys
4. Interpretation of microstructure-property correlations through binary phase diagram of metals and alloys and heat treatment of plain carbon steel
5. Analysis and applications of metals and alloys

Question paper pattern:

Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred.

Text books:

Williams F Smith, Javad Hashemi and Ravi Prakash, " Materials Science and Engineering" 5th Edition, McGraw Hill Education

Reference Books:

Sidney H. Avner "Introduction to Physical Metallurgy" 2nd edition, Tata McGraw Hill Edition

3. V. Raghavan ,"Physical Metallurgy" Prentice Hall of India Pvt. Ltd

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**
19MST242	**CO1**	Discuss about crystal structure, crystal imperfection and solidification of metals
	CO2	Explain strengthening mechanism of metals and alloys through solid solutions
	CO3	Differentiate elastic and plastic deformation mechanisms in metals and alloys
	CO4	Interpretation of microstructure-property correlations through binary phase diagram of metals and alloys and heat treatment of plain carbon steel
	CO5	Analysis and applications of metals and alloys

19MST243

Course Title: Non-Traditional Machining				
Subject Code	19MST243			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: To impart knowledge to the students to understand the 1. Significance of non traditional machining in engineering and technology 2. Abrasive jet machining working methodology, its uses and limitations 3. Working of electrochemical machining process their importance and limitations 4. Working of plasma arc machining and electron beam machining process their advantages and limitations 5. Basic heat transfer, evaporator calculations, drying and dimensional analysis				

Modules	**Contents**	**Teaching Hours**
I	Introduction: Need for non-traditional machining processes. Process selection. Classification, comparative study of different processes. Ultrasonic machining: Introduction-mechanism of metal elements of the process-Tool feed mechanism, theories of mechanics of causing effect of parameter applications.	**10 Hours**
II	Abrasive Jet Machining: Operating principles, equipment, material removal rate, operational summary, applications, advantages and disadvantages. Thermal Metal Removal Processes: Electrical Discharge Machining-Principle of operation, electrode material, equipment, wire cut electrode discharge machine, process parameters and their effects, gap flushing, operational summary, applications.	**10 Hours**
III	Electro chemical and chemical processes**:** Electro chemical machining(ECM): Classification, ECM process, principle of ECM, Chemistry of the ECM, parameters of the processes, determination of the metal removal rate, dynamics of ECM process, hydrodynamics of ECM process, polarization-Tool Design, advantages, disadvantages and applications. Electro Chemical Grinding, Electro Chemical honing, Electrochemical deburring. Chemical Machining: Introduction, fundamental principle, types of chemical machining, Maskants-Etchants-Advantages and disadvantages-applications**.**	**12 Hours**
IV	Plasma Arc cutting(PAM): process, principles, generation of plasma from an equipment, mechanism of metals removal, PAM parameters, process characteristics, types of torches, applications. Electron beam machining (EBM): Introduction, equipment for production of electron beam, theory of electron beam machining, thermal and non thermal types characteristics,	**10 Hours**

	applications**.**	
V	Laser Beam Machining (LBM): Introduction, principle of generation of lasers Equipment and Machining procedure, types of Lasers, Process characteristics, advantages, applications and limitations. Ion Beam Machining (IBM) : Introduction, mechanism of metal removal and associated equipment, process characteristics, applications. High Velocity forming process(HVF): introduction, development of specific process selection, comparison of conventional and high velocity forming methods, types of high velocity forming methods.	**10 Hours**

Question paper pattern:
Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

Reference Books:
1. O.A. Hougen, K.M. Watson, R.A. Ragatz "Chemical process principles (Part 1)", Asia Publishing House.
2. D.C. Sarkar "Chemical Process Calculations", PHI Publications
3. W.L. McCabe, J.C. Smith, P. Harriott, "Unit operations of Chemical Engineering" 7th Ed., McGraw Hill International Edition
4. P.K.Mishra "Nonconventional Machining" Volume-1, Narosa Publishing House, The institution of engineers (India) text book series

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**
19MST243	**CO1**	Identify the basic differences between non traditional and traditional machining operations.
	CO2	Describe, abrasive and electric discharge machining operations
	CO3	Explain, electro chemical and chemical machining operations
	CO4	Experiment with plasma and electron beam machining methodology
	CO5	Explain, laser beam, ion beam machining methods and high velocity forming methods

Elective V: 19MST25X

19MST251

Course Title: Electrical and Magnetic Materials					
Subject Code	19MST251				CIE: 50
Number of Lecture Hours/Week	4	Theory	Credits	4	SEE: 50
Total Number of Hours	52				SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level					
Course Objective: To impart knowledge to 1. Conceptualize basic of electrical conductors, insulators, semiconductors and dielectric materials 2. Establish structure-property correlations for properties such as piezoelectric, ferroelectric, electro-optic, magnetic materials 3. Infer the composition and functions of capacitors, transducers, ceramic sensors and ZnO varistors 4. Familiarize the mechanisms of ionic conductivity and superconductivity					

Modules	**Contents**	**Teaching Hours**
I	Electrical conduction in metals; Classic model for electrical conduction in metals, drift velocity of electrons in a conducting metal, electrical resistivity of metals, energy band models for electrical conduction in metals and insulators. Intrinsic and extrinsic semiconductors, semiconductors devices and microelectronics. Applications of p-n junction diode. Properties of insulators and materials application as insulators	**11 Hours**
II	Linear and Non-linear dielectrics; Classification, Dielectric constant, Dielectric strength and Dielectric materials. Effect of piezoelectricity, pyro-electricity and ferro-electricity phenomenon. Structure and origin of ferroelectric state, hysteresis description of ferroelectricity, effect of temperature on polarizability. Basic relationship and phenomena of electro-optic ceramics, optical phase retardation, PLZT compositional system and processing and fabrication method	**10 Hours**
III	Basic theory of magnetism and magnetic properties. Definition and examples of diamagnetism, paramagnetism, ferromagnetism, anti-ferromagnetism, ferrimagnetisms. Classes of magnetic ceramics; spinal ferrites structure, spinel spin lattice interactions, effect of composition in ferrites, effect of thermal treatment, manganese and nickel zinc ferrite and hexagonal ferrites, structure, properties and applications. Rare earth garnets, YIG structure, properties and applications	**11 Hours**
IV	Classification of Class-I, Class-II and Class-III capacitors, varieties of film capacitors, discrete capacitors and multilayer	

	capacitors. Processing of multilayer capacitors. Ceramic sensors; NTC devices, PTC devices, chemical gas sensors, transducers. Mechanism of ZnO varistor behavior, characteristics and manufacturing	**10 Hours**
V	Elementary idea of ionic conductivity and its mechanisms in terms of electrode polarization, glass composition/structural effect and molten silicates. Solid electrolytes and fast ion conductors; β-Alumina and β″-Alumina, fuel cells working principles working and fuel cell materials. Superconductivity phenomena, Meissner effect, types of superconductors, application and future scope	**10 Hours**

Question paper pattern:

Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

Reference Books:

1.Hench L.L. and West J.K. “Principles of Electronic Ceramics” A Wiley-Interaction Publication John Wiley and Sons USA 1989

2.Relva C. Buchana “Ceramic Materials for Electronics-Processing, Properties and Applications” Marcel Dekker Inc. New York 1986

3.David W. Richerson “Modern Ceramic Engineering- Properties, Processing and Use in Design” Marcek Dekker Inc.,New York 1992

4.Williams F Smith, Javad Hashemi and Ravi Prakash, "Materials Science and Engineering" 5th Edition, McGraw Hill Education (India) Pvt. Limited New Delhi

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**
19MST251	**CO1**	Explain the basics of electrical conductors, semiconductors and insulators
	CO2	Analysis and applications of linear and non-linear dielectric materials properties and processing
	CO3	Analysis and evaluation of different class of magnetic materials composition and processing
	CO4	Categories different types of capacitors and applications of capacitors, gas sensors and transducers
	CO5	Analysis and applications of ionic conductors as solid electrolytes and superconductors

19MST252

Course Title: Production and Operation Management				
Subject Code	19MST252			CIE: 50
Number of Lecture Hours/Week	4(Theory)	Credit	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Common with M.Tech. Production Engineering of Mechanical Engg. Dept. and syallbus and Question Paper as per BoS of PG Production Engineering				

19MST253

Course Title: Smart Materials				
Subject Code	19MST253			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: 1) Fundamentals of materials science and engineering and able to relate the structures with properties 2) Classify the smart materials with examples and define the terms related to smart materials 3) Stimuli and output of smart materials 4) Explain the materials preparation and mechanism of all smart materials 5) Applications of smart materials				

Modules	**Content**	**Teaching Hours**
I	Introduction to material science :Classification of materials, Atomic structure ,Crystal system, Bravias lattices. Chemical bond, Defects, Grain structure and Properties. Structure and Property correlation	**10 Hours**
II	Definition of Smart Materials, Classification of Smart materials stimuli and outputs. Peizoelectric Material: Peizoelectricity, Symmetry, Mechanism, Preparation, Properties , Application of materials and Structure of Barium Titanate(BaTiO3).	**10 Hours**
III	Thermoelectric materials;- Seebeck effect, pelter effect, thermoelectric figure of merit, reparation properties applications Pyroelectric materials Electrostrictive and Magnetostrictive Materials	**11 Hours**

IV	Shape Memory Alloys : Mechanism, Materials , Applications. Chromogenic (Thermochromic, electrochromic and photochromic) Materials: Mechanism, Properties and Applications	**10 Hours**
V	Magneto-rheological Fluids: Mechanism, Properties and Application. Thermistors, varistors, smart concrets , nanomaterials in smart designs ,biomimetic smart designs and fiber optics	**11 Hours**

Course outcomes:
After studying this course, students will be able to:

Question paper pattern:
Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books: Not Avaialable

Reference Books:
1. A.V. Srinivasan and D. Michael McFarland "Smart Structures - Analysis and Design" CAMBRIDGE UNIVERSITY PRESS
2. Van Vlack "Introduction to Materials Science and Engineering"
3. , Antony R. West "Solid state chemistry and its Applications" Wiley Student Edition 2008

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST253	**CO1**	Classification of materials ,differentiate ceramics polymers and metals	2
	CO2	Classify the smart materials and properties of piezoelectric smart materials	2
	CO3	Analysis of crystal structure and properties of thermoelectric materials	4
	CO4	Analysis of correlation between microstructure and properties of shape memory alloys	4
	CO5	Applications of other related smart materials	5

19MST26X

Course Title: Bio-Materials				
Subject Code	19MST261			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				

Course Objective: To impart knowledge and enable students to understand

1. Biomaterial, Classification of Biomaterials, Cell- material interaction bone and cell structure
2. Various types of metallic and polymeric materials and their application ,tests on biomaterials
3. Biocermic materials and their applications including orthopaedic and dental materials
4. Processing of biocomposites, biomaterials for heart valves and ophthalmological applications

Modules	**Contents**	**Teaching Hours**
I	Introduction to basic concepts of material science - salient properties of important material classes. Property requirement of biomaterials: concept of biocompatibility, some definitions related to biomaterials. Genaral classification of Biomaterials: Bioinert, bioactive, bioresorbable materials.. Structure and properties of biological cells and tissues; natural bones structure and properties. Cell material interactions and foreign body response, Assesement of biocompatibility of biomaterials cell signaling process cell migration, cell differentiation cell apoptosis	**12 Hours**
II	In vitro Tests : Cellular adhesion, cellular viability using MTT test. Osteogenetic differentiation using ALP assay, Invivo testing Metallic biomaterials; Ti-based, stainless steel based Co-Cr-Mo alloys. Nitinols. Biopolymers Natural polymers; Proteins, collagens, chitin, chitosan etc. Synthetic polymers; PMMA, HDPE, PTFE, PLA, PLGA, PCL,PU, PEO Bacterial polyesters, polymeric blends. Applications of biopolymers and biometallic alloys. Merits and surface modifications.	**10 Hours**
III	Bioceramics –. Categories of ceramic biomaterials, historical perspective of bioceramics, merits of ceramic biomaterials over metals and polymers, desired properties of bioceramics implants. Bio-inert bio ceramics: alumina, zirconia, calcium aluminates and pyrolytic carbon. Bio-active glasses and glass ceramics, novel bio-medical materials based on glasses, preparation, composition and properties of bio-glass. Bone bonding mechanism of bio-glass, glasses for radiotherapy of cancers, glass ceramics for hyperthermia treatment of cancer.	**10 Hours**

IV	Ceramic substitutes for orthopedic applications, hydroxyapatite. Synthesis, properties of hydroxy-apatite, crystalline silicate biomaterials. Bio-degradable / resorbable bioceramics like aluminum – calcium - phosphorous oxide, tricalcium phosphate, plaster of Paris, applications of resorbable bioceramics. Characterization of bio-ceramics like index of quality, index of bioactivity,toxicity, etc. Regulation of medical devices. And antibacterial materials. Dental materials: Inelastic impression materials like zinc oxide / eugenol etc. Anterior and posterior dental ceramics. Dental cements for restorations, luiting cements, dental porcelains - composition, preparation, properties. Castable glass ceramic crowns, porcelain veneers, inlays and onlays and mechanical behavior of dental porcelain	**10 Hours**
V	Processing and properties of hydroxyapatite based biocomposites, biocompatible coatings polymer based biocomposites. Fabrication of porous scaffolds. Design concept of developing new materials for bioimplant applications. Cardiovascular devices – Heart valves, Vascular grafts, coronary stents. blood substitutes. Opthomolgical applications. Implant retrieval and evaluation. Drug delivery and polymeric biomaterials	**10 Hours**

Question paper pattern:

Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

Reference Books:

1. Ratner, Hoffman, Schoen, Lemons "Biomaterials Science" (Elsevier; ISBN 0-12-582461
2. Bikramjit Basu, Dhirendra Katti and Ashok Kumar editor "Advanced Biomaterials Fundamentals Processing and Applications" A John Wiley & Sons Inc. Hoboken, New Jersey 2009
3. Ralph W. Phillips "SKINNER'S Science of Dental Materials", 9th Ed. Prism Books Pvt Ltd.. Bangalore.
4. Donald L. Wise et al "Human biomaterials application"
5. Joon B. Park et al., Editor "Biomaterials: Principles and applications" CRC Press
6. James F. Shackelford "Bioceramics: Applications of Ceramic and Glass Materials in Medicine"
7. Larry L. Hench Editor "An introduction to bioceramics"

Course outcomes:

On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**
19MST261	**CO1**	Describe the definition and classification of Biomaterials, Cell-material interaction, bone and cell structure.
	CO2	Explain preparation properties applications of metallic and polymeric bio materials tests on biomaterials

	CO3	Explain preparation properties applications of ceramic bio materials
	CO4	Describe preparation properties applications orthopedic and dental ceramics .
	CO5	Design development of hydroxyapatite based biocoposites Explain cardiovascular and othomological bio materials

Course Title: High Temperature Materials				
Subject Code	19MST262			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Hours	52			SEE Hours: 03
Prerequisite: Basic materials science knowledge at the undergraduate level				
Course Objective: To impart knowledge and enable students to understand				

Modules	**Contents**	**Teaching Hours**
I	Factors influencing functional life of components at elevated temperatures, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate	**12 Hours**
II	Design of transition creep, time hardening, strain hardening, expression for rupture life of creep, ductile and brittle materials, monkam-grant relationship	**10 Hours**
III	Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage, ductile fracture due to microvoid coalescence - diffusion controlled void growth; fracture maps for different alloys and oxides	**10 Hours**
IV	Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation - defect structure and control of oxidation by alloy additions - sulphation, hot gas corrosion deposit, modified hot gas corrosion, effect of alloying elements on hot corrosion	**10 Hours**
V	Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase - embrittlement, solidification of single crystals	**10 Hours**

Question paper pattern:
Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to

maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**
Text books:
Reference Books: 1. Raj R, 'Flow and Fracture at Elevated Temperatures', American Society for Metals, 1985 2. Hertzberg R. W, 'Deformation and Fracture Mechanics of Engineering Materials', 4th Edition, John Wiley, 1996 3. Courtney T.H, 'Mechanical Behaviour of Materials', McGraw Hill, 1990
Course outcomes: **On completion of the course, the student will have the ability to:**

Course Code	**CO #**	**Course Outcome (CO)**
19MST262	**CO1**	Establish the factors that influence life span of materials at high temperature application with special emphasis on creep properties
	CO2	Design of materials composition and engineering for desired high temperature applications
	CO3	Differentiate brittle and ductile fractures and elimination of micro voids for metals and oxide materials
	CO4	Interpretation of causes of failure due to oxidation reactions and its prevention
	CO5	Applications of solutions to problems of strengthening mechanism as high temperature materials and super alloys.

Course Title: Sustainable Solid Electrolytes

Subject Code	19MST263			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credit	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Fundamentals of physics at the undergraduate level				
Course Objective: To impart basic concepts of ionic conductivity phenomena and mechanisms, solid state solid electrolytes, their characterizations techniques and applications along with dielectric properties measurement methods				

Modules	**Contents**	**Teaching Hours**
I	Types of bonding in solids-Fundamentals of Crystallography-Simple Crystal structures, X-ray diffraction-band structures of metals, semiconductors and insulators Ionic and electronic conductivities. Concept of solid state ionics; Importance of	**12 Hours**

	super-ionic materials and structures. Classification of Superionic solids-	
II	Ionic conducting mechanisms, theories proposed and discussion on ionic conducting ceramic and other related materials. Experimental probes pertaining to solid state ionics- Theoretical models of fast ion transport- Applications of fast ionic solids Hydrogen storage materials- Nano-ionic materials..	**10 Hours**
III	Concept of a thin film solid state battery- electrolyte thin films-flash evaporation technique-pulsed laser deposition technique-applications-electromotive force reversible cells-free energy changes-capacity of a cell-power and energy density of a cell-polymer electrolytes-application of polymer electrolytes in micro batteries, Fuel cells-solid state battery-super capacitors	**10 Hours**
IV	Characterization of new cathode materials; Phase identification- Thermal analysis-DTA-DSC-TG- Energy dispersive X-ray fluorescence spectroscopy (EDX)-Atomic absorption(AAS)- Structural characterization-XRD, Electron microscopy, local environment studies-Extended X-ray absorption fine structure-FTIR-Transport measurements-Electrical transport-transient transport.	**10 Hours**
V	Applications of Solid State Ionic Materials; Primary lithium batteries-lithium sulphur dioxide, Li-Vanadium Pentoxide, Secondary lithium batteries-Li-ion electrode materials-preparation and fabrication- - characterization of Li-ion cells-Comparison of Li-iodine and NiCd cells in CMOS-RAM applications. Applications of Lithium batteries in electronic devices, electric vehicle, fuel cells, sensors -Solar energy	**10 Hours**

Question paper pattern:
Question paper to be framed for hundred marks containing ten questions of twenty marks each and mandatorily two questions from each module. Each question may be split up to maximum four subdivisions. The student to answer mandatorily one full question from each module so that students will answer five questions which maximize marks to one hundred**.**

Text books:

Reference Books:
1.H.V.Keer, Principles of solid state physics, Wiley Eastern Ltd, New Delhi, 1993.
2. S.Chandra, Superionic solids-Principles and applications, North Holland Amsterdam (1981)
3. D.S.Clive, Modern Battery Technology, Alean International Ltd, Banbury, Elis Horwood Publishers,(1991)
4. T.R.Crompton, battery reference book, Reed Educational and Professional publishingLtd, SAE International 1996 5. Ozin, Geoffrey.A, Arsenault, Andre C, Nanochemistry, A chemical approach to nanomaterials, Springer (2005)

Course outcomes:
On completion of the course, the student will have the ability to:

Course Code	**CO #**	**Course Outcome (CO)**

19MST263	**CO1**	Differentiate ionic and electronic conductivity in materials and ionic conductivity phenomena
	CO2	Analysis of experimental probes pertaining to solid state ionics-Ionic conductivity mechanisms
	CO3	Analysis of composition and materials requirement for thin film batteries
	CO4	Interpretation of microstructure-property correlations for ionic conductivity through characterization techniques
	CO5	Analysis and applications of sustainable solid state solid electroytes