HKE Society's PDA College of Engineering, Gulbarga Karnataka

M.Tech. Materials Science and Technology

Revised Scheme of Teaching and Examination for M.Tech. Degree (Materials Science and Technology):2020-21

First Sem. : M Tech. Materials Science and Technology

Code No.	Course	Hours/Week				Maximum Marks		
		Lecture	Tutorial	Practical	Credits	CIE	SEE	Total
19MST11	Concepts in Materials Science	4	--	--	4	50	50	100
19MST12	Powders Processing Techniques	4	--	--	4	50	50	100
19MST13	Advances in Cement Materials	4	--	--	4	50	50	100
19MST14X	Elective – I	4	--	--	4	50	50	100
19MST15X	Elective – II	4	--	--	4	50	50	100
19MST16X	Elective – III	4	--	--	4	50	50	100
PRACTICAL								
19MST17	Materials Processing Lab.	--	--	4	2	50	50	100
					26	350	350	700

Electives					
19MST14X	**Elective-I**	**19MST15X**	**Elective-II**	**19MST16X**	**Elective-III**
19MST141	Physical Metallurgy	19MST151	Phase Transformations in Solids	19MST161	**Ceramic Technology**
19MST142	**Project Management**	19MST152	**Non-Destructive Testing**	19MST162	Materials and Environment
19MST143	Process Operations and Calculations	19MST153	Thermodynamics in Materials Science	19MST163	Polymer Technology

PDA COLLEGE OF ENGINEERING, KALABURAGI
Autonomous College under VTU

Course Title: Concepts in Materials Science				
Subject Code	19MST11			CIE: 50
Number of Lecture Hours/Week	4 (Theory)+1(Tutorial)	Credits	5	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 and enable students to understand a) Types of materials, atomic structure, crystal systems and chemical bonds b) Crystal Imperfections, diffusion in solids and phase-diagrams c) Nucleation kinetics solidification and transformations in steel d) Simple Ceramic and polymeric structures e) Corrosion, electronic magnetic properties of materials				

Modules	**Contents**	**Teaching Hours**
I	Classification of materials, Ceramics, Polymers, Metals & their salient properties, applications, periodic table. Electron configuration, Atomic structure, chemical bonds. Space lattice, Unit cell, crystalline & amorphous materials, crystal systems, bravis lattices, crystal planes & miller indices Atomic packing efficiencies, density calculations, polymorphism, crystal structure analysis (XRD)	**10 Hours**
II	Crystal Imperfections: point, line and volume . Diffusion in solids; Ficks laws of diffusion applications of Ficks laws, Kirkendall effect Phase diagrams (Binary,Ternary) & their applications, lever rule, Al_2O_3-SiO_2, Fe-C, Pb-Sn phase diagrams	**10 Hours**
III	Phase transformation; Nucleation and growth, nucleation kinetics, the growth and overall transformation kinetics and applications, Transformations in steel, precipitation process, solidification and crystallization, the glass transition, recovery recrystallization and grain growth	**10 Hours**
IV	Structural materials - metals, ferrous, non ferrous, polymer. Classification, properties application and processing of ceramics , simple ceramic structures; clay, silicates ,spinel, fluorite etc. Paulings rules for ionic solids	**12 Hours**
V	Corrosion, principles types preventions of corrosion. Electronic, mechanical and magnetic properties of materials. selection of materials and materials design	**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: Williams F Smith, Javad Hashemi and Ravi Prakash, " Materials Science and Engineering" 5th Edition, McGraw Hill Education New Delhi 2014			
Reference Books: 1.W.D.Kingery, H.K.Bowen and D.R.Uhlmann “Introduction to Ceramics” WILEY(John Wiley and Sons) Publications 2. Sidney H. Avner "Introduction to Physical Metallurgy" 2nd edition, Tata McGraw Hill Edition 3. V. Raghavan ,"Materials Science and Engineering" Prentice Hall of India Pvt. Ltd			
One hour tutorials for demonstration of models of crystals and computation of crystal structure determination techniques			

Course Code	CO #	Course Outcome (CO)	Blooms Level
19MST11	**CO1**	Explain Bravis lattice crystal system, chemical bonding, Miller indices planes and directions	**L2**
	CO2	Explain crystal imperfections, diffusion in solids	**L2**
	CO3	Interpretation and computation of binary phase diagram	**L4**
	CO4	Differentiate properties of different kinds of materials	**L4**
	CO5	Analysis and selection of suitable material for given applications	**L4**

Course Title: Powder Processing Techniques				
Subject Code	19MST12			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. To conceptualize various techniques and methods adopted for preparation of ceramics, metals and alloys fine particles 2. To establish structure-property correlations by inferring the characteristics of ceramic, metal and alloys fine particles 3. To identify the various processing steps to prepare ceramic/metal powder compact in to sintered products				

Modules	**Contents**	**Teaching Hours**
I	Historical perspective of engineering ceramic evolution and classification of ceramic/metal powder products, category of ceramic raw materials, specifications of ceramic raw materials, significance of objectives of ceramic processing from science and engineering point of view. General ceramic/metal processing flow diagram and steps of manufacturing process units for ceramic and metal powders.	**12 Hours**
II	Ceramic powder preparation methods; Mechanical comminuting, chemical route synthesis such as precipitation, co-precipitation, hydrothermal synthesis, sol-gel technique, solution combustion synthesis and vapor phase reaction. Characterization of powders by X-ray diffraction techniques, Thermal gravimetric analysis, Differential thermal analysis, Dilatometer, Mercury porosimetry, Transmission electron microscopy, density measurement by pyconometric method, specific surface area by physical adsorption of gas at cryogenic temperature (type IV adsorption isotherm) and Fourier transform infrared spectroscopy	**10 Hours**
III	Metal powder preparation methods; mechanical communition of solid materials mechanical alloying. Disintegration of liquid metals and alloys i.e.atomization techniques such as gas atomization, water atomization, centrifugal atomization and atomization limitation. Production of metals powders by reduction of oxides and electrolytic method. Characterization of metal powders; physical characteristics such as particle shape and particle size distribution, surface area analysis, apparent and tap density and compressibility of metal powders.	**10 Hours**
IV	Particle packing characteristics, hindered packing, granulation of ceramic powders, spray-drying and consolidation of ceramic fine powders in to different shapes by various fabrication	

	techniques. Powder compaction and pressureless powder shaping of metal powders. Sintering mechanisms of metals and ceramic powders.	**10 Hours**
V	Colloidal processing of ceramic fine particles, attractive surface forces, electrostatic stabilization, polymeric stabilization, stabilization of ceramic particulate suspension and rheological properties of colloidal suspension and shaping techniques by colloidal processing route and densification. Applications of powder metallurgy and engineering ceramic products	**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. James Reed "Princples of Ceramic Processing" 2nd Editions, Wiley-Blackwel Publishers New York 1995
2. Mohamed N. Rahaman "Ceramic Processing and Sintering" 2nd Edition CRC Press Taylor and Francis group 2013
3. B. K. Datta "Powder Metallurgy" 2nd Edition PHI Learning Pvt Ltd.Delhi 2014

Course outcomes:

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

Course Code	**CO #**	**Course Outcome (CO)**	**Bloom Level**
19MST12	**CO1**	Significance of objectives of science and engineering of ceramic and metals powders.	**L2**
	CO2	Analysis of ceramic fine powders characteristics that are prepared using different techniques	**L4**
	CO3	Interpretation of metal powders characteristics prepared using different processing techniques.	**L4**
	CO4	Design of compositions, processing techniques, compaction and sintering of fine powders in to final or desired products	**L4**
	CO5	Analysis and applications of metal, ceramic powders and colloidal processing products.	**L4**

Course Title: Advances in Cement Materials				
Subject Code	**19MST13**			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 science and technology of Portland cement and other alternative and newer cementing materials				

Modules	**Contents**	**Teaching Hours**
I	Historical perspective of cement materials, various types of cement, development of Portland cement, types of Portland cement. General manufacturing process of Portland cement. Calcareous and Argillaceous materials, corrective materials, Portland cement phases, silica modulus, alumnia modulus and lime saturation factor, study of $CaO\text{-}Al_2O_3$ and $CaO\text{-}SiO_2$ binary phase diagram, burnability factors, reaction sequence of cement phase formation, computation of cement phases and study of proposed mechanism of setting and hardening of Portland cement.	**12 Hours**
II	Steps of dry process to manufacture Portland cement; various methods adopted in cement industry for prehomogenization, homogenization, preheaters, precalciners, rotary kiln, coolers and dust collectors. Refractory for cement rotary kiln, installation of refractories in rotary kiln. Overview of modern grinding practices in cement industries.	**10 Hours**
III	Cement quality testing methods; fineness, setting time, density, specific gravity, soundness of cement by Lechatliers apparatus and length comparator autoclave test, heat of hydration test, compressive strength of cement and concrete. Infrared spectroscopy studies of cement and raw materials.	**10 Hours**
IV	Advances in special and newer cement: High Alumina cement (HAC); composition and mineralogy, manufacturing, phase formation, hydration of Aluminous phases, hydration of blends of calcium alumniates with additives and setting of HAC. Oil well cement; Oil well cement slurries, cement blends with different types of silica, hydration of oil well cements and types of oil well cement	**10 Hours**
V	Types and properties of fly ash, Portland flyash cement; manufacturing, performance and durability, heat resistance, hydration and properties of fly ash concrete. Silica fume- a supplementary cementious materials, Rice-husk ash based cement, hydration of slag cement and Zeolite cement composites. Review and development of modern cementing materials.	**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. S. N. Ghosh editor "Cement and Concrete Science and Technology" Volume-I part-I, ABI Book Private Ltd New Delhi 1992
2. S. N. Ghosh editor "Cement and Concrete Science and Technology" Volume-I part-II, ABI Book Private Ltd New Delhi 1992
3. S. N. Ghosh editor Mineral Admixture in Cement and Concrete Volume-4, ABI Book Private Ltd New Delhi 1992

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

Course Code	**CO #**	**Course Outcome (CO)**
19MST13	CO1	Computation of cement raw mix and phase analysis in cement
	CO2	Analysis and selection of cement processing equipments and Installation of refractories
	CO3	Evaluation of cement raw mix and cement powder quality testing analysis
	CO4	Analysis and evaluation of quality of different types of cement materials
	CO5	Analysis of composition of admixtures for utilization of industrial waste as cementing materials

Electives

19MST 14X Elective-I

Course Title: Physical Metallurgy				
Subject Code	19MST141			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 elementary knowledge about structure-property correlations and phase transformation in metals and alloys				

Modules	**Contents**	**Teaching Hours**
I	Characteristic properties of metals, bonding in solids, crystal system of materials. Solidification of pure metals, homogenous and heterogeneous nucleation processes, Grain structure of Industrial castings, Solidification of single crystals, Metallic solid solutions, crystal imperfections and microstructures of pure metals, processing of metals and alloys.	**10 Hours**
II	Annealing: recovery; recrystallization and grain growth; hot working. Concept of alloy formation, types of alloys, solid solutions, factors governing solid solubility viz. size factor, valence factor, crystal structure factor and chemical affinity factor; order-disorder transformation.	**10 Hours**
III	Concept of plastic deformation of metals, deformation by slip and twin, plastic deformation in polycrystalline metals, yield point phenomenon and related effects, concept of cold working.	**10 Hours**
IV	Binary phase diagrams: (a) Isomorphous system , (b) Eutectic system, (c) Peritectic system, (d) Eutectoid system and (e) Peritectoid system. Allotropic transformation, Lever rule and its application, Effect of non equilibrium cooling, coring and homogenization. Iron-Carbide phase diagram to correlate microstructure and properties of steels and cast irons. Heat treatment of Plain-Carbon steel: Martensite, Austenite, CCT Diagram of Eutectoid, Annealing and Normalizing, tempering, Nitriding, Cyaniding, carbonitriding, Induction hardening, Age hardening, powder metallurgy	**12 Hours**
V	Classification and harden-ability of alloy steels. Precipitation strengthening/hardening of low alloy steels. Nonferrous metals and alloys; Aluminum alloys, Copper alloys, Manganese alloys, Nickel alloys, Tin alloys, Zinc alloys and Titanium alloys	**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: Williams F Smith, Javad Hashemi and Ravi Prakash, " Materials Science and Engineering" 5th Edition, McGraw Hill Education
Reference Books: 1.Sidney H. Avner "Introduction to Physical Metallurgy" 2nd edition, Tata McGraw Hill Edition 2. 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)	Blooms Level
19MST141	**CO1**	Discuss about crystal structure, crystal imperfection and solidification of metals	**L2**
	CO2	Explain strengthening mechanism of metals and alloys through solid solutions	**L4**
	CO3	Differentiate elastic and plastic deformation mechanisms in metals and alloys	**L4**
	CO4	Interpretation of microstructure-property correlations through binary phase diagram of metals and alloys and heat treatment of plain carbon steel	**L4**
	CO5	Analysis and applications of metals and alloys	**L4**

Course Title: Project Management **(Common with M.Tech. Production Engineering)**				
Subject Code	**19MST142**/19MPE142			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Syllabus as per the BoS of PG Production Engineering 19MPE142				

Course Title: Process Operations and Calculations				
Subject Code	**19MST143**			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: No Specific Requirement				
Course Objective: To impart basic knowledge of certain unit operations and calculations of processes				

Modules	**Contents**	**Teaching Hours**
I	Materials technological process, unit operations and their general classification, Characteristics of solid particles, particle size and shape, sphericity and equivalent diameter, average particles diameters, screening and screen analysis, screen efficiency, industrial screening equipments.	**10 Hours**
II	Size reduction, Laws of size reduction, classification and description of size reduction equipments, Derivations and problems on size reduction equations	**10 Hours**
III	Heat transfer, its scope and importance in process industries, derivations of heat transfer for conduction through plane wall, cylinder, sphere, composite walls, insulation and its importance, critical radius of insulation for cylindrical and spherical surface, numerical problems. Convection: Natural and forced convection, determination of heat transfer coefficient using dimensional analysis, dimensionless numbers and their significance.	**12 Hours**
IV	Introduction to process calculations, design of a chemical process, classification of problems associated with the same (brief study), composition relations, mole concept and methods of expressing composition of mixture, basic gas calculations, laws associated with the same, average molecular weight and density calculations for mixture of gases.	**10 Hours**
V	Elementary material balance without chemical reactions, material balance applied to various operations like mixing, distillation, phase separation, evaporation and crystallization, elementary problems on combustion of fuels.	**10 Hours**

Question paper pattern:
Question paper to be framed such that two questions in each module of 20 marks each and each question may be split up to maximum 4 subdivisions. The students to answer mandatorily one full question from each module so that students will answer 5 questions considering one full from each module which maximize marks to 100.

Text books:

1. O.A.Hougen, K.M.watson and R.A.Ragatz “Chemical process principles(part 1)” Asia publishing house

2. W.L.Mc Cabe, J.C.Smith, P.Harriott "Unit operations of chemical engineering(Seventh edition)" McGraw hills international Ed.
Reference Books: 1. D.C Sikdar "Chemical Process Calculations" PHI Learning Pvt. Ltd., Delhi 2. Christie J. Geankoplis "Transport Process and Unit Operations (Third Edition)" Prentice-Hall International Inc.
Course outcomes: **On completion of the course, the student will have the ability to:**

Course Code	CO #	Course Outcome (CO)	Blooms Level
19MST143	**CO1**	Describe operations and processing units of manufacturing of materials	**L3**
	CO2	Develop size reduction equipments for the operations	**L4**
	CO3	Derive expressions of heat transfer and solve numerical problems.	**L2**
	CO4	Compute composition relations and gas calculations.	**L4**
	CO5	Solving problems by applying material balance on various operations and also combustion problems	**L2**

20MST15X Elective-II

Course Title: Phase Transformations in solids				
Subject Code	**19MST151**			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 Objectives : To impart knowledge about 1. Microstructure changes that occurs in solids due to influence parameters related to diffusion and diffusionless mechanisms 2. Formulation and discussion on various phase transformation in solids due the effects of temperature, driving forces and its impact on resulting microstructure 3. The tools required to understand causes and mechanism of phase transformation and parameters to control and develop microstructure in solids				

Modules	**Content**	**Teaching Hours**
I	Definition, long range and short range diffusion and diffusionless changes. Types of phase transformations, Homogenous and heterogeneous transformation and Buerger's classifications	**10 Hours**
II	Diffusion in soildis: Fick's Laws of diffusion, thin film solutions, Grube solution and Matano-Boltzman solutions. The Kirkendall effect, Darken's analysis, Atomic theory of diffusion and other diffusions and elementary discussion about thermodynamics of transformation	**10 Hours**
III	Homogenous nucleation barrier, rate of homogenous nucleation, temperature dependence of nucleation and time dependent of the nucleation rate, strain energy effects and heterogeneous nucleation	**10 Hours**
IV	Interface-Controlled growth: Growth rate at constant temperature and as function of temperature and experimental measurements. Diffusion controlled growth: Growth of spherical particles, small particles and plane front growth.	**10 Hours**
V	Overall Transformation kinetics: Transformation kinetics for interface-controlled growth, Diffusion controlled growth. Driving force and kinetics of particle coarsening. Elementary about different kinds of transformation; Pearlitic Massive, Martiensitic transformation and transformation-toughness	**12 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: V. Raghavan ,"Solid State Phase Transformation" PHI Prentice Hall of India Pvt. Ltd New Delhi 2015			
Reference Books: Porter, Easterling and Sherif, Phase Transformations in Metals and Alloys, 3rd edition, ISBN: 1420062107 (2009)			
Course outcomes: **On completion of the course, the student will have the ability to:**			
Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST151	**CO1**	Differentiate diffusion and diffusionless changes in solids and its classifications	**L2**
	CO2	Interpretation and computation of diffusion in solids	**L4**
	CO3	Illustration of homogenous and heterogeneous nucleation's in solids	**L4**
	CO4	Analysis of interfacial and diffusion controlled growth of particles	**L4**
	CO5	Interpretation of microstructure-property correlations of different mechanisms of transformations	**L4**

Course Title: Non Destructive Testing				
Subject Code	**19MST152**			CIE: 50
Number of Lecture Hours/Week	4 Theory	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: No specific Requirements				
Course Objectives: To impart knowledge about Non-Destructive Testing Methodologies adopted for testing of materials as per ASTM standards				

Modules	**Contents**	**Teaching Hours**
I	Introduction to NDT: Selection of NDT methods. Visual inspection, leak testing, Liquid penetration inspection- advantages and limitations.	10
II	Magnetic particle inspection: Methods of generating magnetic field, types of magnetic particles and suspension liquids, steps in inspection – applications and limitations of the test. Eddy current inspection: principle of operation, process variables , inspection coils- applications and limitations the test.	11

III	Ultrasonic inspection**:** Basic equipment, characteristics of ultrasonic waves, variables during ultrasonic inspections. Inspection methods - normal incident pulse echo, angle beam pulse echo and transmission type. Method of display- A,B and C scan mode. Transducer elements, couplets, search units, contact type and immersion types inspection methods, inspection of products like casting, extrusions, rolled product, weld set-applications and limitations of the test.	10
IV	Radiography inspection**:** Principles, radiation sources. X-Rays and their generation, gamma rays and their generation. Radio graphic films. X-ray filters, image intensifiers. Industrial radiography. Image quality indicators, radiography sensitivity- applications and limitations of the test. Neutron radiography working methodology its application and limitations. Thermal NDT inspection principles, inspection methods-applications and limitations of the test.	11
V	Optical Holography**:** Basics of Holography, recording and reconstruction-info metric techniques of inspection, procedures of inspection, typical applications. Acoustical Holography: working principle, applications and limitations. Microwave NDT- working principle and applications	10

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. Non-Destructive Testing Techniques- by Ravi Prakash, first revised edition, new age international publications.
2. Basics of Non-Destructive testing- by Lari and Kumar, S.K. Kataria & Sons publication.
3.Non-Destructive Test and Evaluation of Materials- by J. Prasad and C.G.K.Nair,2nd edition, Mcgraw Higher Ed publication.

Reference Books:

1. Mc Gonnagle JJ "Non Destructive testing" – Garden and reach New York
2. Non destructive Evolution and quality control” volume 17-metals hand book, 9th edition Asia internal 1989
3. Davis H.E Troxel G.E Wiskovil C.T "The Testing instruction of Engineering materials" Mcgraw Higher Ed publication.

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

Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST152	**CO1**	Differentiate NDT and destructive testing and examine visual, leak and liquid NDT methods	L2
	CO2	Illustrate magnetic particle and eddy current testing and conduct of experimental procedures	L4
	CO3	Application of Ultrasonic testing tools and their imitations	L4
	CO4	Analysis of the components for presence of defects using radiographic and Non-destructive testing tools	L4

	CO5	Applications of Optical, Acoustic and Microwave testing methods and assess their applications and limitations	L4

Course Title: Thermodynamic in Materials Science				
Subject Code	**19MST153**			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: Basic thermodynamics course must have been completed at undergraduate level				
Course Objective: To impart basic thermodynamics and laws of thermodynamics and its application in Materials Science and Engineering				

Modules	**Content**	**Teaching Hours**
I	Kinetic Theory of Matter, Different States of Matter, Concept of Ideal or Perfect Gas, Kinetic Theory of Gases, Expression for the Pressure of a Gas, Kinetic interpretation of Temperature.	**10 Hours**
II	Concept of equilibrium, material properties, and equations of state. Examples: Define extensive and intensive variables, Define equilibrium material properties for gases, solids and liquids, Stipulate requirements for a thermodynamic equation of state	**10 Hours**
III	First and second law of thermodynamics to describe material properties, phase transformations, chemical reactions, and processing operations. Examples: Construct equations of state to describe elastic and inelastic solids that comply with the laws of thermodynamics. Construct equations of state for elastic solids, dielectric materials, and magnetic systems. Construct equations of state to describe the response of dielectric materials, in compliance with the laws of thermodynamics.	**10 Hours**
IV	Laws of thermodynamics for the construction of single and multicomponent phase diagrams. Incorporation of experimental data into analytical and numerical descriptions of phase diagrams. Examples: The concept of regular solution for the description of spinodal decomposing solids.	**10 Hours**
V	Concepts of chemical potential, activity, activity coefficient, and apply it to graphically build Gibbs free energy descriptions to perform simple calculations. Construct temperature-composition diagrams for regular solutions. Construct and Identify thermodynamically consistent phase diagrams	**12 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: Robert DeFoff "Thermodyanmics in Materials Science" Second Edition CRC Press Taylor and Francis Group USA (2006)
Reference Books: 1. Richard E. Sonntag and Claus Borgnakke, Introduction to Engineering Thermodynamics, Wiley; 2 edition (March 3, 2006), ISBN-10: 0471737593. 2. Ken A. Dill and Sarina Bromberg, Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology Garland Science. (Taylor & Francis Group), 2003. 3. Textbook of Chemical Engineering Thermodynamics – K.V. Narayanan, Prentice Hall of India Pvt. Ltd., New Delhi, 2001

	Course outcomes: **On completion of the course, the student will have the ability to:**		
Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST153	**CO1**	Explain kinetic theory of matter including gases	**L2**
	CO2	Distinguish equilibrium state, related equations and variables with specific examples	**L3**
	CO3	Develop expertise on the mathematics of thermodynamic systems with examples	**L4**
	CO4	Analysis and Construction equations of phase diagram with specific examples	**L4**
	CO5	Construct temperature-composition phase diagram and identification of thermodynamically consistent phase diagrams	**L4**

20MST16X Elective-III

Course Title: Ceramic Technology				
Subject Code	**19MST161**			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: No Specific Requirements				
Course Objective: To impart knowledge and enable students to understand the 1. Definition classification scope of ceramic materials 2. Ceramic raw materials and principles of ceramic processing 3. Preparation, properties and applications of claywares, refractories, glasses and cement 4. Composition, fabrication and applications of specific advanced ceramics				

Modules	**Contents**	**Teaching Hours**
I	History of development of ceramics from traditional to engineering ceramics, classification of ceramic products, applications of ceramic products, scope for ceramic products and industries, advantages and limitation of ceramics over polymers and metals. Industrial and synthetic raw materials for ceramic products; Quartz, polymorphism of quartz, feldspar and its classification, cornish stone, nephelyne syanite, talc, steatite, pyrophyllite, sericite, pyrophyllite, mica.	**12 Hours**
II	General manufacturing process of ceramics products; size reduction equipments, mixing, blending, shaping techniques, and drying methods. Design and working principles of furnaces and pyrometry.	**10 Hours**
III	Different kinds of clay and non-clay plastic materials, properties of kaolin mineral clays. Classification, preparation, properties, applications of clay products Definition of refractories, classification, refractories preparation, properties, testings and applications.	**10 Hours**
IV	Glass formation, glass melting process, glass viscosity versus temperature. Different kinds of glasses their properties and applications. Cement definition, different types of cement, Thermochemistry of clinkerizaion and hydration reaction of ordinary Portland cement and testings.	**10 Hours**
V	Newer ceramics: Classification – cermets and abrasives, electro-ceramics, bio-ceramics, space ceramics, super conducting ceramics, automotive ceramics. Elementary idea of their preparation and their application, evaluation of ceramics (Mechanical and thermal properties)	**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: NA

Reference Books:
1.F. Singer and Singer S.S. " Industrial ceramics" Springer Publications ISBN 978902752596
2. F.H. Nortan "Elements of Ceramics" Longman Higher Education; 2nd Revised edition edition (1 June 1974) ISBN-10:0201053063, ISBN-13:978-0201053067
3.Solomon Mushikant "What every engineer should know about ceramics" Marcel and Dekker New york 1992.
4.W . Rayon "Properties of Ceramic Raw Materials" Elsevier 2003
5.A. Rashid Chesti "Refractories – Manufacture, Properties and Applications" Prentice Hall of India Pvt. Ltd.
6. S N Ghosh "Portland and blended Cements" A.H. Wheeler Publishing, Allahabad, Ed. 1980.
7.Samuel Ray Scholes, Charles H. Greene "Modern Glass Practice" Canners books 1975
8.Shigeyuki Somiya "Advanced Technical Ceramics" Academic Press Inc., Harcourt Brace Jovanovich Publishers, 1984
9.L. Coes Jr. "Abrasives" Springer-Verlag 1971.

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

Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST161	**CO1**	Classify the ceramics and compare them with polymers and metals	**L2**
	CO2	Explain general raw materials of ceramics and processing of ceramics	**L2**
	CO3	Illustration of preparation, properties and applications of clay, triaxial compositions and refractories	**L2**
	CO4	Illustration of preparation, properties, applications of glass and cement and their evaluation	**L2**
	CO5	Describe the properties and applications of advanced ceramics	**L2**

Course Title: Materials and Environment

Subject Code	**19MST162**			CIE: 50
Number of Lecture Hours/Week	4 (Theory)	Credits	4	SEE: 50
Total Number of Lecture Hours	52			SEE Hours: 03
Prerequisite: No Specific Requirements				

Course Objective: To impart elementary knowledge about corrosion and its control and behavior of materials in different environment		
Modules	**Contents**	**Teaching Hours**
I	Basics of Corrosion, Different forms of Corrosion, electrochemical corrosion, thermodynamic principles of electrochemical reactions	**10 Hours**
II	Electromotive Force Series, Pourbaix Diagrams, Evans Diagrams, Mixed Potential Theory, Passivity. Electrochemical methods to Measure Corrosion: DC Polarization, linear polarization method, AC Impedance; Experimental measurement of corrosion Quantification of corrosion	**10 Hours**
III	Environmentally Induced Cracking, Corrosion Fatigue, Hydrogen Induced Cracking, Application of Fracture mechanics. Atmospheric Corrosion, Oxidation in Gaseous Environments, Ellingham Diagrams, Role of Protective Scale, Molten Salt Corrosion	**10 Hours**
IV	Environmental degradation of ceramics, Degradation of Polymeric Materials, Microbial corrosion, Corrosion of Bio-Implants, Corrosion Prevention methods	**10 Hours**
V	Environmental effects from the processes industries such as cement, refractories, iron and steel, other metals and alloys. Control measures required to avoid hazardous to environment and its sustainability	**12 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: Not suggested

Reference Books:

1. D. A. Jones: Principles and Prevention of Corrosion, Macmillan Publ. Co. (1996)
2. M.G. Fontana: Corrosion Engineering, 3rd. Ed., McGraw Hill. (1986)
3. C. Scully: The Fundamental of Corrosion, 2nd ed., Pergamon Press: E. E. Stansbury and R. A. Buchanan, Fundamentals of Electrochemical Corrosion, ASM International (2000)

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

Course Code	**CO #**	**Course Outcome (CO)**	**Blooms Level**
19MST162	**CO1**	Explain corrosion principles and different forms of corrosion	**L2**
	CO2	Analysis of Evans and Pourbaix diagrams and AC-DC Polarizations	**L4**

	CO3	Differentiate failure of materials with various kinds of corrosion	**L4**
	CO4	Analysis of environmental degradation of different materials	**L4**
	CO5	Applications of control measures towards hazardous to environment and sustainability	**L4**

Course Title: Polymer Technology				
Subject Code	**19MST163**			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 understand the basic principles in polymer technology				

Modules	**Contents**	**Teaching Hours**
I	Basic concepts of polymer science - introduction, classification of polymers, condensation polymerization or step-growth polymerization-characteristics, relation between average functionality, extent of reaction and degree of polymerization, bifunctional system, polyfunctional system. Molecular weight in a step-growth polymerization. Step-growth polymerization kinetics. Chain growth polymerization, Ionic polymerization and copolymerization,Co-ordination polymerization	**12 Hours**
II	Polymerization techniques - Bulk polymerization, solution polymerization, suspension polymerization, Emulsion polymerization, solid-state, gas – phase and plasma polymerization. Plastic materials and processing techniques - Introduction, polyethylene, polypropylene, polystyrene, methyl methacrylite, acrylic fibers, vinyl acetate, vinyl chloride, polyesters, polyurethanes, polycarbonates, epoxy resins, cellulose plastics. Additives for plastics, plastic processing technology	**10 Hours**
III	Solid state properties of polymers - The Amorphous state, chain entanglements and repetition, glass transition range, the crystalline state. Measurement techniques. Mechanical properties - Mechanism of deformation. Methods of testing. Polymer degradation and the environment, polymer degradation and stability, oxidative and UV stability, chemical and hydrolytic stability, effects of radiation,	**10 Hours**

	mechanodegradation, incineration, bio- degradation. Additives- plasticizers, fillers and reinforcements, other important additives - stabilizers, flame retardants, biocides, processing additives, curing agents, colorants, heat distortion and impact modifiers, antistatic agents, blowing agents	
IV	Biopolymers, natural polymers and fiber – proteins, polynucleotides, polysaccharides. Fibers - natural and synthetic fibers, cellulosics, non- cellulosics, fiber spinning operation. Engineering and speciality polymers- engineering thermoplastics- polyamides, Polycarbonates, acetal, engineering polyesters, fluropolymers. Speciality polymers - polyamides, ionic polymers, polyaryletherketones, inorganic polymers, conductive polymers, high-performance fibers, dendritic polymers	**10 Hours**
V	Polymer processing and rheology – Basic prosessing operations, introduction to polymer rheology, rheometry. Polymers for advanced technologies- Membrane science and technology- Barrier polymers, membrane separations, membrane prepation biomedical engineering and drug delivery	**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: NA

Reference Books:
1. Polymer Science and Technology, Second edition by Joel R. Fried
2. Polymer Science and Technology, Second edition by Premamoy Ghosh
3. Polymer science, First edition by VR Gowariker, NV Viswanathan , Jayadev Sreedhar.

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

Course Code	CO #	Course Outcome (CO)	Blooms Level
19MST163	**CO1**	Discuss about crystal structure, crystal imperfection and solidification of metals	**L2**
	CO2	Explain strengthening mechanism of metals and alloys through solid solutions	**L4**
	CO3	Differentiate elastic and plastic deformation mechanisms in metals and alloys	**L4**
	CO4	Interpretation of microstructure-property correlations through binary phase diagram of metals and alloys and heat treatment of plain carbon steel	**L4**
	CO5	Analysis and applications of metals and alloys	**L4**