BIKANER TECHNICAL UNIVERSITY, BIKANER

बीकानेर तकनीकी विश्वविद्यालय, बीकानेर

SCHEME AND SYLLABUS

M. TECH.

MATERIAL SCIENCE AND ENGINEERING

Effective from Academic Session 2020-21

M. Tech.
Material Science and Engineering
Teaching and Examination Scheme
1st Year –I Semester

THEORY											
SN	**Category**	**Course**		**Contact hrs/week**			**Marks**				**Cr**
		Code	**Title**	**L**	**T**	**P**	**Exam Hrs**	**IA**	**ETE**	**Total**	
1	PCC	1CRMMSE1-01	Fundamental of Materials Science and Engineering	3	-	-	3	20	80	**100**	**3**
2		1CRMMSE1-02	Thermodynamics of Materials	3	-	-	3	20	80	**100**	**3**
3		1CRMMSE1-03	Materials Characterization	3	-	-	3	20	80	**100**	**3**
4	PEC-I	1CRMMSE2-04	Biomaterials	3	-	-	3	20	80	**100**	**3**
		1CRMMSE2-05	Advanced Composite Materials								
		1CRMMSE2-06	Phase Diagram and Phase Transformation								
		1CRMMSE2-07	--								
5	PEC-II	1CRMMSE2-08	Materials for Functional Applications	3	-	-	3	20	80	**100**	**3**
		1CRMMSE2-09	Mathematical Methods in Engineering								
		1CRMMSE2-10	Polymer Science and Engineering								
		1CRMMSE2-11	---								
6	OES	1CRMMSE3-12	Human Values and Professional Ethics	2	-	-	3	20	80	**100**	**2**
		Sub Total		17						**600**	**17**
PRACTICAL & SESSIONAL											
7	PCC	1CRMMSE1-13	Materials Science and Engineering Lab-I	-	-	2	-	60	40	**100**	**2**
8	FW	1CRMMSE4-14	Field Work	-	-	2	-	60	40	**100**	**2**
9	AC	1CRMMSE5-15	Human Values Practice School	-	-	2	-	30	20	**-**	**-**
		Sub Total				6				**200**	**4**
		TOTAL OF I SEMESTER		17		6				**800**	**21**

L: *Lecture,* ***T:*** *Tutorial,* ***P:*** *Practical,* ***Cr:*** *Credits* ***ETE:*** *End Term Exam, I****A:*** *Internal Assessment*
PCC: *Program Core Courses*
PEC: *Program Elective Courses Electives Courses (3-4Nos.) should be relevant to the chosen specialization/branch*
OES: *Other Emerging Subjects:(i)Human Values and Professional Ethics,*
(ii)Research Methodology It is decided common for all branches.
FW: *Field Work Student is required to work in the organization/industry concerned with his/her course.*
AC: Audit Course It is mandatory to pass the audit course. However, credit shall not be awarded

M. Tech.
Material Science and Engineering
Teaching and Examination Scheme
1st Year –II Semester

SN	Category	Course Code	Course Title	Contact hrs/week L	T	P	Marks Exam Hrs	IA	ETE	Total	Cr
THEORY											
1	PCC	2CRMMSE1-01	Science and Technology of Ceramic Materials	3	-	-	3	20	80	**100**	**3**
2		2CRMMSE1-02	Properties of Engineering Materials	3	-	-	3	20	80	**100**	**3**
3		2CRMMSE1-03	Mechanical Behaviour of Materials	3	-	-	3	20	80	**100**	**3**
4	PEC-I	2CRMMSE2-04	Electrical and Electronic Ceramics	3	-	-	3	20	80	**100**	**3**
		2CRMMSE2-05	Ceramic Materials for Energy Applications								
		2CRMMSE2-06	Diffusion and Sintering								
		2CRMMSE2-07	---								
5	PEC-II	2CRMMSE2-08	Nanomaterials	3	-	-	3	20	80	**100**	**3**
		2CRMMSE2-09	Corrosion Engineering								
		2CRMMSE2-10	Oxide and Non-Oxide Ceramics								
		2CRMMSE2-11	----								
6	OES	2CRMMSE3-12	Research Methodology	2	-	-	3	20	80	**100**	**2**
			Sub Total	17						**600**	**17**
PRACTICAL & SESSIONAL											
7	PCC	2CRMMSE1-13	Materials Science and Engineering Lab-II	-	-	2	-	60	40	**100**	**2**
8	FW	2CRMMSE4-14	Field Work	-	-	2	-	60	40	**100**	**2**
			Sub- Total			4				**200**	**4**
			TOTAL OF II SEMESTER	17		4				**800**	**21**

M. Tech.
Material Science and Engineering
Teaching and Examination Scheme
2nd Year –III Semester

PRACTICAL & SESSIONAL											
SN	**Category**	**Course**		**Contact hrs/week**			**Marks**				**Cr**
		Code	**Title**								
				L	**T**	**P**	**Exam Hrs**	**IA**	**ETE**	**Total**	
1	PSD	3CRMMSE6-16	Industrial/Field Project	-	-	28	-	360	240	**600**	**14**
2	PSD	3CRMMSE6-17	Seminar	-	-	4	-	60	40	**100**	**2**
		TOTAL OF III SEMESTER				32				**700**	**16**

PSD: Industrial/Field Project, Seminar, Dissertation

M. Tech.
Material Science and Engineering
Teaching and Examination Scheme
2nd Year –IV Semester

PRACTICAL & SESSIONAL											
SN	**Category**	**Course**		**Contact hrs/week**			**Marks**				**Cr**
		Code	**Title**								
				L	**T**	**P**	**Exam Hrs**	**IA**	**ETE**	**Total**	
1	PSD	4CRMMSE6-18	Dissertation	-	-	32	-	420	280	**700**	**16**
		TOTAL OF IV SEMESTER				32				**700**	**16**

1st Year –I Semester

1CRMMSE1-01: FUNDAMENTAL OF MATERIALS SCIENCE AND ENGINEERING

Bonding in Crystals – Ionic bond, covalent bond, molecular bond, hydrogen bond, metallic bond & Van der Waals bond. Crystalline and Noncrystalline materials – Crystal structure, space lattice, unit cell, crystal systems, atomic packing factor, Co-ordination numbers, crystal structure for metallic elements, Crystal directions & Planes, miller indices, stacking sequence in HCP & FCC. Defects in Crystalline Materials: Point, line, surface and volume defects Diffusion: Diffusion mechanism, laws of diffusion-Fick's I law, II law, Metals and Alloys: solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, iron-iron carbide phase diagram, recovery, recrystallization and grain growth. Ceramics: Structure and basic idea about its properties. Polymers: Classification, polymerization, structure and its properties. Corrosion and degradation of materials, introduction to composites, particle reinforced, fiber reinforced, structural composites, carbon, carbon nanotubes (single and multi walled CNT's), graphene (bonding, structure, properties, uniqueness), carbon foams, fullerenes etc. Advanced Materials and Materials Engineering: materials exhibiting ferroelectric, piezoelectric, optoelectric, semiconducting behavior, lasers and optical fibers, photoconductivity and superconductivity, nanomaterials: synthesis, properties and applications; biomaterials, superalloys, shape memory alloys; superhard cutting tool materials and superhard coatings. Ultra light Materials and Metallic Foams: Definition and processing, characterization of cellular metals, properties; various materials and coatings for implants; Coatings and high temperature materials.3D Printing: Materials process and applications.

Suggested Readings:

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. The Science and Engg. of Materials, Donald R. Askeland, Pradeep P. Fulay, Wendelin J. Wright, Global Engg.
3. Introduction to Physical Metallurgy, Avner S. H., 2nd ed., McGraw Hill.
4. Physical Metallurgy, Raghavan V., Prentice Hall of India.
5. Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, Butterworth-Heinemann.
6. Elements of Material Science and Engineering, by Van Vlack L. H.,Reading, Mass. : Addison-Wesley Pub. Co.
7. Materials Science and Engineering by Smith,Tata McGraw-Hill
8.Materials Science and Engineering by V. Raghvan, Prentice Hall India Learning Private Limited.

1CRMMSE1-02: THERMODYNAMICS OF MATERIALS

Introduction, definition of terms, first law of thermodynamics: Heat and work, internal energy, isometric process, isobaric process, isothermal process and enthalpy, heat capacity. Second law of thermodynamics: spontaneous process, entropy and irreversibility, entropy and reversible heat, reversible isothermal compression, adiabatic expansion of ideal gases, second law of thermodynamics, maximum work, criterion of equilibrium, combined statement of first and second laws. Third law of thermodynamics. Statistical interpretation of entropy: Entropy and disorder, microstate, most probable state and equilibrium, Boltzmann equation, thermal entropy and configurational entropy.

Thermodynamics behaviour of solutions: Raoult's and Henry's Laws, The thermodynamics activity, Gibbs-Duhem equation, Gibbs free energy of formation of a solution, properties of ideal solutions, non-ideal solutions, Gibbs-Duhem equation and activity relationship, regular solutions. A statistical model for solution, sub regular solutions.

Phase equilibrium in a one component system: Variation of Gibbs free energy with temperature and pressure, equilibrium between different phases- solid liquid equilibrium, Clapeyron equation, Clausius-Clapeyron equation. Graphical representation of equilibrium in one component system. Two component system: Gibbs free energy-composition diagrams and phase equilibrium. Gibbs free energy and thermodynamics activity, Gibbs free energy of formation of regular solutions, criteria for phase stability, contimous solid solution, eutectic reaction, liquid phase separation, peritectic reactions, compound formation; congruently and incongruently melting compound. Electrochemistry: chemical reactions and electrochemical reactions, chemical and electro- chemical driving forces. Electrochemical cell- EMF, different types of electro chemical cells.

Suggested Readings:

1. Introduction to the Thermodynamics of Materials by D. R. Gaskell, Taylor & Francis, New York.
2. Thermodynamics of Solids by R. A. Swalin, John Wiley and Sons.
3. Chemical Thermodynamics of Materials by C. H. P. Lupis, Elsevier Science Publishing Co., New York.
4. Stoichiometry and Thermodynamics Computations in Metallurgical Processes by Y. K. Rao, Cambridge University Press
5. Problems in MetallurgicalThermodynamics and Kinetics by G. S. Upadhyaya and R. K. Dube,Pergamon Press, New York

1CRMMSE1-03: MATERIALS CHARACTERIZATION

X-ray Diffraction Techniques: Production of X-rays, its properties and hazards, X-ray diffraction and Bragg's law, intensities calculations, Laue techniques, Debye-Scherrer techniques. moderndiffractometers, 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.

Optical Microscopy: Principles and operations of microscopy, resolution, magnification, numerical aperture, depth of field, viewing area, contrast, geometry of optical microscopes etc., application of microscopy, sample preparation.

Transmission Electron Microscopy (TEM): Types of Electron sources. Focusing systems for parallel beams & probes.Image contrast & interpretation of images. Specimen preparation techniques, Contrast theory for electron microscopes

Scanning Electron Microscope (SEM): Working, detectors, Back Scattered & secondary electron imaging. channeling patterns. Specimen preparation techniques

Scanning Probe Microscopy: Principles and operation of scanning probe microscopes, scanning tunneling microscope, atomic force microscope, magnetic force microscopy, topography studies, nano-indentation and its probing.

Thermal Analysis: Thermo gravimetric analysis, differential thermal analysis, differential scanning calorimetery, thermo-mechanical analysis and their applications.

UV-visible spectroscopy ,Solid State and Surface Spectroscopies: Electron Energy Loss Spectroscopy (EELS), Reflection Absorption Infrared Spectroscopy (RAIRS), Transmission IR, Raman, Photoelectron Spectroscopy (PES), Auger Electron Spectroscopy (AES), X-ray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), Extended X-ray Absorption Fine Structure (EXAFS).
EBSD and atom probe tomography

Suggested Readings:

1. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co.
2. Electron Microscopy and Analysis, P.J. Goodhew, F.J. Humphreys, Taylor &francis, Second edition.
3. Solid state chemistry and its Applications, Antony R. West, Wiley Student Edition.
4. Fundamentals of Molecular spectroscopy, Colin N. Banwell and Elaine M. McCash, Tat McGraw-Hill Publishing Co. Ltd., Fourth edition.
5. Materials Characterization:Introduction to Microscopic and Spectroscopic, Yang Leng, John Wiley&Sons.
6. Transmission Electron Microscopy, D.B. Williams and C.B. Carter, Springer.
7. Scanning Electron Microscopy and XRay Microanalysis, J.R. Michal, N.W.M. Ritchie, J.H.J. Scoot and C. David, Springer
8. Principles of Instrumental Analysis, Douglas A. Skoog, F James Holler and Stanley R. Crouch, Thomson Brooks/Cole
9. Thermal Analysis of Materlals, Robert F. Speyer, Marcel Dekker, Inc

1CRMMSE2-04: BIOMATERIALS

Classes of biomaterials, Bulk Properties of Materials, Surface properties and surface characterization of materials, Properties of biomaterials: Physical, thermal, electrical and optical properties of bio-materials. Biocompatibility, Biofunctionality , Mechanical and Biological Testing of Biomaterials Metallic Implant Materials: Stainless steels, Co-based alloys, Ti and Ti-based alloys and Other metals. Corrosion of metallic implants. Ceramic Implant Materials: Aluminum oxides, Calcium Phosphate, Glass Ceramics and Carbons. Medical applications of Ceramic Materials. Polymeric implant: Polymerization, Polymeric implant materials, Degradable Polymers used for Biomedical Applications. Silicone used for Biomaterials, Hydrogels, Smart Polymers as biomaterials, Polymers used for drug delivery and Tissue Engineering Applications. Natural polymers found in human body, Composites as Biomaterials, Cardiovascular Biomaterials, Orthopedic Biomaterials, Ophthalmological Biomaterials, Biomaterials for soft tissue applications and hard tissue application. Biomaterials used for artificial skin, artificial hair implantation etc. Novel Biomaterials and Uses in Engineering and Tissue Engineering.

Suggested Readings:

1. Buddy D. Ratner Allan S. HoffmanFrederick J. SchoenJack E. Lemons Biomaterials Science, Second Edition: Wiley Science.
2. Jef A. Helsen H. Jürgen Breme Metals as Biomaterials Wiley.
3. Kinam Park and Randall J. Mrsny Controlled Drug Delivery Designing Technology for the future American chemical society Publication.
4. Park .J.B. & Lakes R.S, Biomaterials: An Introduction, Plenum Press, New York.
5. Silver F .H, Biomaterials, Medical Devices &TissueEngineering: An Interated approach, Chapman &Hall.

1CRMMSE2-05: ADVANCED COMPOSITE MATERIALS

Introduction to Composite Materials: Definition, Classification, Types of matrices material and reinforcements, Characteristics & selection, Fiber composites, laminated composites, Particulate composites and sandwich construction. Macro Mechanics of a Lamina: Hooke's law for different types of materials, Number of elastic constants, Derivation of nine independent constants for orthotropic material, Two-dimensional relationship of compliance and stiffness matrix. Hooke's law for two-dimensional angle lamina, engineering constants.Invariant properties.Stress-Strain relations for lamina of arbitrary orientation.

Micro Mechanical Analysis of a Lamina Introduction, Evaluation of elastic moduli, Rule of mixture, Biaxial Strength Theories: Maximum stress theory, Maximum strain theory, Tsa-Hill theory, Tsai, Wu tensor theory.

Manufacturing and Testing: Layup and curing - open and closed mould processing, Hand lay-up techniques, Bag moulding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection moulding, Cutting, Machining, joining and repair, Testing: Destructive and Non-Destructive tests.

Metal Matrix Composites: Re-inforcement materials, Types, Characteristics and selection, Base metals Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment future potential of composites.

Suggested Readings:

1. Composite Materials Handbook, Mein Schwartz McGraw Hill Book Company.
2. Mechanics of composite materials, Autar K. Kaw CRC Press New York.
3. Mechanics of Composite Materials, Rober M. JonessMc-Graw Hill Kogakusha Ltd.
4. Stress analysis of fiber Reinforced Composite Materials, Michael W, HyerMc-Graw Hill International.
5. Composite Material Science and Engineering, Krishan K. Chawla Springer.
6. Fibre Reinforced Composites, P.C. Mallik Marcel Decker.
7. Handbook of composite fabrication by GuneriAkoval, Rapra

1CRMMSE2-06: PHASE DIAGRAM AND PHASE TRANSFORMATION

Phase rule and phase diagram, Allotropy of Iron and Fe-C Phase diagram, Nucleation and growth kinetics, Atomic models of Diffusion, Steel, Functions of alloying elements in steel, Importance of Austenite Grain size. Formation of Austenite, TTT and CCT Diagrams, Pearlitic, Bainitic and Martensitic Transformations (Mechanisms, Kinetics and Morphologies).Pearlitic transformation, Factors influencing pearlitic transformation, Mechanism of transformation, Nucleation and growth, Orientation relationship. Bainitic transformation: Mechanism of transformation, Nucleation and growth, Orientation relationships, Surface relief, Classical and non-classical morphology, Effect of alloying elements. Martensitic transformation: Characteristics of transformation, Thermodynamics and kinetics, Nucleation and growth, Morphology, Crystallography, Stabilization. Heat treatment of steels: annealing, normalizing, hardening, tempering, austempering, patenting, industrial practices, Strengthening mechanisms, Recovery, Recrystallization and Grain growth

Suggested Readings:

1. R. E. Reed-Hill, Physical Metallurgy Principles, East-West Press
2. V. Raghavan, Solid State Phase Transformations, PHI
3. Vijendra Singh, Physical Metallurgy, Standard Publisher
4. D. A. Porter and K E Easterling, Phase Transformations in Metals and Alloys, CRC Press

1CRMMSE2-08: MATERIALS FOR FUNCTIONAL APPLICATIONS

Superconductivity and its basic properties, flux dynamics, high-Tc superconductors and their applications. Ferroelectric and dielectric materials.Their fundamental properties.Types of ferroelectric materials and their applications.Theory of magnetism (diamagnetic, paramagnetic, ferromagnetic, antiferromagnetic and ferrimagnetic materials) and their applications.Magneto-resistance, gaint magneto resistance (GMR) and colossal magneto resistance (CMR) materials.Double exchange and John Tellor distortion mechanism to explain the concept of CMR materials.The applications of CMR materials.Spintronics; the basic theory, spin polarization, dilute magnetic semiconductors (DMS). Materials engineering of spintronics and their applications.Multi-ferroic materials and their applications.

Suggested Readings:

1. Magnetism and Magnetic Materials by J. P. Jakubovics, Institute of Materials, London.
2. High Temperature Superconductivity by J. W. Lynn, Springer- Verlag.
3. Characterization of nanophase materials by Z.L Wang, Wiley- VCH.
4. The Science and Engineering of Microelectronics Fabrication by S. Compbell, Oxford.

1CRMMSE2-09: MATHEMATICAL METHODS IN ENGINEERING

Probability Theory and Sampling Distributions, Basic probability theory along with examples.Standared discrete and continuous distribution like Binomial, Poisson, Normal, Exponential etc..Central limit theorem and its significance. Some sampling distributions like $\chi 2$, t, F.
Testing of Statistical Hypothesis: Testing a statistical hypothesis, tests on single sample and two samples concerning means and variances, ANOVA: One-way, Two-way with / without interactions
Ordinary linear differential equations solvable by direct solution methods; solvable nonlinear ODE's
Partial differential equations and concepts in solution to boundary vale problems:
First and second order partial differential equations;canonical forms
Major equation types encountered in engineering and physical sciences:
Solution methods for wave equation, D' Alembert solution, potential euation, properties of harmonic functions, maximum principle, solution by variable separation method.

Suggested Readings:

1. Ronald E, Walpole, Sharon L. Myers, Keying Ye, Probability and Statistics for Engineers and Scientists, Pearson Prentice Hall. 07
2. J.B. Doshi, Differential Equations for Scientists and Engineers, Narosa, New Delhi.
3. Douglas C. Montgomery, Design and Analysis of Experiments, Wiley Student Edition.
4. S.P. Gupta, Statistical Methods, S. Chand&Sons,
5. Advanced Engineering Mathematics, Erwin Kreyszig, Wiley India
6. William W. Hines, Douglas C. Montgomery, David M. Goldsman, Probability and Statistics for Engineering, Wiley Student Edition.

1CRMMSE2-10: POLYMER SCIENCE AND ENGINEERING

Basic concepts on polymers, Classification of polymers; Polymer structure: Copolymers, Tacticity, Geometric Isomerism, Nomenclature. Polymerization principles and processes Structure and properties of polymers: Amorphous state, crystalline state, Thermal transitions; Glass transition; Crystalline melting temperature; Structure property relationships, Effect of weight, composition and pressure on Tg, Mechanical properties of polymers, Viscoelastic properties of polymer solutions and melts; Dielectric analysis; Dynamic calorimetry, Additives, Blends and Composites: Plasticizers, Fillers and reinforcements, polymer blends; Polymer processing: Extrusion, Molding; Calendering; Coating, Polymer Rheology, Biopolymers, Natural polymers; Fibres; Engineering and Specialty polymers: Polyamides; Polycarbonates; Engineering polyesters etc; Ionic polymers; Liquid crystal polymers; Conductive polymers; High performance fibres; Dendritic polymers, environmental Problems with polymers.

Suggested Readings:

1. Polymer Science,W.Billmerycr
2. Structure & Properties of Polymeic materials, D.W. Clegg & A. A. Collyer
3. Engineering Materials Vol. I and II, Jones
4. Polymer Science & Technology,J.R.Fried
5. Fundamentals of Polymer Engineering by Arie Ram, Springer.
6. Polymer Science by V.R. Gowariker, N.V. Viswanathan and J. Sreedhar, Wiley-Eastern.

1CRMMSE3-12: HUMAN VALUES AND PROFESSIONAL ETHICS

Need, Basic Guidelines, Content And Process For Value Education: Understanding the need, basic guidelines, Self Exploration - its content and process; Natural Acceptance and Experiential Validation, Continuous Happiness and Prosperity- Human Aspirations, Right understanding, Relationship and Physical Facilities, Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario. Method to fulfill the above human aspirations: understanding and living in harmony at various levels. Understanding Harmony in The Human Being - Harmony in Myself: Understanding human being as a co-existence of the sentient 'I' and the material 'Body' Understanding the needs of Self ('I') and 'Body' - Sukh and Suvidha Understanding the Body as an instrument of 'I', Understanding the characteristics and activities of 'I' and harmony in 'I' Understanding the harmony of I with the Body: Sanyam and Swasthya; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Swasthya. Understanding Harmony in the Family And Society- Harmony in Human-Human Relationship: Understanding harmony in the Family, Understanding values in human-human relationship; meaning of Nyaya and program for its fulfillment to ensure Ubhay-tripti; Trust (Vishwas) and Respect (Samman) , meaning of Vishwas; Difference between intention and competence, meaning of Samman, Difference between respect and differentiation; the other salient values in relationship, harmony in the society , Samadhan, Samridhi, Abhay, Sah-astitva as comprehensive Human Goals ,Visualizing a universal harmonious order in society- Undivided Society (AkhandSamaj), Universal Order (SarvabhaumVyawastha)- from family to world family. Understanding Harmony in the Nature And Existence - Whole Existence As Coexistence: Understanding the harmony in the Nature. Interconnectedness and mutual fulfillment among the four orders of nature- recyclability and self-regulation in nature.Understanding Existence as Co-existence (Sah-astitva) of mutually interacting units in all pervasive Space. Holistic perception of harmony at all levels of existence Implications of the Above Holistic Understanding of Harmony on Professional Ethics. Natural Acceptance of Human

Values: Definitiveness of Ethical Human Conduct. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order. Competence in Professional Ethics: a) Ability to utilize the professional competence for augmenting universal human order, b) Ability to identify the scope and characteristics of people-friendly and eco-friendly production systems, technologies and management models. Strategy for transition from the present state to Universal Human Order: At the level of individual: as socially and ecologically responsible engineers, technologists and managers. Case studies related to values in professional life and individual life.

Suggested Readings:

1. A Foundation Course in Human Values and Professional Ethics, R. R. Gaur, R Sangal, G P Bagaria, Excel Books.
2. Professional Ethics includes Human Values, R. Subramanian, Oxford Univ. Press.
3. Human Values, A. N. Tripathy,New Age International Publishers. BTU/SYLLABUS/M.TECH. COURSE/SCHEME AND SYLLABUS Page 11/17
4. Engineering Ethics (including Human Values), M. Govindrajran, S. Natrajan, V.S. Senthil Kumar, Eastern Economy Edition,Prentice Hall of India Ltd.
5. Foundations of Ethics and Management, B. P. Banerjee, Excel Books.
6. Indian Ethos and Modern Management, B. L. Bajpai, New Royal Book Co.

1CRMMSE1-13: MATERIALS SCIENCE AND ENGINEERING LAB-I

1. Study of X-Ray Diffractometer.
2. To prepare sample for powder XRD pattern. Recorddiffraction data for an unknown sample and determine its crystallite size &lattice parameters.
3. Study the working of DTA/TGA, analyze the given data for unknown sample from DTA/TGA.
4. Study of UV-Visible spectrum of a given material.
5. Synthesis ofbarium titanate material by solid-state reaction methodand measure its Curie temperature.
6. Calculation of activation energy for sample using two probe conductivity measurement setup.
7. Study of dielectric behavior of a dielectricusing Cole-Cole Plots.
8. Fabrication of any crystal structure using 3D Printing technique.

1CRMMSE4-14: FIELD WORK

Student is required to work in the organization/industry concerned with his/her course.

1CRMMSE5-15: HUMAN VALUES PRACTICE SCHOOL

This practice school in first semester will have two parts –

I. Industry Interaction

In this, students will start his industry interaction in the very first semester of the M.Tech. Course. He/ She have to visit an organization for 3 hours /week in any industry finalized/selected by competent authority. This interaction will give him feel and insight to the real time working.

A. This 3 hours /work will be after the classroom studies

B. Selection criteria of organisation:

1. Have turnover more than 20 lakhs.
2. Have more than 20 employees.

C. During these hours, student will observe following points in the organisation:

1. Organisational structure and hierarchy.
2. Different kind of jobs/works done by the employees at all levels in the company.
3. Working of different departments.
4. Types of skills required to work in an organisation.
5. Ways of internal and external communication.
6. Formal dressing and attitude.
7. Coordination and team work.

II. Social Responsibility

To make students understand his role and responsibility in society & nature and co-existence as whole, student has to take an initiative towards contribution in any relevant social and environmental issue.

A. This work will be performed after the time of regular classes.

B. Student will perform one or more of the following activities after the approval of mentor and HOD:

1. Making contribution in increasing the income of any street vender or any needy person from under privileged section.
2. Cleanliness Campaign.
3. Donation of his/her belongings which is of no use to him/her to needy ones.
4. Plantation and care for nature (soil, natural resources, plants and animals).
5. Girl child and women safety, education and empowerment.
6. Blood donations and help of needy people at hospitals.
7. Helping the under – privileged section of the society.
8. Educating the street children or in schools when and where needed.
9. Nukkad Natak on any topic of social or environmental concern.
10. Any other relevant activities

1st Year –II Semester

2CRMMSE1-01: SCIENCE AND TECHNOLOGY OF CERAMIC MATERIALS

Conventional Ceramics: Introduction and classification, Refractories - Classification of refractories, modern trends and developments, basic raw materials, elementary idea of manufacturing process, basic properties and areas of application. classification and type of whitewares, elementary idea of manufacturing process, basic properties and applications. Types of glazes and enamels, elementary ideas on compositions, process of enameling and glazing and their properties. Introduction 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.

Advanced Ceramics: Bio-ceramics, space ceramics, automotive ceramics, electronic ceramics, superconducting ceramics, porous ceramics, piezo electric, pyroelectric, ferroelectric and electrooptic ceramics, nano-ceramics, green ceramics, basic 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.Introduction about thin film and thick film techniques for electronic applications, cermets, ceramics for application in armored, aerospace and space vehicles.

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. Powders synthesized by coprecipitation, hydrothermal, 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., electrophoretic casting and electro-spinning. Drying and Firing of ceramics, brief idea about of various furnaces used in ceramic industries. Sintering of ceramics

Properties of Ceramics: Thermal, chemical, mechanical, electrical, dielectric, magnetic and optical properties of ceramics.

Suggested Readings:

1. Introduction to Ceramics, W. D. Kingery, Harvey Kent Bowen, Donald Robert Uhlmann.
2. Ceramic Materials: Science and Engineering, C. Barry Carter, M. Grant Norton, Springer.
3. Handbook of Advanced Ceramics Vol II, Processing and their Applications, Shigeyuki Somiya, Elsevier Acadmic Press.
4. Mechanical Properties of Ceramics, Watchman J. B., John Wiley, New York.
5.Fundamentals of Ceramics, Michel W. Barsoum, Institute of Physics Publishing, Bristol and Philadelphia.
6. Modern Ceramic Engineering - Properties Processing and Use in Design.,D. W. Richerson, CRC Press,
7. Ceramic Processing and Sintering, M. N. Rahman, Marcel Dekker, Inc./CRC Press
8. Elements of Ceramics,F. H. Norton. , Addison Wesley.
9. Chemistry of Glasses, Ed. Amal Paul, Chapman Hall, London
10. Introduction to Glass Science and Technology, J.E. Shelby, RSC

2CRMMSE1-02: PROPERTIES OF ENGINEERING MATERIALS

Electrical Conduction in Materials: Classical and Quantum Theory of Electrical Conduction, Electrical conduction in Metals-Hall Effect, Temperature dependence of resistivity. Periodic potential, Origin of band gap, carrier concentration, carrier mobility, Equation of motion of an electron in an energy band, concept of hole, effective mass, Semiconducting Materials: Intrinsic, extrinsic semiconductors, direct and indirect band gap semiconductors.

Magnetic Properties of Materials: Basic concepts in magnetism, Classical theory of magnetic phenomena & their interpretations: Diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism, Quantum mechanical considerations of the magnetic phenomena, Applications: Soft magnetic materials, Hard

magnetic materials, Magnetic recording & magnetic memories, Applications to novel materials: Ferromagnetic shape-memory alloys & Dilute magnetic semiconductors.
Dielctric Propertiesof Materials:Claussius-Mossoti relation, dielectric dispersion and losses, piezo-, ferro-andpyroelectricity.
Capacitor to Supercapacitor: An Introduction, Supercapacitors: Fundamental Aspects, Measurement Techniques, Mechanisms on energy storage by supercapacitor. Materials for supercapacitor application.
Superconductivity: Origin, Type I and II superconducting materials and their applications.
Thermal Properties: Thermal conductivity, Specific heat, Thermal expansion, thermal shock resistance, Thermoelectric effects: Seebeck, Peltier and Thomson effects.
Optical Properties: Absorption, Transmission, Luminescence, Photoluminescence, Themoluminescence, Electroluminescence, Opacity and Translucency in insulators, Materials for Laser Applications

Suggested Readings:

1. Introduction to Solid State Physics by C. Kittel,
2. Solid State Physics by Ascroft and Mermin,
3. Elementary Solid State Physics by M. Ali Omar
4. Materials Science and Engineering by W.D. Callister, Jr.
5. The Science and Engineering of Materials by Donald R. Askeland, Chapman & Hall.
6. Materials Science and Engineering by V. Raghvan, Prentice Hall India Learning Private Limited.
7. Nanostructured ceramic oxide for supercapacitor applications by A.Balakrishan and K.R.V. Subramanian.

2CRMMSE1-03: MECHANICAL BEHAVIOUR OF MATERIALS

Elasticity: Atomic structure and bonding, Atomic interaction, physical origin of elastic modulus, Generalized Hooke‟s law, orientation dependence of elastic modulus.
Plasticity: Theoretical shear strength of crystals, point, line and volume defects, edge and screw dislocations, Burgers circuit and Burgers vector, force between dislocations, movement and interactions of dislocations, slip planes, twinning, strengthening mechanisms, work hardening, grain boundary strengthening and solid solution strengthening, true stress-strain curve, necking phenomenon, yield criteria, plastic stress- strain relationships.
Viscoelasticity and viscoplasticity: Responses of viscoelastic materials under different loading, creep and relaxation, Maxwell and Kelvin models.
Creep and Fracture: Primary, secondary and tertiary creep, creep mechanisms, dislocation creep, diffusion creep and grain boundary creep, creep laws, Analysis and Applications in Design. Brittle, ductile and fatigue fracture, fracture surfaces, Griffith‟s theory, modes of fracture, energy release rate, stress intensity factor, crack tip plasticity, J-integral and Crack Tip Opening Displacement
Fatigue: Cyclic loads, constant amplitude and variable amplitude loads, cycle counting techniques, infinite life, safelife, fail-safe, damage-tolerant design philosophies, Low cycle and high cycle fatigue, Stress-Life approach, Strain-Life approach and Fracture mechanics approach, Cumulative damage theories.
Mechanical testing: Concept of stress/strain. Tensile, compression, shear, hardness and impact testing. Brief idea about NDT.

Suggested Readings:

1. Mechanical behavior of materials : Engineering Methods for Deformation,
Fracture and Fatigue, Norman E. Dowling, Prentice Hall.
2. Mechanical behavior of materials, Marc Meyers and Krishnan K. Chawla,Cambridge University Press.

3. Mechanical behavior of materials, William F. Hosford, Cambridge University Press.
4. Mechanical behavior of materials, Thomas H. Courtney, Overseas Press.
5. Mechanical Behavior of Engineering Materials, Joachim Roesler, HaraldHarders, and Martin Baeker, Springer.
6. Elements of fracture mechanics, Prashant Kumar, Tata McGraw Hill.
7. Fatigue of Materials, S. Suresh, Cambridge University Press
8. Deformation and Fracture Mechanics of Engineering Materials, R.W Hertzberg, John Wiley & Sons.
9. Introduction to dislocations, D. Hull, DA Bacon, Pergamon.
10. Mechanical Metallurgy, G. E. Dieter, McGraw Hill.

2CRMMSE2-04: ELECTRICAL AND ELECTRONIC CERAMICS

Point defects in ionic compounds. Stoichiometry & Non-stoichiometry. Kroger Vink notation of Defect, Defect Equilibria in Non-stoichiometric Oxides such as Oxygen Deficient Oxide, Oxide with excess Metal, Metal Deficient Oxide, Metal Oxide with Excess Oxygen, Effect of alliovalent impurities on concentration of defects. Effect of partial pressure of oxygen and temperature on defect concentration.Ferroelectricity, ferroelectric transitions in $BaTiO_3$, $PbTiO_3$ and other related materials.Effect of compositional modifications and grain refinement.Relaxor ferroelectrics.Performance categories of ceramic capacitors with typical compositions.Powder synthesis, electroding and packaging of discrete, multilayer and barrier layer capacitors. Symmetry considerations and equations of state for piezoelectric and electrostrictive effects. Poled ferroelectric ceramics.Measurement of coupling factor and strain coefficient. Phase diagram, preparation and properties of PZT ceramics. Thin films of PZT.Piezoelectric positioners, loud speakers and gas igniters.Pyroelectric and electro-optic ceramics and their applications.Introduction to NTC and PTC thermistors andZnOvaristors, their processing & applications.Classification and structural features of superionic solids.Applications in oxygen sensors, fuel cells, high density energy storage batteries.Magnetic ceramics and their crystal structure.Effect of composition on magnetic behaviour.Processing, microstructure, properties and applications of magnetic ceramics.

Suggested Readings:

1. Electroceramics: Materials, Properties and Applications, A.J. Moulson and, J.M. Herbert, Wiley.
2. Principal of Electronic Ceramics, L.L. Hench and West J.K, Wiley .
3. Ceramic Processing and Sintering, M.N. Rahaman, CRC.
4. Principles of Ceramics Processing, Reed, J. John Wiley & Sons.
5. Introduction to Ceramics, W.D. Kingery, Wiley .
6. Ceramic Materials for Electronics , R. C. Buchanan, Marshal Dekker, New Yark

2CRMMSE2-05: CERAMIC MATERIALS FOR ENERGY APPLICATIONS

Definition, classification, scope. Insulators and dielectrics: low-loss ceramics, Capacitors: Types and Applications ceramic capacitors and other emerging capacitors, processing, properties Piezoelectric: properties, processing and application Fuel cells and solid oxide fuel cells (SOFC): Fundamentals, Cathode materials, Anode materials, Electrolyte, Interconnect, Glass ceramic seals, Design of fuel cell. Ceramic based Membrane for fuel cell. Li-Battery Technologies and Energy Storage. High Temperature Batteries Thermoelectric materials: Fundamentals and current advances Solar Cell: basics and materials Materials issues in Non-conventional solar cell Light-Emitting Diode. White Light Generation.Phosphor.Up-conversion and down-conversion phosphor.Rare earth phosphor.

Suggested Readings:

1. Materials, Properties and Applications, A. J. Moulson and J. M. Herbert,John Wiley and Sons, London,
2. Cell Science and Technology of Ceramic Fuel, N.Q.Minh and T.Takahashi,,Elsevier
3. High-temperature Solid Oxide Fuel Cells: Fundamentals, Design and Applications, S.C. Singhal, K. Kendall, Elsevier Science
4. Thermoelectric Materials and Devices, Edited by Iris Nandhakumar, Neil M. White, Stephen Beeby,The Royal Society of Chemistry

2CRMMSE2-06: DIFFUSION AND SINTERING

Introduction, Deriving force for sintering. Defects and diffusion in crystalline solids, Chemical Potential of Atoms and Vacancies in a Crystal and Beneath a Curved Surface, Vapor Pressure over a Curved Surface, Diffusional Flux Equations; Flux of atoms and vacancies. Ambipolar diffusion, Diffusion in nano-crystalline solids.
Solid State Sintering, Mechanisms of Sintering, stages of sintering, Phenomenological sintering equations, Sintering diagrams, sintering in nano-crystalline solids.
Liquid phase sintering, stages of liquid phase sintering, Thermodynamic and kinetic factors, Mechanisms of liquid phase sintering.Grain growth and microstructure control, Ostawald ripening, Normal and abnormal grain growth, grain growth and pore evolution in porous solids. Pressure assisted sintering, Hot pressing, Hot isoststic pressing, Sintering in vacuum and in different atmospheres. Spark and spark plasma sintering. Sintering technology, Sintering furnaces, Process variables and controls.

Suggested Readings:

1. Introduction to Ceramics - W.D Kingery
2. Fundamentals of Ceramics- Michel W Barsoum
3. Sintering of Ceramics – M. N. Rahaman
4. Ceramic Processing & Sintering, M.N. Rahaman

2CRMMSE2-08: NANOMATERIALS

Introduction to Nanomaterials: Amorphous, Crystalline, microcrystalline, quasicrystalline and nanocrystalline materials- historical development of nanomaterials – Nanomaterials classification (Gleiter‟s Classification), Bottom up and Top Down approach, Properties of Nanomaterials, Quantum Confinement, Density of State, Zero dimension, one dimension and two dimensional nanostructures Physical Methods: Inert gas condensation, Arc discharge, RF-plasma, Plasma arc technique, Ion sputtering, Laser ablation, Laser pyrolysis, Ball Milling, Molecular beam epitaxy, Chemical vapor deposition method and other variants, Electrodeposition. Chemical Methods: Metal nanocrystals by reduction, Solvothermal synthesis, Photochemical synthesis, Electrochemical synthesis, Nanocrystals of semiconductors and other materials by arrested precipitation, Thermolysis routes, Sonochemical routes, , Liquidliquid interface, Hybrid methods, Solvated metal atom dispersion, Post-synthetic size selective processing. Sol-gel, Micelles and microemulsions, Cluster compounds. Lithographic Techniques: AFM based nanolithography and nanomanipulation, E beam lithography, Ion beam lithography, oxidation and metallization. Mask and its application.Deep UV lithography, X-ray based lithography. Groups of Carbon: Fullerenes, Carbon Nanotubes, Types of Carbon Nanotubes, Functionalization of Carbon nanotubes, Properties and Synthesis of Carbon nanotubes. Thin Films: Electro plating, Electroless plating, Langmuir-Blodget films, Thermal growth, Chemical vapour deposition, sputtering deposition, molecular beam epitaxy atomistic nucleation process, cluster coalescence and deposition, grain structure of films and coatings, amorphous thin films.

Suggested Readings:

1. Nanostructured materials, Processing, Properties and Potential Applications by Carl C. Koch, Noyes Publications, Norwich, New York, U.S.A.
2. Springer Handbook of Nanotechnology by Bhusan, Bharat
3. Nano Technology by Mark Ratner and Daniel Ratner, Pearson Education, New Delhi.
4. Introduction to Nanotechnology by Charles P. Poole Jr., Frank J. Ownes, Wiley Intersciences

2CRMMSE2-09: CORROSION ENGINEERING

Fundamentals of Corrosion: Chemical, electrochemical and metallurgical aspects of corrosion. Thermodynamics of corrosion- Pourbaix diagrams. Corrosion kinetics-over voltage and polarization. Exchange current density. Mixed potential theory, Passivity and corrosion rate measurements, Tafel Linear polarization and Impedance techniques, Forms of Corrosion: Uniform corrosion.Galvanic corrosion.Crevice corrosion.Intergrannular corrosion.Selective leaching and radiation damage. High-Temperature Corrosion: Mechanism and kinetics of oxidation. Decarburization.Hydrogen attack. Corrosion by sulpher compounds. Design-based corrosion processes: Stress corrosion cracking. Hydrogen embrittlement.Corrosion fatigue. Corrosion of Nonmetallics: Synthetic rubbers and other elastomers. Plastics.Thermoplastics and thermosets.Ceramics.carbon and graphite. Prevention of Corrosion: Material selection and design. Surface coatings.Cathodic and anodic protection.Corrosion inhibitors. Corrosion & its control in industries, Some case studies-Corrosion and its control in different engineering materials: concrete structures, duplex, super duplex stainless steels, ceramics, composites and polymers

Suggested Readings:

1. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill
2. Jones.D.A. Principles and Prevention of Corrosion, Prentice Hall
3. D.R. Jones - Principals and Prevention of Corrosion, 2nd intl. Ed., Prentice Hall International Singapore
4. L.L.Shrier- Corrosion Volume I & II, 1994, Butterworths, London

2CRMMSE2-10: OXIDE AND NON-OXIDE CERAMICS

Important structural ceramics in oxide and non –oxide ceramics. Alumina ceramics effect of microstructure and strengthening and toughening – thermal expansion anisotropy and micro-crack toughening. Zirconia Ceramics- polymorphic modifications, stabilization and toughened zirconia. Composites: strengthening and toughening mechanisms, composite fabrication. Composites of some oxides and non-oxides. Non-oxide ceramics- classification, issues of densification. Reaction bonding and non-oxide ceramics fabrication. Discussion of important non-oxide ceramics- silicon carbide, silicon nitride Sialon, Boron Carbide, Boron Nitride, phase diagrams, processing, sintering and properties. Failure analysis, fractography, Friction and Wear.Importance of design consideration, material selection and failure analysis for application and reliability of structural ceramics.Weakest link theory, probabilistic design, and Weibull modulus.Strength and toughness –different methods, limitations, and effect of test protocol and sample specification of strength and toughness.Thermal shock resistance – the effect of material parameter and microstructure.The standard protocol of thermal shock measurement tests.

Suggested Readings:

1. Structural Ceramics, Treatise on Materials Science & Technology Vol- 29,, J. B. WachtmanJr.,Academic Press, New York
2. Ceramic Microstructures: Property Control by Processing, W. E. Lee and W. M. Rainforth, Springer
3. Processing, Properties and Applications, E. Dorre and H. Hubner, Springer-Verlag, Berlin Heidelberg.
4. Mechanical Properties of Ceramics, J. B. Wachtman, W.R Cannon and M. J. Mathewson, John Wiley & Sons.

2CRMMSE3-12: RESEARCH METHODOLOGY

Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research Methods verses Methodology, Research and Scientific Method, Important of Research Methodology, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India, Benefits to the society in general.
Defining the Research Problem: Definition of Research Problem, Problem Formulation, Necessity of Defining the Problem, Technique involved in Defining a Problem.
Literature Survey: Importance of Literature Survey, Sources of Information, Assessment of Quality of Journals and Articles, Information through Internet.
Literature Review: Need of Review, Guidelines for Review, Record of Research Review.
Research Design: Meaning of Research Design, Need of Research Design, Feature of a Good DesignImportant Concepts Related to Research Design, Different Research Designs, Basic Principles ofExperimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standardsand Codes.

Data Collection: Collection of primary data, Secondary data, Data organization, Methods of datagrouping, Diagrammatic representation of data, Graphic representation of data. Sample Design, Needfor sampling, some important sampling definitions, Estimation of population, Role of Statistics forData Analysis, Parametric V/s Non Parametric methods, Descriptive Statistics, Measures of centraltendency and Dispersion, Hypothesis testing, Use of Statistical software. Data Analysis: Deterministicand random data, Uncertainty analysis, Tests for significance: Chisquare, student's t-test, Regressionmodeling, Direct and Interaction effects, ANOVA, F-test, Time Series analysis, Autocorrelation andAutoregressive modeling.
Research Report Writing: Format of the Research report, Synopsis, Dissertation, Thesis itsDifferentiation, References/Bibliography, Technical paper writing/Journal report writing, makingpresentation, Use of visual aids, Intellectual property, Plagiarism. Research Proposal Preparation:Writing a Research Proposal and Research Report, Writing Research Grant Proposal.

Suggested Readings:

1. Research Methodology, Methods & Technique, C.R Kothari, New Age International Publishers, 2004.
2. Research Methodology for Engineers, R. Ganesan, MJP Publishers, 2011.
3. Research Methodology, RatanKhananabis and SuvasisSaha, Universities Press, Hyderabad, 2015.
4. Statistical Methods: Concepts, Application and Computation, Y. P. Agarwal, Sterling Publs., Pvt., Ltd., New Delhi, 2004.
5. Research Methodology, Vijay Upagade and AravindShende,S. Chand & Company Ltd., New Delhi, 2009.
6. Research Methodology and Quantitative methods, G. NageswaraRao, BS Publications, Hyderabad, 2012.
7. Business Research Methods, Naval Bajjai,Pearson 2011.
8. Business Research Methods, PrahaladMishra,Oxford 2016.

2CRMMSE1-13: MATERIALS SCIENCE AND ENGINEERING LAB-II

1. Synthesis of thin film semi conductor by solution process and calculation of band gap.
2. Fabrication and characterization of diode.
3. Synthesis of thin film dielectric by solution process and calculation of dielectric constant.
4. Fabrication and characterization of thin film capacitor.
5. Fabrication and characterization of thin film transistor.
6. Calculation of mobility of thin film transistor.
7. Measurement of cyclic voltammetry, galvanostatic charge-discharge and Impedance of supercapacitive materials using three-electrode configuration.
8. Measurement of cyclic voltammetry, galvanostaticcharge-discharge, Impedance and stability of supercapacitor device using two-electrode configuration.

2CRMMSE4-14: FIELD WORK

Student is required to work in the organization/industry concerned with his/her course.

2nd Year –III Semester

3CRMMSE6-16: INDUSTRIAL/FIELD PROJECT

3CRMMSE6-17: SEMINAR

4CRMMSE6-18: DISSERTATION

2nd Year –IV Semester