Master of Technology

in

MATERIAL SCIENCE AND ENGINEERING

Course Structure, Scheme of Evaluation and Syllabi

(*Effective from July 2017*)

Department of Applied Mechanics

Motilal Nehru National Institute of Technology Allahabad
Allahabad, U.P. -211004, INDIA

Course Structure

I Semester (Total Credits = 20):

I Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2101	Applied Mathematics and Computation	4	0	0	4	20	20	60
AM2103	Advanced Material Science and Engineering	4	0	0	4	20	20	60
AM21XX	**Elective-I**	4	0	0	4	20	20	60
AM21XX	**Elective-II**	4	0	0	4	20	20	60
AM21XX	**Elective-III**	4	0	0	4	20	20	60

List of Electives (Semester I):

Elective-I		Elective-II		Elective-III	
AM2120	Thermodynamics & Kinetics of Materials	**AM2123**	Mechanical Behaviour of Materials	**AM2124**	Ceramic Technology
AM2121	Electrical, Electronic, Magnetic and Optical Materials	**AM2110**	Applied Elasticity	**AM2125**	Non-Destructive Testing
AM2122	Polymer Science & Engineering	**AM2102**	Continuum Mechanics	**AM2126**	Nanomaterials

II Semester (Total Credits = 20):

Course Code	Subject Name	L	T	P	Credits	Distribution of Marks out of 100		
						TA	Mid Sem. Exam	End Sem. Exam
AM2202	Characterization of Materials	4	0	0	4	20	20	60
AM2252	Material Synthesis and Characterization Laboratory	0	0	6	4	50	-	50
AM22XX	**Elective-IV**	4	0	0	4	20	20	60
AM22XX	**Elective-V**	4	0	0	4	20	20	60
AM22XX	**Elective-VI**	4	0	0	4	20	20	60

List of Electives (Semester II):

Elective-IV		Elective-V		Elective-VI	
AM2203	Bio-Materials	**AM2222**	Carbon Nanotube and Carbon Nanostructures	**AM2225**	Materials in Service
AM2220	Computational Material Science	**AM2223**	MEMS and Bio-MEMS	**AM2213**	Mechanics of Composite Materials
AM2221	Energy Materials	**AM2224**	Electroacoustic Transducers	**AM2218**	Continuum Damage Mechanics

III Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2393	**Special Study/Term Project/State of the Art/Colloquium/Industrial/Research Training**	4
AM2394	**Thesis/Project**	16

IV Semester (Total Credits = 20):

S. No.	Subject Name	Credits
AM2494	**Thesis/Project**	20

Note: The distribution of thesis evaluation marks will be as follows:

1. Supervisor(s) evaluation component: 60%
2. Oral Board evaluation component: 40%

Semester-I

AM2101 Applied Mathematics and Computation		
Designation	:	Compulsory
Pre-requisites	:	Engineering Mathematics and computer programming
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for Assignment submission, Surprise tests, Term paper, Quiz tests, etc.)

Syllabus

Review of Elementary Engineering Mathematics: Solution of homogeneous and non-homogeneous equations; Power series; Laplace transform and its applications; Fourier series and Fourier transform

Linear Algebra: Matrices and Linear Transformations, Operational Fundamentals of Linear Algebra, Systems of Linear Equations, Gauss Elimination Family of Methods, Special Systems and Special Methods, Numerical Aspects in Linear Systems, Eigenvalues and Eigenvectors, Diagonalization and Similarity Transformations, Jacobi and Givens Rotation Methods, Tri-diagonal Matrices, QR Decomposition Method, Eigenvalue Problem of General Matrices, Singular Value Decomposition, Direct and Iterative solvers.

Ordinary Differential Equations: Introduction to ordinary differential equations, homogeneous linear equations of second order, non-homogeneous linear equations of second order, free and forced oscillation problems, problems with variable coefficients, system of equations.

Partial Differential Equations (PDEs): Existence and uniqueness of differential equations, nature of solution, Hyperbolic, Parabolic and Elliptic PDEs, nonlinear PDEs.

Nonlinear Equations: Motivation, Open and braketing method, Bisection, Fixed point, Newton's method, Secant and False position method, Rate of convergence, Merits and demerits of methods.

Numerical Integration: Motivation, Newton-Kotes method, Trapezoidal rule, Simpson's rule, Rhomberg integration, Gauss Quadrature.

Initial Value Problem: Motivation, Euler's method, Modified Euler method, Runge-Kutta methods, Adaptive integrations and multistep methods.

Boundary-value and Eigen-value Problem: Methods and Applications in Mechanics.

References books

1. "Numerical Methods in Engineering", M. Salvadori, Prentice Hall International, 1961.
2. "Applied Numerical Methods", B. Carnahan, Krieger Pub, 1990.
3. "Applied Numerical Analysis", C.F. Gerald and P.O. Wheatley, 5th edition, Addison-Wesley, 1998.
4. "Numerical Mathematics & Computing", W. Cheney and D. Kincaid, 5th edition, Brooks/Cole, 2004.
5. "Applied Partial Differential Equations", Paul DuChateau and David Zachmann.
6. "Partial Differential Equations for Scientists and Engineers", Stanley J. Farlow.
7. "Numerical Methods for Partial Differential Equations", William F. Ames.
8. "Numerical Methods for Elliptic and Parabolic Partial Differential Equations**",** John R Levison, Peter Knabner, Lutz Angermann.

AM2102 Continuum Mechanics		
Designation	:	Elective
Pre-requisites	:	Basic Engineering Mathematics, Linear Algebra
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Mathematical Preliminaries and Introduction: Index notation, range and summation convention, free and dummy indices, Kronecker delta, Levi-Civita symbol, co-ordinate transformations, Cartesian tensor, properties of tensors, tensors as linear operators, invariants of tensor, eigen values and Eigen vectors, polar decomposition, scalar, vector and tensor functions, comma notation, gradient of a scalar, gradient of a vector, divergence and curl of a tensor, integral theorems of vectors and tensors. Notion of a continuum, configuration, mass and density, descriptions of motion, material and spatial coordinates.

Kinematics of Deformation and Motion: Deformation gradient tensor, stretch and rotation, right and left Cauchy-Green deformation tensors, Eulerian and Lagrangian strain tensors, strain-displacement relations, infinitesimal strain tensor, infinitesimal stretch and rotation, compatibility conditions, principal strains and strain deviator, material and local time derivatives, stretching and vorticity, path lines, stream lines, vortex lines, Reynolds transport theorem, circulation and vorticity.

Forces and Stresses: Body and surface forces, Cauchy Stress Tensor, First and Second Piola-Kirchhoff Stress Tensor, Deviatoric and Pressure Components, Principal Stress.

Fundamental Balance Laws of Continuum Mechanics: Balance of Mass – Continuity Equation; Balance of Linear Momentum – Equations of Motion / Equilibrium Equations; Moments of Momentum (Angular Momentum); Balance of Energy - First Law of Thermodynamics, Energy Equation; Equations of State – Entropy, Second Law of Thermodynamics; Clausius-Duhem Inequality, Dissipation Functions

Constitutive Relations and Material Models: Constitutive Assumptions; Ideal Fluids; Elastic Fluids, Hyperelastic Material; Notion of Isotropy; Isothermal Elasticity - Thermodynamic Restrictions, Material Frame Indifference, Material Symmetry; Hooke's law, Stokes problem and Newtonian fluids.

References books

1. Lawrence E. Malvern, Introduction to the Mechanics of a Continuous Medium, Prentice Hall Inc.
2. An Introduction to Continuum Mechanics: Morton M. Gurtin, Academic Press.
3. Introduction to Continuum Mechanics for Engineers: Ray M. Bowen, Plenum Press.
4. G. Thomas Mase and George E. Mase, Continuum mechanics for engineers, CRC Press.
5. Theory and Problems of Continuum Mechanics: George E. Mase, Schaum's Outline Series-McGraw-Hill.
6. Nonlinear Continuum Mechanics for Finite Element Analysis: J. Bonet & R.D. Wood, Cambridge Uni. Press.
7. Han Chin Wu, Continuum mechanics and plasticity, Chapman and Hall.

AM2103 Advanced Material Science and Engineering		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering, Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Crystal Structure: Types of bonding, crystal structures of metals and alloys, imperfections in crystals, structure, and properties relationships in engineering materials.

Equilibrium Diagrams: Phase rule. binary equilibrium diagrams, micro-structural changes during cooling; the iron carbon equilibrium diagram; principles and effect of alloying elements on transformation characteristics, Copper-Zinc equilibrium diagram, ternary equilibrium diagrams, experimental determination of equilibrium diagrams.

Phase Changes: Types of phase changes, diffusion in solids, nucleation and growth kinetics, solidification, T-T-T-diagrams, C-C-T diagrams; effect of heat treatment on properties, precipitation and age hardening; recovery, recrystallization and grain growth.

Processing of Metals: Solidification of metals, casting, extrusion, drawing, forging and rolling; powder metallurgy techniques, fabrication through welding, influence of processing and heat treatment on microstructure. quantitative survey of processing,

Engineering Alloys and Applications: Introduction to steel and alloy specifications; important alloy steels and non-ferrous alloys; cast irons– types, high temperature alloys, light alloys: aluminium and its alloys copper and its alloys, bearing alloys, shape memory alloy.

Advanced Materials and Materials Engineering: Smart 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.

Fundamentals of Molecular Self-Assembly: Nanoscale and colloidal systems, fundamentals of surface and interfacial chemistry, surface tension and wettability, insoluble monolayers, surface chemistry and monolayers, electrostatic interactions in self assembling systems, self-assemble of amphiphiles monolayers, micelles and microemulsions, structure and properties of micelles.

Term Paper: On recent advances based on literature survey and/or lab/industry visit**.**

References books

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. Principles of Thermal Analysis and Calorimetry, Peter J. Haines, Royal Society of Chemistry.
6. Modern Physical Metallurgy and Materials Engineering, R. E. Smallman, R. J. Bishop, Butterworth-Heinemann.
7. Phase Transformations in Metals and Alloys, David A. Porter, Kenneth E. Easterling, 2nd Ed., Nelson Thornes Ltd. (Chapman & Hall).
8. Structure of Metals, Barrett C. S. & Massalski T. B., McGraw Hill, New York.

AM2110 Applied Elasticity		
Designation	:	Elective
Pre-requisites	:	Mechanics of Materials
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Analysis of Stress: Concept of Stress, Stress Components, Equilibrium Equations, Stress on a General Plane (Direction Cosines, Axis Transformation, Stress on Oblique Plane through a point, Stress Transformation), Principal Stresses, Stress Invariants, Deviatoric Stresses, Octahedral Stresses, Plane Stress, Stress Boundary Condition Problem.

Analysis of Strain: Deformations (Lagrangian Description, Eulerian Description), Concept of Strain, Strain Components (Geometrical Interpretation), Compatibility Equations, Strain transformation, Principal Strains, Strain Invariants, Deviatoric Strains, Octahedral Strains, Plane Strain, Strain Rates.

Stress-Strain Relations: Introduction, One-Dimensional Stress-Strain Relations (Idealized Time independent and Time–dependent stress-strain laws), Linear Elasticity (Generalized Hooke's Law), Stress-Strain Relationships for Isotropic and Anisotropic Materials (Plane stress and Plane Strain)

Basic Equations of Elasticity for Solids: Introduction, Stresses in Terms of displacements, Equilibrium Equations in terms of displacements, Compatibility equations in Terms of Stresses, Special cases of Elasticity equations (Plane Stress, Plane strain, Polar Co-ordinates), Principle of Superposition, Uniqueness of Solution, Principle of virtual work, Potential and Complementary energy, Variational Principles, St. Venant's Principle, Methods of analysis for Elastic Solutions, Elastic solutions by Displacement and stress Functions, Airy's Stress Function (Plane stress, Plane strain, Polar Co-ordinates).

Torsion: Introduction, Circular shaft, Torsion of non-circular cross-section, St. Venant's theory, Warping function, Prandtl's stress function, Shafts of other cross-sections, Torsion of bars with thin walled sections.

Viscoelasticity: Introduction, Viscoelastic models (Maxwell, Kelvin-Voigt, Generalized Maxwell and Kelvin models), Viscoelastic stress-strain relationships.

References books

1. Mathematical Theory of Elasticity" by I. S. Sokolnikoff.
2. "Advanced Mechanics of Materials" by Boresi.
3. "Theoretical Elasticity" by A. E. Green and W. Zerna.
4. "Theory of Elasticity" by Timoshenko.
5. "Advanced Strength and Applied Elasticity" by A. C. Ugural and S. K. Fenster.
6. "Applied Elasticity" by R.T.Fenner.
7. "Advanced Strength of Materials" by L. S. Srinath.

AM2120 Thermodynamics & Kinetics of Materials		
Designation	:	Elective
Pre-requisites	:	Thermodynamics
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Review of thermodynamic functions, laws of thermodynamics, enthalpy, heat capacity, internal entropy, configurational entropy, free energy functions and their relationships, Gibbs-Helmholtz relations, Maxwell relations, Clausius-Clapeyron equation, importance of thermodynamics in materials science-illustrations and examples; applications in areas of materials technology, industrial and process metallurgy, related calculation.

Thermodynamic Reactions and Rate of Processes: Thermally activated processes in materials, stability of materials, activation energy, potential barrier, Arrhenius equation, rate of reactions- first order, second order, etc, introduction to solutions, mixing functions, ideal and non-ideal solutions, related calculations, thermodynamics involved with rate of loading (anelastic behaviour / adiabatic loading.

Thermal Properties of Materials: Specific heat - Debye and other models, heat capacity, thermal expansion, thermal conduction, thermal stress and shock, melting point.

Phase Equilibria: Thermodynamics of solutions, equilibrium stability of phases, single phase system, Evolution of phase diagrams – construction, interpolation and thermodynamic evaluation, Hume-Rothery rules, phase rule, free-energy, composition diagrams, solidus–liquidus lines; retrograde solidus, binary, ternary and quaternary phase diagrams, pseudo-binary and pseudo-ternary systems with examples, calculations in phase thermodynamics.

Crystal Growth: Formation of crystals, theories of crystal growth, homogeneous and heterogeneous nucleation/crystal growth; criteria for equilibria in crystal growth; solid solubility; kinetics of growth - nucleation, diffusion and surface migration, dislocation; motion of dislocation, dislocation density; super-cooling; growth of single crystal of high perfection, whiskers and whiskers growth.

Phase Transformations: Classification of phase transformations, order of transformation, Gibbs rule and applications, rapid solidification and its methods, glass transformation, alloy solidification – cellular, dendritic, eutectic, peritectic, eutectoid; boundary transformations; recrystallization, grain growth; effect of alloying elements; strengthening mechanisms, shape memory effects/alloys, thermodynamics and metallography / polymorphism.

Thermodynamics of Multi-Component System: Gibbs-Duhem equation for ternary and multi-components systems, kinetics of solidification and melting, thermodynamics of melts.

Thermodynamics of Defects / Dislocations: Thermodynamics of lattice defects. enthalpy of formation of vacancy, interstitial and substitutional impurity, Frenkel's defects, calculations on all these topics, thermal energy required to minimize the dislocations.

Thermodynamics of Ceramics, Polymers and Composites: Phase changes in Ceramics, glass transition, glasses, phase changes in polymers and amorphous materials, phase changes in composites, metallic glasses.

Thermodynamics of Surfaces and Interfaces: Surface energy, surface tension, absorption kinetics of diffusion in solids. rate controlling mechanism of interface reactions, energy, shape, segregation at external and internal interfaces, theory of interface stability.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Gaskell David R, 'Introduction to Metallurgical Thermodynamics', McGraw Hill, Latest edition.
2. Jere H. Brophy, Robert M. Rose and John Wulff, 'The Structure and Properties of Materials, Vol II; Thermodynamics of structure', Wiley Eastern Pvt. Ltd., New Delhi, Latest edition.
3. Tupkary R. H., 'Introduction to Metallurgical Thermodynamics', Latest edition., Tu Publishers, Nagpur, 1995 onwards edition.
4. Upadhyaya G. S. and R. K. Dube, 'Problems in Metallurgical Thermodynamics and kinetics', Latest edition Pergamon Press, 1977 onwards.
5. Kenneth M. Ralls, Thomas H. Courtney and John Wulff, 'Introduction to Materials Science and Engineering', Wiley Eastern Ltd., Latest edition.
6. W. Kurz and D. J. Fisher, 'Fundamentals of Solidification', Trans. Tech. Publication, Switzerland.
7. R. W. Balluffi, S. M. Allen and W. C. Carter, 'Kinetics of Materials', John Wiley.
8. G. Khachaturyan, 'Theory of Structural Transformation in Solids', Wiley Interscience Publishers.
9. M. Alper, 'Phase Diagrams: Material Science and Technology', Vol 6, Academic Press.
10. Alok Gupta and Chatterjee, 'Thermodynamics and Phase Equilibrium'

AM2121 Electrical, Electronic, Magnetic and Optical Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Classification of materials on the basis of energy gap, conductors, semiconductors, dielectrics, superconductors, ferroelectrics, pyroelectrics, piezoelectrics, perovskites (titanates, zirconates, hafnates) etc.

Electrical Properties and Conducting Materials: Mechanism of electrical conduction, electron theories of solids, free electron theory, factors affecting electrical conductivity, Wiedemana-franz law, Lorentz number, thermoelectric properties, characteristics, properties and examples of high voltage conducting materials, high and low resistance materials, contact fuse and fuse materials. conductors, cable & wire materials, solder, sheathing, and sealing materials, electrical properties of these materials, related calculations.

Electronic Properties and Semiconducting Materials: Energy band theory, Brillouin zone theory, Fermi energy level, effective mass, concept of doping, energy diagrams, types of semiconductors, semiconductor compounds and alloys and their properties. structures of semiconductors, amorphous semiconductor, materials for different devices, related calculations.

Superconductivity and Superconducting Materials: Concept of superconductivity, Phenomenon, properties of superconductors, Meissner effect, critical magnetic field & critical temperature, types of superconducting materials, Type I & II superconductors, Silsbee rule, mechanism of superconduction. BCS theory, Debye temperature. London's & Glag theories, high temperature ceramic superconductors, applications: NMR, maglev, MHD etc., recent advances, related calculations.

Dielectric Properties and Insulating Materials: Dielectric constant, dielectric strength and dielectric loss, polarizability, mechanism of polarization, factors affecting polarization, polarization curve and hysteresis loop, types of dielectric materials-solid, liquid and gaseous types; natural and synthetic types, characteristic, properties, and applications of different types of mica, transformation oil, vacuum etc., ferroelectrics, piezoelectric, pyroelectrics, electrostriction effect, Clausius -Mosotti equation, related calculations.

Magnetic Properties and Magnetic Materials: Origin of magnetism, basic terms and properties, types of magnetic materials, introduction to dia, para, ferro, antiferro and ferrimagnetic materials, Curie temperature, laws of magnetic materials, domain theory, domain growth and domain wall rotation, magnetic anisotropy, magnetostriction & its mechanism, ferrites, spinels & garnets, ferromagnetic domains, magnetic hystersis. magnetoplumbite, hexaferrite, magnetic hysteresis loop, hysteresis loss, hard and soft magnetic materials, magnetic tape, magnetic bubble, magnetic glasses, high energy hard magnetic materials, commercial magnetic materials such as supermalloy, alnico, cunife, cunico etc., conventional and non-conventional applications, characterisation of magnetic materials, recent developments, related calculations.

Optical and Optoelectronic Materials: Optical properties, solar cell, principles of photoconductivity, effect of impurities, principles of luminescence, types; semiconductor lasers; LED materials, photoelectronic materials, effect of composition on band gap, LCD materials, photo detectors, application of photoelectronic materials, introduction to optical fibers, light propagation, electro-optic effect, Kerr effect.

Recent Advances. Developments and Researches: Spintronics: materials and devices, diamond semiconductors, ferromagnetic semiconductors, giant magneto- resistance (GMR), left handed materials, left and right handed (LH & RH) composite materials, diluted magnetic semiconductor etc.

Fabrication of Electronic and Opto-electronic Devices: Methods of crystal growth, zone refining.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Electrical Properties of Materials, L. Solymar, D. Walsh, Oxford University Press, USA.
2. Introduction to the Electronic Properties of Materials, David C. Jiles, Taylor and Francis.
3. Introduction to Magnetism and Magnetic Materials, D.C. Jiles, Springer.
4. Optoelectronic Materials and Device Concepts, Manijeh Razeghi, SPIE-International Society for Optical Engine.
5. Structure and Properties of Materials Volume IV, Rose R. M., Shepard L. A., Wulff J.
6. Electrical and Electronics Engineering Materials, 4th Edition, K.M. Gupta,Umesh Publication, Delhi.
7. Introduction to Magnetic Materials, B. D. Cullity, Addison-Wesley Publishing Company, California, London, 1972.

8. Modem Ferrite Technology, A. Goldman, Van Nostrand, New York, 1990.
9. Magnetism and Magnetic Materials, J. P. Jakubovics, Institute of Materials, London, 1994.
10. Physics of Dielectric Materials, Tareev B.,MIR, 1975.
11. Electronic Properties of Materials, Rolf E. Hummel, Springer, 2004.
12. Principles of Electronic Materials and Devices, Safa O. Kasap, McGraw-Hili, 2005.
13. Electronic Materials Science, Irene, Wiley-Interscience, 2006.
14. Smart Electronic Materials: Fundamentals and Applications, Jasprit Singh, Cambridge University Press, 2005.
15. Principles and Applications of Ferroelectrics and Related Materials, M. E. Lines, A. M. Glass, Oxford University Press, USA, 2001.
16. Solid State Physics, Dekker A. J. Macmillan India, 1995.
17. Modem Magnetic Materials: Principles and Applications, Robert C., O' Handley, Wiley-Interscience, 1999.

AM2122 Polymer Science & Engineering		
Designation	:	Elective
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Chemistry of Polymers: Monomers, functionality, degree of polymerizations, classification of polymers, criteria for rubberiness, polymerization methods: addition and condensation; their kinetics, copolymerization, monomer reactivity ratios and its significance, different copolymers, random, alternating, azeotropic copolymerization, block and graft copolymers, techniques for copolymerization-bulk, solution, suspension, emulsion. molecular weight and size of polymers, glass transition temperature and associated properties for polymers, kinetics of polymerization, crystalinity in polymers.

Polymer Characterization: Solubility and swelling, concept of average molecular weight, determination of number average, weight average, viscosity average and Z-average molecular weights, polymer crystallinity, analysis of polymers using IR, XRD, thermal (DSC, DMTA, TGA), microscopic (optical and electronic) techniques.

Synthesis and Properties: Commodity and general purpose thermoplastics: PE, PP, PS, PVC, Polyesters, Acrylic, PU polymers. Engineering Plastics: Nylon, PC, PBT, PSU, PPO, ABS, Fluoropolymers Thermosetting polymers: PF, MF, UF, Epoxy, Unsaturated polyester, Alkyds. Natural and synthetic rubbers: Recovery of NR hydrocarbon from latex, SBR, Nitrile, CR, CSM, EPDM, IIR, BR, Silicone, TPE.

Polymer Blends and Composites: Difference between blends and composites their significance, choice of polymers for blending, blend miscibility-miscible and immiscible blends, thermodynamics, phase morphology, polymer alloys, polymer eutectics, plastic-plastic, rubber-plastic and rubber-rubber blends, FRP, particulate, long and short fibre reinforced composites. Polymer Technology: Polymer compounding-need and significance, different compounding ingredients for rubber and plastics, cross-linking and vulcanization, vulcanization kinetics.

Polymer Rheology: Flow of Newtonian and non-Newtonian fluids, different flow equations, dependence of shear modulus on temperature, molecular/segmental deformations at different zones and transitions, measurements of rheological parameters by capillary rotating, parallel plate, cone-plate rheometer, viscoelasticity-creep and stress relaxations, mechanical models, control of rheological characteristics through compounding, rubber curing in parallel plate viscometer, ODR and MDR.

Polymer Processing: Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.

Polymer Testing: Mechanical-static and dynamic tensile, flexural, compressive, abrasion, endurance, fatigue, hardness, tear, resilience, impact, toughness. Conductivity-thermal and electrical, dielectric constant, dissipation factor, power factor, electric resistance, surface resistivity, volume resistivity, swelling, ageing resistance, environmental stress cracking resistance. ASTM codes for polymer testing.

Degradation of Polymers: Effects of vapours and solvents on polymeric materials, oxidation, mechanical, photodegradation and thermal degradation of polymers, compatibility, solubility, permeability, radiation damage and chemical resistance of polymers.

Processing of polymers: Flow properties of polymers, extrusion, injection and blow moulding, calendering, vacuum and pressure forming and warm forging, casting of fibres and filaments, assembly by adhesion, thermal and mechanical bonding, control of properties like chain length, molecular weight distribution etc.

Heat Treatment: Standard heat treatment procedures for polymers.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Polymer Science, Vasant R. Gowariker, N. V. Viswanathan & Jayadev Sreedhar.
2. Encyclopedia of Polymer Science and Technology, Herman F. Mark.
3. Essentials of Polymer Science and Engineering, Paul C. Painter and Michael M. Coleman.
4. Physical Properties of Polymers, James Mark, Kia Ngai, William Graessley, Leo Mandelkern, Edward Samulski, Jack Koenig, George Wignall.
5. Plastics Engineering, R. J. Crawford, Pergamon Press.
6. Text Book of Polymer Science, Billmeyer, John Wiley & Sons.
7. Polymer Physics, Ulf W. Gedde, Chapman & Hall

AM2123 Mechanical Behavior of Materials		
Designation	:	Elective
Pre-requisites	:	Strength of Materials, linear Algebra
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Overview: Different responses of material to loading, material properties, macroscopic experiments and its relevance, physical mechanisms controlling the behavior.

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, safe-life, 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 Characterization of Materials: Mechanical testing for material Characterization, Measurement techniques in experimental solid mechanics, Non destructive testing

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Norman E. Dowling, Mechanical behavior of materials : Engineering Methods for Deformation, Fracture and Fatigue, Prentice Hall.
2. Marc Meyers and Krishnan K. Chawla, Mechanical behavior of materials, Cambridge University Press.
3. William F. Hosford, Mechanical behavior of materials, Cambridge University Press.
4. Thomas H. Courtney, Mechanical behavior of materials, Overseas Press.
5. Joachim Roesler, Harald Harders, and Martin Baeker, Mechanical Behavior of Engineering Materials, Springer.
6. Prashant Kumar, Elements of fracture mechanics, Tata McGraw Hill.
7. S. Suresh, Fatigue of Materials, Cambridge University Press
8. RW Hertzberg, Deformation and Fracture Mechanics of Engineering Materials, John Wiley & Sons.
9. D. Hull, DA Bacon, Introduction to dislocations, Pergamon.
10. G. E. Dieter, Mechanical Metallurgy, McGraw Hill.

AM2124 Ceramic Technology		
Designation	:	Elective
Pre-requisites	:	Basic Material Science and Engineering
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Introduction, history, types and nature, conventional ceramics, applications, bonding, crystallography, etc.

Structure of Ceramics: Lattice points, directions, and planes, basic structures, silicates, silica, glass, ceramic oxides, perovskite structure, etc.

Defects in Ceramics: Point defects, linear defects, planar (surface) defects, interfaces, and non-equilibrium structure.

Properties of Ceramics: Mechanical properties, thermal properties, electrical properties, optical properties, magnetic properties, failure modes in ceramics, property structure relationship.

Ceramic Phase Diagrams and Phase Equilibrium: Law of partial pressures, determination of phase diagrams, uniary (carbon, SiO_2), binary (NiO/CoO, MgO/CaO, $MgO/MgAl_2O_4/Al_2O_3$, BeO/Al_2O_3, MgO/TiO_2), ternary ($MgO/Al_2O_3/SiO_2$, $CaO/Al_2O_3/SiO_2$, $Na_2O/CaO/SiO_2$), and quaternary ($SiO_2–Al_2O_3–AlN–Si_3N_4$) systems.

Processing: Powder synthesis and sintering, glass forming processes, drawing, hot & cold pressing, fibre forming, blowing, powder crushing, slip casting, hydro plastic forming, extrusion, centring, jiggering, sol-gel processing, anvil technologies, ceramic coating, fusion casting, dyeing and firing, gas phase, liquid phase, solid phase ceramic fabrication processes, CVD, directed metal oxidation, reaction bonding, polymerisation, metal casting, ceramic-composite processing, etc.

Bioceramics: Introduction, history, and uses, biological properties, processing of bioceramics, etc.

Ceramics Environmental Impact: Life cycle assessment of ceramics, emissions and consumptions, case studies.

Advanced Ceramics and their Applications: Toughened ceramics, cermets, functionally graded materials, piezoelectric ceramics, ceramic magnets, high temperature super-conducting magnets, glass ceramic composites, chemically bonded ceramics, ceramics in electrical applications, electro ceramics, etc.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

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. Series in Materials Science and Engineering – Fundamentals of Ceramics, Michel W. Barsoum, Institute of Physics Publishing, Bristol and Philadelphia.
6. Phase Equilibria and Crystallography of Ceramic Oxides, Journal of Research of the National Institute of Standards and Technology, Volume 106, Number 6, November–December 2001.
7. Electronic Ceramics, IEEE transactions.
8. Ceramic Processing and Sintering, M. N. Rahman, Marcel Dekker, Inc./CRC Press.

AM2125 Non-Destructive Testing		
Designation	:	Elective
Pre-requisites	:	Physics
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).

Syllabus

Overview of NDT: NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT, Visual inspection Unaided and aided.

Surface NDE methods: Liquid Penetrant Testing – Principles, Types and properties of liquid penetrants, Developers, Advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, Inspection materials Magnetisation methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing (ET): Thermography- Principles, Contact and non contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation – infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing- generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

Ultrasonic testing (UT) and acoustic emission (AE): Ultrasonic Testing-Principle, Transducers, Transmission and pulse-echo method, Straight beam and angle beam, Instrumentation, Data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique, AE parameters, Applications

Radiography (RT): Principle, Interaction of X-Ray with matter, Imaging, film and film less techniques, Types and use of filters and screens, Geometric factors, Inverse square law, Characteristics of films – graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Baldev Raj, T.Jayakumar, M.Thavasimuthu, 'Practical Non-Destructive Testing', Narosa Publishing House, 2009.
2. Ravi Prakash, 'Non-Destructive Testing Techniques', 1st revised edition, New Age International Publishers, 2010.
3. 'ASM Metals Handbook, Non-Destructive Evaluation and Quality Control', American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4. Paul E Mix, 'Introduction to Non-destructive testing: a training guide', Wiley, 2nd Edition New Jersey, 2005.
5. Charles, J. Hellier, 'Handbook of Nondestructive evaluation', McGraw Hill, New York 2001.
6. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, 'NDT Handbook Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing'.

AM2126 Nanomaterials		
Designation	:	Elective
Pre-requisites	:	Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction to Nanotechnology: Nano technology, nano science, MEMS, CNT, fullerene, nano machines, semiconductor technology etc.

Solid State Physics: Introduction, structure (physics of solid state), FCC nanoparticle, semiconductor structures lattice vibration, energy band, reciprocal space, fermi surfaces, localized particles, mobility, exciton, etc.

Methods of Measuring Properties: Measurement methods, structure – atomic, crystallography, particle size, mass spectroscopy, LEED, RHEED, surface structures, microscopy – TEM, SEM, FIM, AFM etc.

Properties of Nanoparticles: Properties of nano-particles, metal nano-clusters, semi conducting nano-particles, semi conducting nano-particles, rare gas & molecular clusters, methods of synthesis.

Carbon Nanostructures: Carbon nano-structures, carbon-molecule, carbon clusters, C_{60}, $C_{20}H_{20}$, C_8H_8, CNT, applications.

Bulk Nanostructured Materials: Solid disordered nanostructures: synthesis, failure, mechanical properties, multilayers, electrical properties, other properties, composite glasses, porous silicon, nanostructured crystals: natural crystals, array in zeolites, metal nanoparticles, photonic crystals.

Nanostructured Ferromagnetism: Basic, para, ferro, ferri, antiferro-magnetism, effect of bilk nanostructuring on magnetic properties, dynamics of nanomagnets, nanopore containment, nanocarbon ferromagnets, giant and colossal magnetoresistance, ferrofluids.

Quantum Nanostructure, Self Assembly and Deposition: Quantum wells, wires and dots, preparation, size effect, single electron tunneling, etc., monolayer, multiplayer, LB film deposition, CVD, PVD, sputtering etc.

Homework: Report on history & current status of nanotechnology, nanomanufacuring, nanomachines, etc.

Project: Small research project summarized in a four-page write-up on the nano-fabrication, nanodevice (abstract style). One presentation based on the research work of any paper of your choice in the field of nanoscience and nanotechnology, visits to various labs.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Introduction to Nanotechnology, C. P. Poole Jr. and F. J. Owens, Wiley Inter Science.
2. Nano Structures and Nano Materials: Synthesis, Properties and Applications, Guozhong Cao- Imperial College Press.
3. Nanomaterials, A. K. Bandyopadhyay, Newage International (p) Limited.
4. Nanostructured Materials Processing, Properties and Applications, Carl C Koch, Jaico Publishing House.
5. Nanotechnology, William Illsey Atkinson, Jaico Publishing House.

Semester-II

AM2202 Characterization of Materials		
Designation	:	Compulsory
Pre-requisites	:	Basic Materials Science and Engineering at UG Level
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Crystallography: Overviews in bonding, Bravais lattices, Miller indices, imperfections in crystals, crystal structures of common metal, ceramics, polymers. symmetries in crystals, point groups, space groups, reciprocal lattice, morphology

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, stereographic projection, pole figure, preferred orientation (texture analysis) and chemical analysis, profile fitting and Rietveld analysis.

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, polarized light microscopy, hot-stage microscopy, sample preparation.

Electron Microscopy: Electron sources, electron diffraction, principles and operation of scanning electron microscope. Construction 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 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.

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), X-ray Fluorescence (XRF), Nuclear Magnetic Resonance (NMR), Extended X-ray Absorption Fine Structure (EXAFS).

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Crystals and Crystal structures, R.J.D. Tilley, John Wiley and Sons, 2006
2. Elements of X-ray Diffraction, Cullity B. D., Addison-Wesley Publishing Co.
3. Electron Microscopy and Analysis, P.J. Goodhew, F.J. Humphreys, Taylor & francis, Second edition.
4. Solid state chemistry and its Applications, Antony R. West, Wiley Student Edition.
5. Fundamentals of Molecular spectroscopy, Colin N. Banwell and Elaine M. McCash, Tat McGraw-Hill Publishing Co. Ltd., Fourth edition.
6. Materials Characterization :Introduction to Microscopic and Spectroscopic, Yang Leng, John Wiley&Sons.

AM2203 Bio-Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

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.

Recent advances in the field of Biomaterials.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

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.

AM2213 Mechanics of Composite Materials		
Designation	:	Elective
Pre-requisites	:	Continuum Mechanics / Solid Mechanics, Basic Engineering Mathematics, Linear Algebra, Differential Equations
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: Classification and characteristics of composites, Conventional vs. Composite materials, Advantages and limitations, Salient applications in various fields, Fabrication technologies, Properties of matrix and reinforcement materials

Micromechanics: Fiber volume fraction, micro-mechanical relations, determination of strength and stiffness, Environmental effects-Hygro-thermal behavior.

Macromechanics: Basic stress-strain relationships for anisotropic materials, engineering constants for orthotropic materials, stress-strain relations for a lamina of arbitrary orientation, effective moduli, invariant properties of anorthotropic lamina, special cases of laminate stiffness, laminate strength analysis, concept of inter-laminar stresses and delamination

Failure theories and Damage mechanics: Failure mechanisms, maximum stress theory, maximum strain theory, Tsai-Hill theory, Tensor polynomial failure criterion, first ply failure theory, Introduction to damage theory based on continuum damage mechanics.

References books

1. Carl T. Herakovich, Mechanics of fibrous composites, John wiley & sons.
2. R. F. Gibson, Principles of Composite Material Mechanics, McGraw Hill Inc.
3. R. M. Jones, Mechanics of Composite Materials.
4. Stephen W.Tsai and H. Thomas Hahn, Introduction to Composite Material.
5. J. R. Vinson and T.W. Chou, Composite Materials and their use in Structures.
6. 6.J. N. Reddy and A.V. Krishna Moorty, Composite Structures, Testing, Analysis and Design.
7. 7.D. Gay, S. V. Hoa, S. W. Tsai, Composite Materials - Design and Applications, CRC Press

AM2218 Continuum Damage Mechanics		
Designation	:	Elective
Pre-requisites	:	Continuum Mechanics, Linear Algebra, Differential Equations
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Essentials of Continuum mechanics: Tensorial notation, stress, strain, invariants, equilibrium equations, Domain and validity of continuum damage mechanics, concept of representative volume element.

Phenomenological aspects of damage: Damage, measurement of damage, modeling of damage through effective area reduction, void volume fraction and stiffness reduction, representation of damage through different orders of tensors, concept of effective stress, hypothesis of strain equivalence, strain energy equivalence, and complementary strain energy equivalence.

Thermodynamics of damage: State variables, damage as state variables, first and second law of thermodynamics, thermodynamics potentials, dissipation potentials, constitutive equations, evolution equations.

Kinetic Laws of Damage Evolution: Unified formulation of damage laws, damage laws for brittle, quasi-brittle, ductile, creep, low cycle and high cycle fatigue.

Damage Analysis of Structures: Implementation of isotropic damage theory, case studies from literature.

References books

1. Jean Lemaitre, A Course on damage mechanics, Springer.
2. S. Murakami, Continuum damage mechanics, Springer.
3. Jean Lemaitre and J. L. Chaboche, Mechanics of solid materials.
4. L. M. Kachanov, An Introduction to damage mechanics, Kluwer Academic publisher.
5. P. I. Kattan and G. Z. Voyiadjis, Damage mechanics with finite elements, Springer
6. Dusan Krajcinovic, Damage mechanics, North Holland.
7. George Z. Voyiadjis and Peter I. Kattan, Damage mechanics, Taylor and Francis

AM2220 Computational Material Science		
Designation	:	Elective
Pre-requisites	:	Applied Mathematics and computation
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction and Fundamentals: Introduction to various regimes, multiscale modelling & simulation of materials, System size vs computation time, Parallel processing

Ab Initio Methods: Density functional theory, quantum mechanics, schrodinger wave equation, many particle system, car parrinello method, born openheimer approximation, hohenberg-kohn theorem, kohn sham formulation, local density approximation, bloch's theorem, pseudo potential, energy minimisation techniques, examples of crystals and non-crystals.

Lattice Mesoscale methods: Lattice gas automata, lattice director model.

Coarse graining: Particle based models-Lattice gas model, connolly williams approximation, spatial models, dynamic (temporal) models, application to polymer and polar materials. grain continuum modelling, computational micro-mechanics, multiscale coupling.

Term Paper on application of Multiscale Modelling to Composite damage, Dislocation behavior, Phase field modeling, Modelling of grain growth and microstructure in polycrystalline materials, Modelling of structural materials And other recent advances based on literature survey

Term paper on material modeling.

References books

1. Introduction to Materials Modelling, Ed Zoe H. Barber, Maney Publishing.
2. Computational Material Science From Ab Initio to Monte Carlo Methods, K. Ohno, K.Esfarjani, Y. Kawazoe, Springer.
3. Multiscale Materials Modelling: Fundamentals and Applications, Ed Z Xiao Guo, Woodhead Publishing Limited, Cambridge.
4. Computational Meso-mechanics of Composites, Leon Mishnaevsky, Jr., John Wiley & Sons.
5. Multi-scale modelling of Composite Material Systems, C. Soutis & P. W. R. Beaumont Woodhead Publishing Ltd.
6. Continuum Scale Simulation of Engineering Materials-Fundamentals, Microstructures, Process Applications, Dierk Rabbe, Barlat,Wiley.
7. Annual Review of Materials Research on Computational Materials Research, Vol 32.
8. Understanding Molecular Simulation- from Algorithm to Application, Frenkel Daan, Smit Berend. Academic Press.
9. Notes of Workshop on Computational Materials Science, Indian Institute of Sciences, Bangalore, 06-08 Mar 2009.
10. Computational Material Science, Dierk Raabe, Wiley-VCH Verlag GmbH
11. Multiscale Modelling & Simulation, Attringer & Coumoutsakos, Springer
12. Computational Materials Design, Tetsuya, Springer
13. Combinatorial Material Science, Balaji narasimhan, Surya K Mallaprajada, Wiley
14. Materials Informatics, Data-Driven Discovery in Material Sc, Krishana Rajan, Wiley.

AM2221 Energy Materials		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Nuclear Metallurgy: Structures and properties of materials with special relevance for nuclear power generation: uranium and other actinides, beryllium, zirconium, rare-earth elements, graphite. The materials of nuclear fuels and nuclear fuel element fabrication. Reprocessing of nuclear fuel elements.

Nuclear Power Plant and Their Materials: Nuclear reactor, pressurised reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding.

Effects of Radiation on Materials Properties: Effects of α,β, γ rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials, Effects on crystal structure, grain size etc.

Materials in Fuel cells and Solar Cells Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic.

Materials in Thermal Power Generation Superalloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, flyash, etc.

Materials in Hydro Power Generation Materials for power plant components, steel, stainless steel, ceramics, etc.

Energy storage Artificial photosynthesis/solar to fuels, CO2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economic.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Introduction to Nuclear Science, Bryan, J. C., CRC Press.
2. Fundamentals of Radiation Materials Science, G.S. Was, Springer
3. Nuclear Reactor Materials and Applications, B.M. Ma, Van Nostrand Reinhold Company.
4. Nuclear Reactor Materials, C.O. Smith, Addison-Wesley Publishing Company.
5. Fundamentals Aspects of Nuclear Fuel Elements, D.R. Olander,
6. Structural Materials in Nuclear Power Systems, J. T. A. Roberts, Plenum Press.
7. Handbook of Fuel Cells, Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.
8. Advanced power plant materials, design and technology, Edited by D Roddy, Woodhead Publishing Series in Energy No. 5 and CRC Press

AM2222 Carbon Nanotube and Carbon Nanostructures		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc).

Syllabus

Introduction to Carbon Nanostructure: Carbon molecule, carbon small clusters, carbon big clusters, fullerenes, discovery of $C_{60,}$ synthesis of C_{60}, properties of C_{60}, other buckeyballs, CNT.

CNT Morphology: From a graphene sheet to a nanotube, structure - chiral nanotubes, singlewall, multiwall and bundled nanotubes, zigzag and armchair nanotubes, Euler's Theorem in cylindrical and defective nanotubes.

Production Techniques of Nanotubes: Growth of single-wall/multiwall nanotubes, carbon arc bulk synthesis in presence and absence of catalysts, high purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite, high-pressure co-conversion (HIPCO), nanotube synthesis based on Boudoir reaction-chemical vapor deposition (CVD), laser ablation, synthesis of aligned nanotube films.

Structural, Electronic Properties: Structural changes in free standing and interacting nanotubes – librations, rotations, twistons, effect of inter tube interactions on the electronic structure, electronic structure of graphite as building block of nanotubes, effect of chirality and discrete atoms, conducting versus insulating nanotubes, band structure of metallic carbon nanotubes, effect of doping on conductivity, electrical properties, vibrational properties, chemical properties, mechanical properties, physical properties, optical properties.

Applications of Nanotubes Harnessing field enhancement, flat panel displays, hydrogen storage, carbon nanotubes & drug delivery, structural application of CNTs, CNT nanocomposites.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Carbon Nanotubes, M. Endo, S. Iijima, M. S. Dresselhaus, Pergamon.
2. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus, Springer.
3. Carbon Nanostructures, Springer.
4. Physics of Carbon Nanostructures, Stefano Bellucci, Alexander Malesevic, Springer.
5. Fullerenes, Nanotubes, and Carbon Nanostructures, F. D'Souza, P. Kamat, N. Martin, R. Weisman, S. Rotkin, H. Shinohara, Z. Slanina, Y. Iwasa, L. Wilson, N. Solladie: ECS Transactions: Vol 6, Issue 16.
6. Carbon Nanotube and Graphene Device Physics, H.-S. Philip Wong and Deji Akinwande, Cambridge University Press, 2011.

AM2223 MEMS & Bio-MEMS		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction: MEMS, microsystem, sensor, actuator, history, market, applications, etc.

Review of Essential Mechanical, Electrical Concepts: Mechanical: stress, strain, beam, cantilever, plates, bending, thermal stress, torsion of beam, fracture, vibration etc, Electrical: Conductor, insulator, semiconductor.

Scaling Laws in Miniaturization: Scaling in geometry, force, electricity, fluid, heat transfer, etc.

Material for MEMS: Review of crystal structure, miller indices, material for MEMS, substrate, device, packaging, silicon, silicon compound, gallium arsenide, piezoelectric martial, quartz, polymer, biomaterials and biocompatibility issues etc.

Micro Total Analysis System (µTAS): Fluid control components, µ-TAS: sample handling, µ-TAS: separation components, µ-TAS: detection, cell handling and characterization systems, systems for biotechnology and PCR, polynucleotide arrays and genetic screening.

Sensing and Actuation: Electrostatic sensing and actuation, thermal sensing and actuation, piezoelectric and piezoresistive sensing and actuation, magnetic sensing and actuation, miniature biosensors, biosensors arrays and implantable devices, neural interfaces, microsurgical tools, micro needles, and drug delivery, Microsystems for tissue engineering, tissue scaffolds, optical biosensors, etc.

Fabrication of MEMS: Bulk micromachining, surface micromachining, lithography, LIGA, SLIGA, etc.

MEMS Packaging: MEMS metrology, Overview of packaging of microelectronics, packaging design, technique, material, etc.

MEMS Design and Software: Design methodologies for MEMS, study of following softwares based on availability: Ansys multiphysics, COMSOL multiphysics, MatLab, Intellisuite, AutoCAD, SolidWorks, Spice, Ledit, etc.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Foundations of MEMS, Chang Liu, Pearson Education International.
2. MEMS and MICROSYSTEM Design and Manufacture, Tai-Ran Hsu, Tata Mcgraw-Hill Publishing Company Ltd., New Delhi.
3. Microsystem Design, S. D. Senturia, Kluwer Academic Publishers.
4. Fundamentals of Microfabrication, Marc Madou, CRC Press, NY.
5. Microsystem Technology in Chemistry and Life Sciences, A. Manz and H. Becker, Eds. Springer-Verlag, New York.
6. Fundamentals of Micro Fabrication, the Science of Miniaturization, M. Madou, Nanogen Corporation, USA, CRC Press.

AM2224 Electroacoustic Transducers		
Designation	:	Elective
Pre-requisites	:	None
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc)

Syllabus

Introduction to Acoustics: Acoustic variables & basic relations, plane & spherical waves, reflection & transmission, radiation & reception of acoustic waves, absorption and attenuation of sound.

Electro-Mechano-Acoustical Analogy: Introduction, basic equations and impedances, transformer and gyrator, simple harmonic oscillator, Helmholtz resonator, loop analysis, circuit elements, Lagrange equation.

Acoustical Elements: Basic acoustic elements, specific acoustic impedance, mechanical impedance, electrical impedance, acoustic radiation impedance, duct impedance, equivalent circuit model, various acoustical examples, frequency and wavelength, dB scale, sound pressure level.

Basic Theory and Modeling of Microphone: Introduction, types, response, sensitivity, specifications, directivity pattern, microphone array, microphone equation, electret condenser microphone (ECM), ECM model for various types of microphone.

Basic Theory and Modeling of Moving Coil Transducer: Introduction, types, reciprocal and anti-reciprocal system, TS parameters, speaker non-linearities, equivalent circuit representation, loudspeaker enclosure, types of loudspeaker enclosure and corresponding circuits, total harmonic distortion, intermodulation distortion, miniature loudspeaker.

Theory and Analysis of Piezoelectric Transducer: Brief introduction to piezoelectricity, piezoelectric materials, piezoelectric devices, polarization, equivalent circuit, piezoelectric accelerometer, piezoelectric speaker, piezoelectric microphone.

Term Paper: On recent advances based on literature survey and/or lab/industry visit.

References books

1. Acoustics, L. L. Beranek, Acoustical Society of America.
2. Introduction to Electro acoustics and Amplifier Design, W. M. Leach, Kendall Hunt Publishing Company.
3. Acoustics-An Introduction, H. Kuttruff, Taylor & Francis.
4. Fundamentals of Acoustics, Kinsler, Frey, Coppens, and Sanders, John Wiley and Sons.
5. Audio Engineer's Reference Book, Edited by Michael Talbot-Smith, Focal Press.

AM2225 Materials in Service		
Designation	:	Elective
Pre-requisites	:	Material Science, Chemistry
Credit and Contact hrs	:	4(L) - 0(T) – 0(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 60 marks Mid Semester Exam: 20 marks
		Internal Assessment: (Scheme) 20 marks (5 marks for attendance + 15 marks for assignment submission, Surprise Tests, Term paper etc.)

Syllabus

Tribology: Components of tribology; Wear, Friction and Lubrication, Laws of friction, Measurement of Friction, Effect of viscosity, Effect of Temperature, Types of wear, Mechanism of wear, Degradation and strength loss of materials due to wear, Surface morphology, Advantage and Disadvantage of lubrication in various application. Preventive measures of wear loss, Methods of surface improvement

Corrosion: Thermodynamics of Corrosion; Free energy change, EMF and galvanic series, Pourbaix diagrams, Nernst equation. Electrochemical Theory; Corrosion rate, activation polarization, concentration polarization, anodic, cathodic, mixed control. Passivation, Tafel equation. Types of Corrosion; Different forms of corrosions-uniform, galvanic, crevice, pitting, intergranular, erosion-corrosion, SCC, hydrogen cracking, corrosion fatigue, fretting corrosion, effect of metallurgical variables and environments on different forms of corrosion. Corrosion Protection; Corrosion prevention methods-anodic protection, cathodic protection, inhibitors. Corrosion Testing; Electrochemical techniques-potentiostat, Tafel extrapolation, linear polarization, galvanostat, impedance spectroscopy. thermogravimetric technique, salt spray test, weight change measurements, corrosion and oxidation resisting materials. Hot Corrosion: High temperature oxidation of metals and alloys, laws governing oxidation, molten salt corrosion, liquid metal corrosion.

Structural Health Monitoring: Introduction, Motivation of SHM, SHM and Non Destructive technique, Passive and Active SHM, Vibration based Techniques for SHM, Damage localization and quantification, Fibre optic sensors, Electrical resistance based SHM, Low frequency Electromagnetic Techniques, Capacitive methods for SHM.

Term Paper: On recent advances based on literature survey and/or lab/industry visit

References books

1. Material Science for Engineers: An Introduction, W. D. Callister, Jr, John Wily and Sons, Inc.
2. G. E. Dieter, Mechanical Metallurgy, McGraw Hill
3. Bharat Bhushan, Introduction to Tribology, Wiley
4. Stachowiak, Wear: Materials, Mechanism and Practice
5. Principles and Prevention of Corrosion, Denny A. Jones, 2nd ed., Prentice-Hall, Inc.
6. Corrosion Engineering, Fontana M. G., and Greene N. D., McGraw Hill.
7. Corrosion and Corrosion Control, Uhlig H. H. and Revie R. W., 3rd Ed., John Wiley & Sons.
8. Corrosion, Metals Handbook, Vol.13 A & B, 9th ed., ASM.
9. The Fundamental of Corrosion, J. C. Scully, 2nd ed., Pergamon Press.
10. Fundamentals of Electrochemical Corrosion, E. E. Stansbury and R. A. Buchanan, ASM International
11. Structural Health Monitoring, edited by Daniel Balageas, Claus-Peter Fritgen and Alfredo Guemes

AM2252 Material Synthesis and Characterization Laboratory		
Designation	:	Compulsory
Pre-requisites	:	None
Credit and Contact hrs	:	0(L) - 0(T) – 6(P) – 4(Cr)
Assessment Methods	:	**Theory Examination: (Scheme)** End Semester Exam: 50 marks
		Internal Assessment: (Scheme) 50 marks (10 marks for attendance + 40 marks shall be for the day-to-day assessment of performance in the all the Lab Sessions evaluated through daily preparedness for conducting Experiments, participation in conduct of Experiments, Report Writing and submission, Interaction, Sincerity, Attendance and Quizzes.

Project	**Details**
1.	Synthesis and characterization of given composition by sol gel, hydrothermal and solid state route.
2.	Role of metallurgical process (e.g. heat treatment processes) on micro-structural and mechanical properties of given alloy
3.	Fabrication and mechanical behavior of any composite
4.	Design and simulation of material using any commercial software
Reference	1. Books and Research articles through referred journals.