

Detailed Syllabi for the M.Tech. Programme in

**MATERIAL SCIENCE AND
TECHNOLOGY**

(With Effect from the Academic Year 2006)

MEE601 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
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Module I (10 hours)

Concepts of crystals, Plastic deformation by slip and twinning, Slip systems in FCC, BCC and HCP lattices, Critical resolved shear stress for slip, Theoretical shear strength of solids, Stacking faults and deformation bands. Observation of dislocations, Climb and cross slip, Dislocations in FCC and HCP lattice, Partial dislocations, Stress fields and energies of dislocations, Forces between dislocations, Interaction of dislocations, Dislocation sources and their multiplications.

Module II (10 hours)

Strengthening from grain boundaries, Grain size measurements, Yield point phenomenon, Strain aging, Solid solution strengthening, Strengthening from fine particles, Fiber strengthening, Cold working and strain hardening, Annealing of cold worked metal. Fracture in metals, Griffith theory of brittle fracture, Metallographic aspects of fracture, Fractography, Dislocation theories of brittle fracture, Ductile fracture, Notch effects, Strain energy release rate in fracture, Fracture toughness and design.

Module III (10 hours)

Fatigue of metals, The S-N curve, Low cycle fatigue, Fatigue crack propagation, Effect of stress concentration on fatigue, Size effect, Surface effects and fatigue, Fatigue under combined stresses, Effects of metallurgical variables and fatigue, Corrosion fatigue, Design for fatigue, Effect of temperature on fatigue. Creep and stress rupture, Creep curve, Stress rupture test, Mechanism of creep deformation, Activation energy for steady state creep, Superplasticity, Fracture at elevated temperature, Creep resistant alloys, Creep under combined stresses.

Module IV (10 hours)

Tension test, Stress-strain curves, Instability in tension, Ductility measurement, Effect of strain rate, temperature and testing machine on flow properties, Stress relaxation testing, Notch tensile test, Anisotropy of tensile properties. Hardness test, Brinell, Rockwell and Vickers hardness, flow of metal under the indenter, relationship between hardness and flow curve, micro hardness testing, Hardness at elevated temperatures.

Text Book: Dieter M. George, Mechanical Metallurgy, McGraw- Hill Inc., 2001.

References:

1. Deformation and fracture mechanics, Richard W Hertzberg John Wiley & Sons
2. Mechanical behaviour of Materials, Frank A McCLINOCK and ALI S ARGON
3. Physical Metallurgy Principles, Reed Hill and Robert E, East West Press
4. Structure and properties of Materials, Hyden W. M. Vol. 3, McGraw Hill
5. Plastic deformation of Metals, Honeycombe, Arnold Press.

* L: Lecture; T: Tutorial; P: Practical; C: Credits

MEE602 FERROUS AND NON-FERROUS METALLURGY

L	T	P	C
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Module I (8 hours)

Ferrous Foundry:

Melting units – cupola and its operation – design of cupola – charge calculation – electric arc furnace and induction furnace – design, fabrication and control of composition – selection – recent developments.

Module II (8 hours)

Solidification of Metals:

General thermodynamic and kinetic considerations – rate of reaction – Arrhenius equation – activation energy – process of nucleation and growth – thermodynamical theory and nucleation – homogeneous and heterogeneous nucleation in solids – growth of new phase in solution – dendritic and cellular growth – freezing of ingots.

Module III (12 hours)

Cast Iron Metallurgy:

Details of various cast iron – casting characteristics and mechanical properties – effect of various elements in cast irons – trace elements – type of graphites – sizes – solidification – nucleators – cooling rate – growth process – inoculants in mould process – theory of inoculation – chill testing and composition control – effect of alloying elements – fluidity – inverse chill – sub-surface blow holes – dispersed shrinkage porosity – specification of cast iron – malleable iron – black heart – composition control – S. G. iron – production – properties – treatment and applications.

Module IV (12 hours)

Steel and Non-Ferrous Metallurgy:

Composition – structure – Fe-Fe C diagram – solidification process – effect of structure on properties – heat treatments of castings – liquid quench and temper – alloy steels – measurements of hardenability and its significance – production – heat treatment – solidification of steels.

General demand survey of non-ferrous metals and alloys - melting units – properties of liquid metal and their significance in foundry practice – oxidation – solution of gases in metals – fluidity – hot tear – shrinkage – grain refinement – modification – various types of defects in non-ferrous alloys – details of aluminium, copper and magnesium base alloys.

References

1. Solidification process – Flemings
2. Cupola practice and Cast Iron – A F S Publication
3. An Introduction to the Solidification of Metals – W. G. Winegard
4. Non Ferrous Foundry Metallurgy – Murphy
5. Metallurgy of Non Ferrous Metals – W. H. Dennis
6. Principles of Metal Casting – Geine, Loper & Rosenthal

SHA601 PHYSICS OF MATERIALS

L	T	P	C
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Module I (10 hours)

Quantum Mechanics – Introduction - Schrodinger's wave equation – significance of wave function – operators and expectation values – applications to a free particle, particle in a box, potential barriers, double well and multiple well problem, linear harmonic oscillator.

Module II (10 hours)

Electron theory of metals –free electron gas, conductivity, mobility – factors affecting resistivity -- quantised theory – Fermi Surface –thermal conductivity in metals– band theory of solids- Bloch theorem – Brillouin zones – nearly free electron model – density of state - Electron Dynamics in electric field and magnetic field - effective mass-determination of band structure

Module III (10 hours)

Dielectrics – mechanisms of polarization – polarisability and dielectric constant in static fields – changes in a.c. fields – dielectric loss -- breakdown mechanisms—ferroelectric materials – features -- domain theory.

Magnetic properties – ferromagnetism – features – domain theory

Module IV (10 hours)

Introduction to nanomaterials: Quantum size effect - Physics of quantum wells and superlattices - Properties and physics of carbon nanotubes and other onedimensional nanomaterials - Physics and properties of quantum dots and nanoclusters - typical synthesize methods – optical characterization – applications

TEXT & REFERENCE BOOKS

1. M A Omar, Elementary Solid State Physics, Addison Wesley
2. J S Blakemore, Solid State Physics, 2nd Edn., W.B Saunders Company, London
3. Gnther Schmid, Nanoparticles: From Theory to Application , Wiley and Son Inc.
4. Charles P. Poole Jr. and Frank J.Owens, Introduction to Nanotechnology, Wiley and Son Inc. New Jersey

MAG604 MATHEMATICAL METHODS

L	T	P	C
3	1	0	3

Module I (10 Hours)

Linear Algebra

Vector spaces, Basis, Dimension, Inner product spaces, Gram-Schmidt Process, Linear Transformations, Range and Kernel, Isomorphism, Matrix of transformations and Change of Basis.

Module II (10 Hours)

Series Solutions of ODE and Sturm-Liouville Theory

Power series solutions about ordinary point, Legendre equation and Legendre polynomials, Solutions about singular points; The method of Frobenius, Bessel equation and Bessel Functions. Sturm-Liouville problem and Generalized Fourier series.

Module III (10 Hours)

Partial Differential Equations

First order PDEs, Linear equations, Lagrange method, Cauchy method, Charpits method, Jacobi method. Second order PDEs, Classifications, Formulation and method of solutions of Wave equation, Heat equation and Laplace equation.

Module IV (10 Hours)

Tensor Calculus

Line, area and volume integrals, Spaces of N-dimensions, coordinate transformations, covariant and mixed tensors, fundamental operation with tensors, the line element and metric tensor, conjugate tensor, Christoffel's symbols, covariant derivative.

References

- 1 D. C. Lay: Linear Algebra and its Applications, Addison Wesley, 2003.
- 2 F. G. Florey: Elementary Linear Algebra with Application, Prentice Englewood, 1979.
- 3 K. Hoffman and R. Kunze: Linear Algebra P. H. I., 1971.
- 4 W. W. Bell: Special Functions for Scientist's and Engineers, Dover Publications, 2004.
- 5 Sokolnikoff and Redheffer – Mathematics of Physics and Engineering. 2nd edition. McGraw Hill, 1967.
- 6 Ian Sneddon, Elements of Partial Differential Equations, McGraw Hill International, 1985.
- 7 Tychonov & Samarski: Partial Differential Equations of Mathematical Physics, Holden-Day, San Francisco, 1964.
- 8 B. Spain: Tensor Calculus, Oliver and Boyd, 1965.
- 9 J. Irving and N. Mullineux: Mathematics in Physics and Engineering, Academic Press, 1959.
- 10 Shepley L Ross, Differential Equations, John Wiley & Sons, Third Edition, 2004.
- 11 L.A. Pipes and L.R. Harwill: Applied Mathematics for Engineers and Physicists, McGraw Hill, 1971.
- 12 M.A. Akivis and V.V Goldberg, An Introduction to Linear Algebra and Tensors, Dover Publications, 1997.

MEE621 THERMODYNAMICS OF MATERIALS

L	T	P	C
3	1	0	3

Module I (8 hours)

First Law of Thermodynamics, heat, work, heat capacity, enthalpy and internal energy, Hess' Law- and Second Law of Thermodynamics – Entropy and Criterion for Equilibrium – Statistical interpretation of entropy – Boltzmann equation.

Module II (10 hours)

Auxiliary Functions – Thermodynamic Relations – Maxwell's Equations – Gibbs - Helmholtz Equation – Examples – Heat capacity, enthalpy, entropy and the third law of Thermodynamics.

Phase Equilibrium in a One – Component System- Solid – Solid Equilibria – examples – Behaviour of gases – The van der Waals Gas – Non ideal gases – examples.

Module III (10 hours)

Behaviour of Solutions – Raoult's and Henry's Law, Gibbs – Duhem Equation – Non ideal solutions – Regular Solutions – Subregular Solutions – Examples.

Gibbs Free Energy – Composition and Phase Diagrams of Binary Systems – Criteria for Phase Stability – Phase Diagrams of Binary Systems.

Module IV (12 hours)

Reaction equilibrium in a Gas mixture and the equilibrium constant – Effect of Temperature and pressure – Reaction equilibrium in a system containing pure condensed phases and a Gas phase – Ellingham Diagrams – Effect of phase transformations – examples – Criteria for Reaction equilibrium in systems containing components in condensed solution – Gibbs Phase rule – Solubility of gases in metals – examples.

Electrochemistry – Formation Cells – Concentration Cells – Pourbaix Diagrams.

Text Book: Gaskell David R., Introduction to the Thermodynamics of Materials, 3rd ed., Taylor & Francis Publishers, 1995.

References:

1. David V. Ragone, Thermodynamics of Materials, Volume I, J. W. Wiley 1995.
2. Thermodynamics in Materials Science, By Robert T. DeHoff, McGraw-Hill, 1993.
3. Stoichiometry and Thermodynamic Computations in Metallurgical Processes, By. Y.K. Rao, Cambridge University Press, 1985.

MEE622 FURNACE AND HEAT TREATMENT TECHNOLOGY

L	T	P	C
3	1	0	3

Module I (10 hours)

Furnace: classification of furnaces based on heat sources – principles of design of recuperators and regenerators – furnace aerodynamics, heat transfer in furnaces – isothermal modelling of furnaces, heat balances.

Constructional and working features of blast furnace cupola, reverberatory, open hearth, crutibele – Induction and Arc furnaces.

Module II (10 hours)

Reheating furnaces – heat treatment furnaces - Materials of furnace construction, refractories and insulating materials – elements of furnace design – design of annealing furnace.

Module III (10 hours)

Heat Treatment: Heat Treatment of steels: Nucleation and growth of austenite on heating steel – Isothermal transformation of austenite to pearlite and bainite.

Annealing, normalising, tempering, marquenching and transforming – surface and case hardening of steels – hardenability and its usefulness.

Module IV (10 hours)

Cast Iron, Fe-C-Si diagram, Heat treatment of cast iron, white, malleable, spheroidal cast iron – alloy cast iron.

Aluminium alloys and age hardening copper alloys – reactive and refractory metals for high temperature service: Ti and Zr alloys, Ni and Co based super alloys heat treatment.

References

1. Industrial Furnaces – E. I. Kazantsev – Mr. Publications
2. Industrial Furnaces – Norton
3. Physical Metallurgy Principles – Reed Hill
4. Elements of Physical Metallurgy – A. G. Guy
5. Heat Treatment of Steel – Gregory and Simons
6. A S M Metals Hand Book Vol.2

SHA621 EXPERIMENTAL TECHNIQUES IN MATERIALS ENGINEERING

L	T	P	C
3	1	0	3

Module I:

X- ray diffraction -- Bragg's condition -- Laue treatment -- reciprocal lattice—intensity of diffracted beam -- crystal structure determination -- atomic scattering factor --geometrical structure factor for s.c, f.c.c and b.c.c structures -- experimental methods – Laue, rotating crystal and powder photograph methods – estimation of stress, texture and other defects -- electron diffraction -- neutron diffraction.

(10 hrs)

Module II:

Macro and micro examination of metals – specimen preparation -- qualitative and quantitative examination – optical microscopy – transmission and scanning electron microscopy.

(10 hrs)

Module III:

Atomic absorption spectroscopy –Activation technique – Mossbauer effect – resonance fluorescence – Temperature dependence -- applications of Mossbauer effect – isomer shift – quadrupole splitting – hyperfine splitting.

(10 hrs)

Module IV

Magnetic resonance – NMR – analysis of the phenomenon – experimental method – NMR spectra – applications – NQR – analysis of the phenomenon – NQR spectra – applications to study of deformed metals and crystalline electric field – ESR -- phenomenon – experimental study – ESR spectra – applications.

(10 hrs)

Text & Reference Books

1. Solid State Physics by S.O Pillai ,New Age International, 5th edn, 2001
2. Straughan and Walker, Spectroscopy – Vols. I & II, Chapman & Hall
3. R L Singhal, Solid State Physics, Kedar Nath Ram Nath & Co., Meerut, 7th edn, 2001.
4. Srivastava and Srinivasan, Science of Engineering Materials by Wiley Eastern Ltd., 1991.
5. Agrawal, Introduction to Engineering Materials, Tata McGraw -- Hill, 1988.

MEE623 NUCLEAR METALLURGY

L	T	P	C
3	1	0	3

Module I (12 hours)

Fundamentals of Nuclear Engineering, Radiation, Fission, Reactor and reactor elements, Fuel Rods, Manufacture of fuel rods, Extraction and fabrication techniques for uranium and thorium, Reprocessing of uranium oxide fuel elements.

Module II (8 hours)

Cladding Materials, Requirements of cladding material, Aluminium, Stainless steel and Zirconium alloys, their preparation and fabrication.

Module III (10 hours)

Coolant Materials, Use of liquid metals, liquid corrosion. Production and use of heavy water, beryllium, reactor grade graphite for reactor components, control rods.

Module IV (10 hours)

Reactor Vessels, Requirements and types of material used for containing vessel fabrication, Shielding Materials, Corrosion of reactor components, Radiation damage and its control.

References

1. J. C. Wright – Metallurgy of nuclear Metals.
Weinstein, Boltax and Langa – Nuclear Engineering Fundamentals

EEE623 ARTIFICIAL NEURAL NETWORKS AND FUZZY SYSTEMS

L	T	P	C
3	1	0	3

Module I (10hours)

Biological foundations, ANN models, Types of activation function, Introduction to Network architectures: Multi Layer Feed Forward Network (MLFFN), Radial Basis Function Network (RBFN), Recurring Neural Network (RNN)

Module II (10hours)

Learning process – Supervised and unsupervised learning – Error-correction learning, Hebbian learning, Boltzmen learning, Single layer and multilayer percepturs, Least mean square algorithm, Back propagation algorithm, Applications in forecasting and pattern recognition and other engineering problems.

Module III (10hours)

Fuzzy sets – Fuzzy set operations – Properties, Membership functions, Fuzzy to crisp conversion – fuzzification and defuzzification methods, applications in engineering problems.

Module IV (10hours)

Fuzzy control systems – Introduction, simple fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems – inverter pendulum – image processing – home heating system – Adaptive fuzzy systems, hybrid systems.

References

1. J.M. Zurada, “Introduction to artificial neural systems”, Jaico Publishers, 1992.
2. Simon Haykins, “Neural Networks – A comprehensive foundation”, Macmillan College, Proc, Con, Inc, New York, 1994.
3. D. Driankov, H. Hellendorn, M. Reinfrank, “Fuzzy Control – An Introduction”, Narora Publishing House, New Delhi, 1993.
4. H.J. Zimmermann, “Fuzzy set theory and its applications”, III Edition, Kluwer Academic Publishers, London.
5. G.J. Klir, Boyuan, “Fuzzy sets and fuzzy logic”, Prentice Hall of India (P) Ltd., 1997.
6. R. Babuska, “Fuzzy modeling for control”, Kluwer Publishers, Boston, 1998.
7. M. Browel & C. Harris, “Neuro fuzzy adaptive modeling and control”, Prentice Hall, New York, 1994.
8. Stamatios V Kartalopoulos, “Understanding neural networks and fuzzy logic – basic concepts and applications”, Prentice Hall of India (P) Ltd., New Delhi, 2000.
9. Timothy J. Ross, “Fuzzy logic with engineering applications”, McGraw Hill, New York.
10. David E. Goldberg, “Genetic algorithms in search optimization and machine learning”, Addison Wesely, 1987.

MEE691 MATERIALS SCIENCE & TECHNOLOGY LAB 1

L	T	P	C
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Specimen preparation and microstructure studies using Metallurgical and Scanning electron Microscope, Testing of metals –hardness, fatigue, Surface roughness measurement, study of Coordinate measuring machine, Metrology, NDT testing such as ultrasonic, die-penetrant and magnetic particle techniques, Testing of weldments. Use of software in materials engineering- Solid modeling exercises on advanced Softwares like ‘I-DEAS’ ‘Pro-Engineer’, ‘CATIA’, Exercises on finite element analysis using ANSYS and ABAQUS software.

MEE693 MATERIALS SCIENCE & TECHNOLOGY LAB II

L	T	P	C
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Sintering and heat treatment furnaces, Thermocouple calibration, Fabrication and testing of composites, Nanocomposites, Wear analysis, Welding of stainless steel, studies and experiments on Micro Machining Center ,Unconventional machining , Porosity studies, Study of solidification software such as Pro-Cast, computational design of gating system, Commercial CAD/CAM softwares.

MEE 611 COMPOSITE MATERIALS: MECHANICS, MANUFACTURING AND DESIGN

L	T	P	C
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Module-I

Introduction: Classification of composite materials and geometric morphology, advanced metal, ceramic, and polymer matrix composites, reinforcing fibers, interfaces, manufacturing of composites.

Module-II

Behavior of unidirectional(UD) composites: review of the theory of elasticity, Hooke's law for generally anisotropic elastic solids, lamina stress-strain relationships, strength of UD composites, failure modes, short fiber composites, theories of stress transfer, analysis of orthotropic lamina, stress strain relationships, strengths.

Module-III

Analysis of laminated composites, stress-strain variation, synthesis of stiffness matrix, construction and properties of special laminates, determination of laminae stresses and strains, analysis of laminates after initial failure, ply-by-ply failure analysis of laminates, laminate analysis through computers, hygrothermal stresses, fatigue failure mechanisms, damage accumulation, methods of fatigue analysis and design, experimental characterization of composites, interlaminar stresses, fracture mechanics of fiber composites

Module-IV

Introduction to composite structures; effective moduli and rigidities of compound laminates, properties of composite sections and stiffened panels, introduction to laminated beams, plates, and shells, introduction to composite structural design.

References:

1. B.D. Agarwal and L.J. Broutman, "Analysis and Performance of Fibre Composites", John Wiley & Sons Inc.
2. Ronald F. Gibson, "Principles of Composite Material Mechanics", McGraw Hill.
3. Stephen W Tsai, H. Thomas Hahn, "Introduction to Composite Materials", Technomic Publishing Company
4. R. M. Jones, "Mechanics of Composite Materials", McGraw-Hill.
5. D. Hull and T. W. Clyde, "An Introduction to Composite Materials", Cambridge University Press.
6. Mel M Schwartz, " Composite Materials Handbook", McGraw-Hill Inc.

MEE612 CERAMIC SCIENCE AND TECHNOLOGY

L	T	P	C
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Module I (8 hours)

Introduction: definition of ceramic materials; overview of physical differences from metals; raw materials; relationship to geology.

Structure-Crystals-potentials and Madelung constant-ionic sizes and Pauling's Rules-oxide structures-silicate structures-*Glasses*-polymerization indices-radial distribution functions-quasi-crystalline models

Module II (15 hours)

Point Defects-mechanistic models-point defect thermodynamics: Kroger-Vink analysis-intrinsic (thermal), extrinsic (doping/impurities) and non-stoichiometric (activity-dependent) defects-defects in ternary compounds- spinel, oxide superconductors.

Line Defects (Dislocations)-crystallography-jogs, kinks and electrical problems

Surfaces and Interfaces

Grain Boundaries-crystallography and structure-electronic and chemical segregation

Interfacial energies-curved surfaces-micro-structural (textural) equilibrium

Atomic Mobility

Diffusion and Atomic Fluxes: Fick - Einstein Relationship-Chemical Diffusion in Ionic Solids-Darken analysis (uncoupled fluxes)-Nernst-Planck analysis (coupled fluxes)-Relationship to Point Defects: Activity Dependence-Grain Boundary and Dislocation (Pipe) Diffusion-Diffusion-induced grain boundary migration.

Phase Equilibria

Gibbs Phase Rule-Types of Phase Diagrams (I, II, III)-Experimental Control of Intensive Thermodynamic Variables-Ternary Phase Diagrams-liquidus diagrams and isothermal sections-divariant and monovariant equilibrium-solid solutions.

Module III (7 hours): Processing of ceramic material

Homogeneous/Heterogeneous Reactions: Definitions-Heterogeneous Reactions-transport through a planar boundary layer: slip-casting, interdiffusion and compound formation, oxidation (Ellingham analysis of force)-transport through a fluid phase: thermal decomposition, chemical vapor deposition-transport in particulate systems: calcining, powder reactions (Jander analysis), Ostwald ripening,Solid State Reactions, Powder Processing, Solid State Sintering-driving forces-models: conservation of driving force-Grain Growth and Grain Boundary Mobility-Liquid-Phase Sintering

Module IV (10 hours): Properties of Ceramics

Mechanical Properties-Creep: High-Temperature Properties and HIP Processing-Brittle Failure: Statistical Design Strength-Thermal Shock/Anisotropy-Induced Microcracking-Composites

Optical and Dielectric Properties

Text book: Y.M. Chiang, D. Birnie and W.D. Kingery, Physical Ceramics: Principles for Ceramic Science and Engineering, John Wiley & Sons, New York, 1997.

References:

1. Kingery, W. D., H. K. Bowen & D. R. Uhlmann, Introduction to Ceramics; Second Edition, John Wiley & Sons, New York, 1976.
2. Barsoum, M., Fundamentals of Ceramics, McGraw Hill, New York, 1997.
3. West, A. R., Solid State Chemistry and its Applications, John Wiley & Sons, Chichester, 1984.
4. CRC Handbook of Chemistry and Physics, CRC Press, Boca Raton, FL.
5. ASM International Handbook Committee, Engineered Materials Handbook; Volume Ceramics and Glasses, ASM International, Metals Park, OH, 1991.
6. Bergeron, C. G. and S. H. Risbud, Introduction to Phase Equilibria in Ceramics, American Ceramic Society, 1984
7. Devereux, O. F., Topics in Metallurgical Thermodynamics, Wiley, 1983
8. Doremus, R. H., Glass Science, Wiley, 1973 (1st edition), 1994 (2nd edition)
9. Green, D. J., An Introduction to the Mechanical Properties of Ceramics, Cambridge Univ. Press, 1998
10. Kelly, A. and G. W. Groves, Crystallography and Crystal Defects, Addison-Wesley, 1970
11. McHale, A. E., Phase Diagrams and Ceramics Processes, Chapman and Hall, 1998
12. McMillan, P. W., Glass Ceramics, Academic Press, 1969 (1st edition), 1979 (2nd edition)
13. Paul, A., Chemistry of Glass, Chapman and Hall, 1982 (1st edition), 1990 (2nd edition)
14. Pauling, L., The Nature of the Chemical Bond, Cornell Univ. Press, 1960 (3rd edition)

MEE613 POWDER METALLURGY

L	T	P	C
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Module I (10 hours)

Versatility and benefits of Powder Metallurgy, PM Process, Secondary operations, Powder production techniques-mechanical, atomisation, chemical-reduction and carbonyl and electro-chemical processes; Ceramic powder production; Ultra fine, whisker and short fibres.

Module II (10 hours)

Powder properties and their characteristics, Particle size distribution, Types of distribution function, Sampling of powders-sieve analysis, Microscopy, Sedimentation analysis; Specific surface and other technological properties; Powder conditioning; Compaction-cold and iso-static, Pressing equipments and tooling; Powder Injection Moulding, extrusion and rolling.

Module III (10 hours)

Hot compaction-axial and isostatic, Hot Iso-static Pressing (HIP) process variants, equipments, tooling and applications; Explosive compaction; Slip casting: Sintering-stages, single component, material transport mechanisms; Model studies; Powder shrinkage experiments; Sintering diagrams and sintering anomalies.

Module IV (10 hours)

Multi-component sintering-solid phase and liquid phase, infiltration and reaction sintering; Sintering atmospheres and equipments; Production routes in practice; Products of PM- Automobile components, Bearings, Cutting tools-HSS and Carbides, Electric bulbs, electric and magnetic parts and ceramic components.

Text Book:

An introduction to Powder Metallurgy by F Thummler and R Oberacker, The Institute of Materials, The University Press, Cambridge Great Britain. ISBN 0-901716-26-X

Reference:

ASM Handbook: Powder Metal Technologies and Applications (ASM Handbook, Vol 7).

MEE624 METAL CASTING AND JOINING

L	T	P	C
3	1	0	3

Module I (8 hours)

Foundry – Sand casting – Pattern layouts – Parting lines – Mould and Core making – Heat transfer between metal and mould – Solidification of casting – Freezing of pure metal – Homogeneous and Heterogeneous nucleation – Crystal growth – Freezing of alloys.

Module II (12 hours)

Design of gating system – Theoretical consideration – Directional solidification – Design of risers – Modulus – Caine's and shape factor methods – Use of CAD in the design of gating and risering – Application of chills.

Special Moulding processes – Shell moulding – Investment casting – Die casting – Centrifugal casting – High Pressure moulding – Casting defects and their remedies – Fettling and testing of casting.

Module III (10 hours)

Metal Joining – Classification – Welding power sources – Arc and Arc characteristics – Behaviour of arc with variation in current and voltage – Welding electrodes – ISI specifications for electrodes – Electrode selection – Newer welding processes such as Plasma arc, Laser beam, Electroslag, and Ultrasonic welding, Joining by brazing, Soldering and Adhesive bonding

Module IV (10 hours)

Welding Metallurgy – Heat flow in welding – Metallurgical transformation in and around weldment – Implication of cooling rates – Heat affected zone (HAZ) – Weldability of plain carbon steels, Stainless steels, Cast iron, Aluminium and its alloys. Design of weldments – Joint design – Residual stresses and distortion – Testing of welded joints – Destructive Tests and Non-destructive tests (NDT)

References:

1. Heine, Loper & Rosenthal, Principles of Metal Casting, TMH Publications.
2. P.C. Mukherjee, Fundamentals of Metal Casting technology, Oxford & I.B.H. Publications.
3. Jail P. L, Principles of Foundry Technology, T.M.H. Publications.
4. Udin, Funk & Wulf, Welding for Engineers, John Wiley and Sons.
5. ASM Metals Hand Book.
6. J.L. Morris, Welding Process and Procedures.

MEE692 SEMINAR I

L	T	P	C
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Each student shall prepare a paper on any topic of interest in the field of specialization – Materials Science and Technology. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

MEA694 SEMINAR II

L	T	P	C
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Each student shall prepare a paper on any topic of interest in the field of specialization – Materials Science and Technology. He/she shall get the paper approved by the Programme Coordinator/Faculty Advisor/Faculty Members in the concerned area of specialization and present it in the class in the presence of Faculty in-charge of seminar class. Every student shall participate in the seminar. Grade will be awarded on the basis of the student's paper, presentation and his/her participation in the seminar.

MEE795 COMPREHENSIVE VIVA

L	T	P	C
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Each student is required to appear for the Comprehensive Viva-Voce examination. This is an oral examination based on the courses (Theory, Laboratory and Seminar) undergone by the student in the first and second semester M. Tech. Programme.

MEA796 PROJECT

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The project work starts in the third semester and extends to the end of the fourth semester. The student will be encouraged to fix the area of work and conduct the literature review during the second semester itself. The topic shall be research and development oriented. The project can be carried out at the institute or in an industry/research organization. Students desirous of carrying out project in industry or other organization have to fulfill the requirements as specified in the “Ordinances and Regulations for M.Tech. under the section - Project Work in Industry or Other Organization.”

At the end of the third semester, the students’ thesis work shall be assessed by a committee and graded as specified in the “Ordinances and Regulations for M. Tech.”. If the work has been graded as unsatisfactory, the committee may recommend a suitable period by which the project will have to be extended beyond the fourth semester.

At the end of the fourth semester, the student shall present his/her thesis work before an evaluation committee, which will evaluate the work and decide whether the student may be allowed to submit the thesis or whether he/she needs to carry out additional work.

The final viva-voce examination will be conducted as per the “Ordinances and Regulations for M. Tech.”.

SHG642 POLYMER NANOCOMPOSITES

L	T	P	C
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Module I (10 hours)

Nanofiller synthesis, applications, Polymer nanocomposites, introduction, particulate and fibre modified nanocomposites, matrices and fibres, polymer- filler interphase, pull- out strength, effect of various treatments.

Module II (10 hours)

Mechanics of polymer nanocomposites, , nterfacial adhesion and charecterisation, factors influencing the performance of nanocomposites, physical and functional properties. Nanocomposite farication,matrices, methods, additives, moulding processes.

Module III (10 hours)

Characterisation of polymer / nanofillers systems, Rheological measurements, Processing characteristics, mechanical, thermal, optical, electrical features, , solvent resistance, ageing.

Module IV (10 hours)

Testing of nanocomposites, Importance of standards and standards organizations, processability and performance, tensile stress/ strain, tear tests, rebound resilience, friction, creep, fatigue, melt flow index, viscosity test, thermal analysis such as TGA, TMA, and DSC.

References

1. Fred W. Billimeyer, Jr, Text Book of Polymer Science, third edition, Wiley Interscience Publication, 1994.
2. Joel R. Fried,mPolymer Science and Technology, Prentice- Hall, Inc. Englewood Cliffs, N. J., USA, 2000.
3. Hand book of Elastomers: New Developments and Technology (Eds. A. K. Bhowmic and H. C. Stephense), Marcel- Dekker Inc., New York, 1995.
4. D. R. Paul and S. Newman, Polymer Blends, Academic Press, New York, 1978.
5. M. J. Folkes, Short Fibre Reinforced Thermoplastics, John Wiley, New York, 1982.

SHG641 POLYMERS FOR BIOMEDICAL APPLICATIONS

L	T	P	C
3	1	0	3

Module I (10 hours)

Biomaterials, requirements, characterization, surface characterisation and surface interactions. Polymer- general characteristics, suitability as biomaterials.

Module II (10 hours)

Applications of polymers as biomaterials, mechanical circulatory assist devices, extracorporeal heart-lung machines, hemoperfusion etc.- theory and practice.

Module III (10 hours)

Rehabilitation engineering-orthosis, prosthesis, functional considerations for orthotic prescription, Principles of force transmission.

Module IV (10 hours)

Material for orthotic and prosthetic prescription, fabrication, modification of existing polymers for new applications, blends, composites.

References

1. Jacob Kline, Handbook of Biomedical Engineering, Academic press, NY, 1988.
2. Joseph D. Bronzino, The Biomedical Engineering Handbook, CRC press, London, 2003.
3. Bhat S, Biomaterials, Narosa Publishing House, New Delhi, 2002. S Horwood, New York (1991).
4. Buddy D. Ratner, Tissue Engineering: an Overview, Journal of Rehabilitation Research and Development, 32, 56, 2002.

SHG622 PHOTONICS MATERIALS AND DEVICES

L	T	P	C
3	1	0	3

Module I (12 hours)

Semiconductors Band gaps - density of states – semiconductor statistics –conduction process-bulk and surface recombination phenomenon. Optical process in semiconductor Electron-hole pair formation and recombination –absorption in semiconductor –effect of electric field on absorption – absorption in quantum wells and quantum confined Stark effect – radiation in semiconductors- luminescence from quantum well. Semiconductor materials for LED.

Module II (10 hours)

Semiconductors Lasers and Liquid-Crystals: Junction Laser operating principle – heterojunction lasers –quantum well lasers. Liquid-Crystals Liquid - nematic, smectic and cholesteric phases - order-parameter - operation of twisted nematic display. Applications

Module III (10 hours)

Polymers Semiconducting polymers - photoluminescence and electroluminescence. Factors determining efficiency - light-emitting diodes and field effect transistors. Polymers for nonlinear optical applications – device applications.

Module IV (10 hours)

Materials for nonlinear Optics: Preparation and characterization second and third order optical materials – calculation of second and third order nonlinear optical coefficient – wavemixing. Frequency conversions- Photorefractive materials. Optical limiting and switching. (12 hrs)

References

1. Pallab Bhattacharya, Semiconductor Optoelectronic Devices Prentice Hall of India Pvt. Ltd.
2. Joseph Zyss , Molecular nonlinear optics , Academic Press Inc, Harcourt Brace & Company, Publishers.
3. Ajoy Ghatak and K.Thyagarajan , Optical Electronics , Cambridge University Press.