MNT 101 – Mathematical Methods & Programming

UNIT I :
Theory of transforms: Fourier sine, cosine and complex transforms, transforms of derivatives, convolution theorem, Parseval's relation, momentum representation; example from electromagnetism, Laplace transforms of simple function and derivatives, LT solution of ordinary & partial differential equation, convolution theorem.

UNIT II :
Bessel function, Hermite, Legendre & Lagurre polynomials occurrence of special functions and applications to physical problems.

UNIT III :
Priory and posteriory probability, Bayes theorem, discrete and contineous distribution, correlation and regression analysis, theory of errors, noise power spectral density, techniques of noise reduction.

UNIT IV :
C++ programming basics, FOR loops, WHILE loops, DO loops. IF statement, IF ELSE, ELSE IF, BREAK, CONTINUE; Function declaration, calling the function, passing arguments to function, returning values from the function, Array elements, initializing arrays, passing arrays to function. Programming for solution of quadratic equations, partial differential equations and matrices.

UNIT V :
Mat Lab programming: symbolic & numerical calculations, graphics, 3D plots, equation solving, matrices, mathematical relations, complex numbers, simplifications, algebraic expressions, mathematical operations, inbuilt functions, differentiation, integration, series, and limits.

References :
1. Mathematcal Physics : Harper
2. Applied Mathematics for Engineers and Physicist : Pipes and Harvil
3. Schaum Series for Vector Calculas, Complex Variables, Transforms and Differential Equations
4. Advanced Engineering Mathematics : Kryszik
5. Numerical Recepies in C : The art of Scientific Computing : W.H.Press
6. Robert Lafore: object oriented programming in turbo C++
7. Schuam series: C++ Programing.
8. Computer Programming Language : Addison Wesely
9. Matlab Programming by Rudrapratap Singh
10. Statistical Methods by George W. Snecdecor , William G. Cochran

MNT 102 - Synthesis of Nanomaterials

UNIT I :

Top-down & Bottom-up techniques: Formation of nanostructures by mechanical milling (ball milling) and mechanical attrition, Chemical vapor deposition (CVD), Physical vapour deposition (PVD) thermal and e beam evaporation, Pulsed laser ablation (PLD).

UNIT II :

Chemical Routes for synthesis of Nanomaterials:Chemical precipitation and coprecipitation, chemical bath deposition (CBD), Sol-gel synthesis, Microemulsions or reverse micelles, Solvothermal synthesis, Thermolysis routes and spray pyrolysis,

UNIT III :

Electrodeposition (DC and pulsed DC & AC), Electrodeposion cell in 3-electrode geometry, Procedure of multilayered thinfilm, nanowire and quantum dots electrodeposition, Electrophoresis, and their growth parameters (temperature, pH, surfactants, precursor ion concentration). Self assembly, self-assembled monolayers, directed assembly, layer by layer assembly, self organization, ordered and colloidal dispersion.

UNIT IV :

Optical lithography: Light sources – photo mask and alignment, Resolution in projection systems – positive and negative photo resists, Electron beam lithography (Maskless lithography), Semiconductor processing. Nanolithography, Nanoimprint lithography, Dip-pen nanolithography.

UNIT V :

Preparation of amorphous materials, metallic glass, thermal evaporation techniques such as sputtering, CVD Techniques, quenching. Glasses, theory of glass transition, glass transition temperature. Structure of disordered materials. Experimental techniques, electronic density of states. Localization phenomenon, transport, optical and dielectric properties.

References:

1. Microlithography Sciences and Technology – Sheats J.R and Amith B.W.Marcel Dekker Inc. New York 1998.
2. Nanolithography: A Borderland between STM, EB, IB, and X-Ray Lithographies – M.Gentili (Ed) Carlo Giovannella Stefano Selci, Springer; I edition (1994)
3. Handbook of Microlithography, Micromachining, and Microfabrication (4 vols.0 – P Rai – Choudhury – 1997 – Bellingham, Wash., USA: SPIE Optical Engineering Press; London.
4. Low Dimensional Semiconductor Structures, K.Bamam and D.Vvedensky(Cambrige University Book) 2001
5. Semiconductor Quantum Dots, L.Banyai and S.W.Koch(World Scientific) 1993
6. An introduction to the physics of low dimensional semiconductors, J.H. Davies, Cambridge Press, 1998.
7. Nanoelectronics and Nanosystems , Karl Goser, Peter Glosekotter, Jan Dienstuhl., Springer, 2004
8. Amorphous Materials : S.R. Elliot
9. Physics of Amorphous Solids : Richard Zylen
10. Electronic process in Non-Crystalline Materials : Davis & Mott.
11. Disordered Material an Introduction : Paolo M. Ossi
13. Nano materials: Synthesis properties ,characterization and application: A.S Edelstein and R.C Cammaratta

MNT 103 – Mechanics at Nano Scale

UNIT I :
Introduction to Quantum Mechanics, Uncertainty relations, Basic postulates of quantum mechanics, Wave functions, Particle in a box, hydrogen atom, linear harmonic oscillator. Schrödinger, Heisenberg & Interaction representations. Angular momention operators : eigen values & eigen vectors of L2 Lz, spin & J2 & Jz.

UNIT II :
WKB method and their applications to study quantum structures, tunnelling through a barrier.

UNIT III :
Degenerate perturbation theory and variational approximation, Zeeman & stark like effects.

UNIT IV :
Time independent perturbation upto second order, time dependent perturbation theory for constant and harmonic perturbation, transition probability, and Fermi Golden rule, atoms in a radiation field, emission and absorption of radiation, selection rules.

UNIT V :
Maxwell-Boltzmann's statistics, Fermi-Dirac statistics and fermions, Pauli's exclusion principle, Bose Einstien statistics, Bosons, Bose condensations.

References :
1. Quantum Mechanics : L.I. Schiff
2. Quantum Mechanics : J.L. Powell and Crasmann
3. Introduction to Quantum Mechanics : Pauling and Wilson
4. Quantum Mechanics : A.K. Ghatak and S. Loknathan
5. The Physics of Low-dimensional Semiconductors: An Introduction , John H. Davies
6. Concepts of Modern Physics, Aurthur Beiser

MNT 104 – Materials at Nano Scale

Unit I :
Single crystalline, polycrystalline and amorphous structures, Crystal structure, unit cells, crystal plane, Miller indices, classification of crystal (symmetry group classification), crystal orientation. Imperfection in solids: Grain boundaries their relation to mechanical properties, dislocations in single crystals (linear defects and screw dislocation), imperfection dependent properties of crystals.

Unit II :
Nanocomposites, Nanopolymers, Nanoceramics, flexible nano ceramics, morphology, crystal structures, imperfections, nano phase diagrams, cemented carbides, ceramics for structural, wear and environmental applications. Composites: Composite materials, large particle and dispersion strengthened composites. Polymer matrix, metal matrix and ceramic matrix composites.

Unit III :
Equilibrium diagrams: The Phase rule**,** Unary diagrams. Two component systemssolid solubility, Binary diagrams, relative amount of phases, Thermal analysis, Limited solid solubility, the Binary Euctectic diagram, the peritectic diagram. Phase transitions and critical pheneomenon: Broken symmetry and ordered parameters in condensed matter.

Unit IV :
Diffusion in Solids: Fick's Law of diffusion. Solution to Fick's second law. Application based on second law solution, The Kirkendall effect. Nucleation and growth; the nucleation kinetics. The growth and overall transformation kinetics. Applications: transformation in steel.

Unit V :
Elasticity: Stress, strain, elastic and plastic deformation, tensile properties, compressive, shear and torsional deformation, hardness.
Electronic and ionic conduction, electron mobility and electrical resistivity, temperature dependence and carrier conductance , electrical properties of polymers, capacitance, polarization and types, frequency dependence of dielectric constant, ferro and piezo electricity, heat capacity thermal expansion , thermal conductivity and stresses.

References :
1. Introduction to solid state physics: C. Kittel
2. Solid state Physics: A.J.Dekker
3. Materials Science and Engineering: An Introduction by W D Callister
4. Solid state physics by Aschroft & Mermin
5. Elements of X ray diffraction, BD Cullity
6. Nanocomposite Science and Technology, Ajayan, Schadler and Braun

MNT 105 – Characterization of Nanomaterials

UNIT I :

X-ray Diffraction (XRD), powder and single crystal Diffraction, X-ray fluorescence (XRF), X ray photoelectron spectroscopy (XPS), Energy Dispersive X-ray analysis (EDAX), Extended X ray absorption fine structures (EXAFS), Dispersive high pressure XRD and Diamond anvil cells (DAC).

UNIT II :

Scanning tunneling microscopy (STM), Contact and non contact atomic force microscopy (AFM), Conductive AFM, Magnetic force microscopy (MFM), scanning tunneling spectroscopy (STS), Nano indentation.

UNIT III :

Nuclear magnetic resonance (NMR) and Raman spectroscopy: description and analysis. Surface analysis methods: Secondary ion mass spectroscopy (SIMS), Auger electron spectroscopy, ESCA, Deep level transient spectroscopy (DLTS), Thermo gravimetric analysis (TGA), Differential scanning calorimetry (DSC).

UNIT IV :

Spectrophotometers, UV-Vis spectrophotometers, IR spectrophotometers, Fourier Transform Infrared radiation (FTIR), photoluminescence, electroluminesce and thermoluminescence spectroscopy, Nearfield scanning optical microscopy (NSOM).

UNIT V :

Scanning Electron Microscopy (SEM), Transmission electron microscoy (TEM), High resolution TEM Field emission SEM, Electron energy loss spectroscopy (EELS), Electron probe micro analyzer (EPMA).

References :

1. Handbook of Analytical instruments: R.S. Khandpur
2. Itroduction to Nanotechnology Charles P. Poele Jr and Frank J. Owens
3. X-ray diffraction procedures H. P. Klung and L.E.Alexander
4. The Powder Method I.V. Azaroff and M. J. Buerger
5. Introduction to Solid I.V. Azaroff
6. Elements of X-ray diffraction B. D.Cullity
7. Differential Thermal Analysis R.C.Mackenzie
8. Thermal Methods of Analysis W.W.Wendlandt
9. Synthesis, Functionalization and Surface treatment of Nanoparticles :Maric Isbella and Buraton
10. Encyclopedia of Nanotechnology : H.S. Nalwa
11. Introduction to Nanotechnology : Charles P. Poole Jr and Frank J. Owens
12. Nanomaterial Systems Properties and Application: A.S.Eldestein and R.C.Cammarata.
13. Handbook of Nanotechnology : Bhushan (Ed), Springer Verlag, New York (2004).