REVISED
CURRICULUM & SYLLABUS

FOR

M.SC (MATERIAL SCIENCE & TECHNOLOGY)
YEAR 2005-2006

PONDICHERRY ENGINEERING COLLEGE
PONDICHERRY

PONDICHERRY ENGINEERING COLLEGE
DEPARTMENT OF PHYSICS
M.Sc Materials Science and Technology
Curriculum: 2005-2006

I Semester	**Credits**	**Hours**	**Marks**
PH900 Mathematical Methods in Physics	4	4	100
PH801 Classical and Statistical Mechanics	4	4	100
PH802 Materials Science- I	4	4	100
PH803 Non-Destructive Testing and Materials Characterization	3	3	100
Elective- I	3	3	100
Elective- II	3	3	100
CE831 Strength of Materials Laboratory	1	3	100
E&I860 Instrumentation Laboratory	1	3	100
Total	23	27	800
II Semester			
PH804 Programming in C	3	3	100
PH805 Analytical Instrumentation	3	3	100
PH806 Materials Science- II	4	4	100
PH807 Quantum Mechanics	4	4	100
Elective- III	3	3	100
Elective- IV	3	3	100
PH815 Materials Science Laboratory-I	1	3	100
CS843 Programming Laboratory	1	3	100
Total	22	26	800
III Semester			
PH808 Nuclear Physics	4	4	100
PH809 Modern Materials	3	3	100
PH810 Electromagnetic Theory	3	3	100
PH811 Laser Spectroscopy	3	3	100
Elective- V	3	3	100
Elective- VI	3	3	100
PH816 Materials Science Laboratory-II	1	3	100
ME850 Workshop Practice	1	3	100
PH812 Project Phase I	2	3	100
Total	23	28	900
IV Semester			
PH813 Seminar	1	3	100
PH814 Major Project	6	18	400
Total	7	21	500
Grand Total	**75**	**102**	**3000**

List of Electives:

PH 817- Physics of Semiconductor Device Technology

PH 818 - Ceramic Materials

PH 819- Polymers and Composite Materials

PH 820- Thermodynamics

PH 821 - High Pressure Physics

PH 822 - Sensor Technology

PH 823- Metallurgy

PH 824 - Crystal Growth And Characterization

PH 825- Corrosion Science and Engineering

PH 826 - Introduction to nano technology

CE830 - Strength of Materials

PH 800 - MATHEMATICAL METHODS IN PHYSICS

Unit – I

Ordinary Differential Equations :- First order differential equations, Linear differential equations of second and higher order, Series solutions of differential equations - Legendre and Bessel equations, Sturm-Liouville problems, Solution of ODEs using Laplace transforms.

Unit – II

Linear algebra : Matrices, Vectors, Determinants, Linear systems of equations - Gauss elimination, Cramer's rule, Inverse of a matrix - Gauss-Jordan elimination, Matrix eigenvalue problems.

Unit – III

Vector Calculus : Vector differential calculus - Vector algebra, Inner product, cross product, Vector and scalar functions and fields - Derivatives, Gradient, Divergence and Curl, Vector integral calculus - Line integrals, Double integrals, triple integrals, Green's theorem, Gauss theorem - Applications, Stoke's theorem.

Unit – IV

Fourier analysis and Partial differential equations : Fourier series, Fourier integrals, Fourier transforms; Partial differential equations - Solution of Wave equation by Separation of variables, diffusion (Heat) equation by Fourier series, integrals & transforms.

Unit - V

Complex Analysis : Complex numbers and functions, Complex integration, Conformal mapping, Power series, Taylor series, Maclaurin series, Laurent series, Singularities and zeros, Residue integration, Complex analysis applied to potential theory.

Text books

1. Erwin Kreyszig, Advanced Engineering Mathematics. 8th ed. John Wiley & Sons, Inc., 1999 (Chapters 1—16).
2. Herbert Kreyszig & Erwin Kreyszig, Students Solution manual - Advanced Engineering, Mathematics 8th ed. John Wiley & Sons, Inc., 2001.

Reference books

1. Merle C. Potter & Jack Goldberg, Mathematical Methods. 2nd ed. Prentice Hall of India Pvt Ltd, 1ff98.
2. K. F. Riley, M. P. Hobson & S. J. Bence, Mathematical Methods for Physics and Engineering. Low Price ed. Cambridge University Press, 1999.
3. George B. Thomas & Ross L. Finney, Calculus and Anaytic Geometry. 9th ed. (low price) Pearson Education, Inc., 1996.
4. Sadri Hassani, Mathematical Physics - A Modern Introduction to Its Foundations. Springer-Verlag New York, Inc., 1999.
5. Ray C. Wiley & Louis C. Barret, Advanced Engineering Mathematics. 6th ed. Tata McGraw-Hill 2003.
6. R. K. Jain & S. R. K. Iyengar, Advanced Engineering Mathematics. 2nd ed. Narosa Publishing House, 2003.
7. Graham, Concrete Mathematics. 2nd ed. Pearson Education, Inc.
8. Greenberg, Advanced Engineering Mathematics. 2nd ed. Pearson Education, Inc.
9. Schaum's outline series; McGraw-Hill Differential Equations, Laplace Transforms, Matrix Operations, Linear Algebra, Fourier Analysis, Partial Differential Equations, Complex Variables, Mathematical Handbook

PH801 - Classical And Statistical Mechanics

UNIT-I: Lagrangian and Hamiltonian formulation

Constraints and their classification, Lagrange's equations of motion of first kind, D'Alembert's principle, generalized coordinates- potentials- momenta and energy, derivation of Lagrange's equations of motion of 2nd kind from D'Alembert's principle, cyclic coordinates and integrals of motion, homogeneity of time and conservation of energy, homogeneity of space and conservation of momentum, Isotropy of space and conservation of angular momentum, derivation of Hamilton's equations of motion using Legendre's dual transformation, configuration space, phase space and state space, principle of least action and Hamilton's principle, derivation of Euler-Lagrange equations of motion from Hamilton's principle.

UNIT-II: Central force, Scattering theory & Canonical transformation

Inertial forces in the rotating frame, non inertial frames-pseudo forces and Coriolis force, central force: definition and properties, two-body central force problem, center-of-mass and laboratory coordinate systems, collision and scattering: scattering cross section, scattering by a central force: Rutherford formula, canonical transformations: definition-properties and examples, Poisson's bracket: definition and properties, invariance of Poisson bracket under canonical transformation.

UNIT-III: Rigid body dynamics and Small oscillations

Derivation of kinetic energy and angular momentum of a rotating rigid body, moment of inertia tensor, transformation of inertia tensor, principal moment of inertia and ellipsoid of inertia, calculation of moment of inertia, Eulerian rotation and Euler angles, Euler's equation of motion for rigid bodies, small oscillations: Types of equilibrium, equations of motion of a coupled system and normal modes.

UNIV-IV: Classical Statistics

Fundamental concepts of phase space, microstate and ensemble, postulates of classical statistical mechanics, relation between entropy and probability, microcanonical ensemble (MCE), derivation of thermodynamics from MCE, the equipartition theorem (without proof). derivation of classical ideal gas equation using MCE, Gibb's paradox-Sackur-Tetrode equation, Canonical ensemble-introduction and energy fluctuation, partition function for canonical ensemble, calculation of thermodynamic quantities from partition function, derivation of classical ideal gas equation using canonical ensemble.

UNIT-V: Quantum Statistics

Introduction to quantum statistics, Maxwell-Boltzmann (MB) statistics-derivation of distribution function, Bose-Einstein (BE) statistics-derivation of distribution function, Fermi-Dirac (FD) statistics-derivation of distribution function, photon statistics and derivation of Plank's distribution law, derivation of Fermi energy of a degenerate fermi gas, Bose-Einstein condensation, first and second order phase transitions, critical point.

References

1. N. C. Rana and P. S. Joag. Classical Mechanics. Tata McGraw Hill Publishing Company Limited, New Delhi, 1991.
2. Federick Reif. Fundamentals of Statistical and Thermal Physics (Chapter 9), McGraw Hill, 1985.
3. Kerson Huang. Statistical Mechanics (Chapters 6, 7), John Wiley & Sons, 2nd edition, 1987.

PH802 - MATERIALS SCIENCE I

UNIT I

Crystal structures

Space group symmetry – Symmetry operations – Point group and Space group symmetry – Crystal structures – chemical binding in solids – Close packed structures – Radius ratio rules – Miller indices – Reciprocal lattice – X-ray diffraction – Atomic scattering factor and structure factor (with out rigorous derivation) – interpretation of X-ray diffraction data to determine simple crystal structures – *{X-ray diffraction experimental methods to determine crystal structure – Laue, rotating single crystal and powder methods – electron and neutron diffraction} – X-ray diffraction by Amorphous materials.

Unit II

Electrical Properties of Metals

Classical free electron theory of metals – Drawbacks of Classical theory – Quantum free electron theory – Fermi Dirac Statistic and Electron distribution in solids – Density of energy states and Fermi energy – The Fermi Distribution function – Heat capacity of electron gas – Electron scattering and Sources of Resistance in metals – Electron-scattering mechanisms and Variation of Resistivity with Temperature – Thermal Conductivity in metals.

Unit III

Thermal Properties

Theories of specific heats – Einstein's and Debye's theories – Lattice vibration in one dimensional – mono atomic and diatomic lattices – Phonons – Thermal Conductivity – umklapp process – Thermal expansion – Interaction of phonons with electron, photon, and phonon (qualitative ideas) –(Phonon Scattering by neutron diffraction) – Thin films – Preparation and properties.

Unit IV

Band Theory of Solids

Formation of Bonds in Solids – Band theory of Solids – Kronig Penney model _ Brillion Zones – motion of electrons in one dimensional periodic potential – Effective mass of electrons – concept of Holes – classification of materials according to Band theory – Fermi Surfaces in metals – Band structure of Semi conductors

Unit V

Semiconductors

Intrinsic Semiconductors – Conductivity and Temperature – Statistics of Electrons and Holes in Intrinsic Semiconductors – Electrical conductivity – Impurity Semiconductors or Extrinsic Semiconductors – Statistics of Extrinsic Semiconductors – Mechanism of current Conduction in semiconductors – mobility of Current carriers - Hall effect – Advantages of Semiconductor Devices – The p-n Junction – Some Special p-n junction Diodes.

Text Book:

1. Solid State Physics, A.J. Dekkar, Mac Millan Student Ed. , 1986.
2. Introduction to Solid State Physics, S.O.Pillai,Wiley Eastern & Sons – 2005.
3. Introductory Solid State Physics, H.P. Mayers, Viva Book Publishers, New Delhi-1998.
4. Electronic Engineering Materials and Devices, J. Allison, Tata Mc Graw Hill, 1985, Fifth Edition.
5. Solid State Physics, J.S. Blackmore, Cambridge University Press, 1985.

Reference Books:

1. Principles of Solid State Physics, H.V. Keer, Wiley Eastern, 1993.
2. Materials Science, J.C. Anderson & KDB Lever, ELBS fifth Edn., 2004.
3. Modern Materials Science, J. Granct, Printice Hall, 1980.

4. Electrical Engineering Materials, A. J. Dekker, Prentice Hall, 1983.
5. Physical Properties of Materials, M.C. Lovell etal, ELBS, 1984.
6. Physics of Magnetic Semiconductors, E.L. Nagaer, Mir Publishers, 1983.
7. Super conductivity, Mical. Cesnot, World University, Classic, 1992.

PH803 - NON DESTRUCTIVE TESTING AND MATERIALS CHARECTERISATION

Unit I

Non Destructive Evaluation Principle, developments of methods, standards and limitations. Possible material defects in Casting, Forging and Welding Metallurgical process, Visual observation and liquid penetrant techniques – Magnetic Particle and eddy current methods: Basic principles – limitations and applications.

Unit II

Ultrasonic methods – Transducers – Ultrasonic beam profile – loss energy in transmission – probe heads – probe selection – angle beam probes – contact type probes – immersion probes – Twin element probe – focused transducers – testing techniques – pulse echo - contact, immersion through transmission – resonance methods – performance evaluation of NDT transducers – calibration blocks.

UNIT III

X ray and gamma ray radiography: X-ray film processing-film types-Geometrical factors-Penetrameters-Weld radiography-pipe radiography-reference radiography-Image intensifiers. Gamma ray radiography: Half life –curie-Roentgen-Half value layer thickness-Gamma ray sources-Permissible exposure-Exposure calculation.

Principles of Neutron Radiography – Sources – Slow neutron beams – Neutron image detectors – flaw detection by Neutron radiography – limitation of Neutron radiography – comparison with X-ray radiography.

Unit IV

Electromagnetic Acoustic transducers – generation of various types of waves – Laser generated Ultrasonics - Thermo elastic generation of Ultrasonics – Ultrasonics in ablation regimes – Laser Ultrasonics at an angle calibration – Acoustic Emission flaw detection.

Unit V

Surface methods using electron low energy electron diffraction (LEED)-reflection high energy electron diffraction (RHEED)-Neutron diffraction technique:neutron spectrometer-neutron diffraction in hydrogeneous matter-detection of antiferroemagentism

Text Book:

1. Ultrasonic Testing of Materials, J. Kraut Kramer and H. Kraut Kramer, Narosa Publishing House, New Delhi 1993.
2. Non Destructive Testing , Hull .B and John V.B., , Mc Millan ELBS, 1998.
3. Transducer for Ultrasonic Flaw Detection, V.N. Bindal, Narosa Publishing House, New Delhi 1999.
4. Non Destructive Testing by Ultrasonic Methods, Beldevraj, Thavasimuthu and Jayakumar, Narosa Publishing House, New Delhi 1999.
5. Surface Physics, Prutton M, Clarenden Press, Oxford, 1975.
6. X-ray and Neutron diffraction, Bacon, GE, Pergamon Press, 1966.
7. Non Destructive Testing of welds, Beldevraj and Jayakumar, Narosa Publishing House, New Delhi 2000.

Reference Books:

1. Non Destructive Testing of Examination- Hand Book, Edr. Knud.G.Boving, Jaico Pub. House, New Delhi, 1995.
2. Principles of Neutron Radiography, N.D. Tyufyakov, and A.S. Shtan, Amerind Pub. Co. New Delhi, 1979.
3. Neutron Radiography – a Monograph, IGCAR Kalpakkam, Sep. 1999.
4. Treatise on Materials Science and Technology, Vol. 27, " Analytical technique for thin films", Academic Press, Inc., New York, 1991.

CE 831- STRENGTH OF MATERIALS LABORATORY

1. Statistical analysis of given experimental results
2. Test on wood Specimen for determining the (I) Shear strength (II) Tensile strength (III) Flexure strength (iv) Compressive strength (Parallel and perpendicular to grains)
3. Torsion test on M.S. rod and flats.
4. Cold bend test on M.S and R.T.S. rods
5. tension test on (I) M.S./ R.T.S rods (II) M.S.wires (III)Non ferrous metals (IV) Plastics
6. Impact test on metals (Charpy and Izod's test) and on plastics
7. R.H.N and B.H.N. of ferrous/ Non ferrous/ Alloy specimens
8. Compression test on Concrete cube/ cylindrical specimens.
9. Determination of spring constant.
10. Eriction and cupping test on sheet metal
11. Use of Poldi's impact test, Portable hardness tester, Rebound hardness tester (demo only)

E&I 860 Instrumentation Laboratory

1. Instrumentation Amplifier
2. Frequency meter
3. LVDT
4. Thermocouple and RTD
5. Anderson & Hay's Bridges
6. Maxwell's & Schering Bridges
7. Calibration of wattmeter and energy meter
8. Clippers and clampers
9. Simulation of filters
10. Simulation of amplifiers

PH 804 - PROGRAMMING IN C

Unit I

Introduction and Importance of C language – Basic structure of C programs – Data types – Constants – Variables – Operators – Arithmetic operators – Precedence of arithmetic operators – Type conversions in expressions – Operator precedence and associativity.

Unit II

Control statements – if- else, switch –case, loop statements – for loop, while loop, do-while – Control breaking statements: break, continue and goto – Functions and program structures – Types of functions – return statement – Actual and formal arguments – Recursive functions Local and global variables – Scope of Variables – Automatic, register – static – external. Preprocessors – Macros and standard functions.

Unit III

Arrays – Introduction – One-dimensional arrays – Two-dimensional arrays – initializing two-dimensional arrays – Multidimensional arrays.
Pointers – understanding pointers – Pointer expressions – Pointers and arrays – Pointers and Character Strings – Pointers and functions – Pointers and structures – Points on pointers.

Unit IV

File management in C – Defining and opening a file – Closing a file – Input/ Output operations on files – Error handling during I/O operations – Random access to files – Command line arguments – Dynamic memory allocations.

Unit V

Numerical analysis – Symbolic manipulation – Minimization and maximization of a function – root finding – set of linear algebraic equation – Numeric solutions – collection and analysis of data – Error, accuracy and stability – Modeling of data – least square fitting – non linear fitting – fitting of data to a straight line data with error in both the co-ordinates. Problems solving using packages (Matlab & Mathematica).
Introduction to simulation – methods – deterministic and stochastic – construction of a model – calculation and analysis of physical properties using the model - Application

1. Motion of a falling object (force and distance calculations)
2. Nuclear decay (mass and energy)
3. Bohr atom model (energy eigen values)
4. Classical and Quantum linear harmonic Oscillators (Non- linearity).

Books:

1. Programming in C – D. Ravichandran, New age International, New Delhi –1999.
2. Programming with C – E.. Balagurusamy, Tata Mc Graw Hill, New Delhi –1999.
3. Programming with C – Byron Gottfried, Schaums' Outline Series, TMH-1999.
4. Working with C – Yashavant Kanethkar, BPB, New Delhi – 1994.
5. Programming with ANSI C – Brian Kernigham and Dennis Ritchie – PHI – 2000.
6. Introduction to numeric methods by M.K. Venkataraman.
7. Numerical Receipes in C (the art of Scientific Computing) by William. H Press etal, Cambridge University Press, India (1996).
8. Introduction to Computer Simulation methods – application to Physical Systems Part I and Part II by Harvey Gould etal, Addison Wesley Publish Co.
9. Computational Physics by K.H. Hoffmann and Schrieber Springer Verlag.

PH 805 - ANALYTICAL INSTRUMENTATION

UNIT I

Basic concepts of Absorption and emission spectroscopy – representation of spectra – basic elements of practical spectroscopy – signal to noise ratio - hardware and software techniques for signal to noise enhancement – resolving power – Fourier transform spectroscopy – evaluation of results – basic principles, instrumentation and applications of atomic absorption, atomic fluorescence and atomic emission spectroscopy – ICP atomic fluorescence spectroscopy – comparison of ICP Vs AAS.

UNIT II

Infrared spectroscopy – correlation of IR Spectra with molecular structure, instrumentation, samplings technique and quantitative analysis. Raman Spectroscopy – Classical and Quantum theory instrumentation, Structural analysis and quantitative analysis.

Nuclear magnetic resonance spectroscopy – basic principles – pulsed Fourier transform NMR spectrometer – elucidation of NMR spectra and quantitative analysis : Electron Spin Resonance Spectroscopy – Basic principle instrumentation and application.

UNIT III

Surface study – x-ray emission spectroscopy (XES), electron spectroscopy for chemical analysis (ESCA) - UV photo electron spectroscopy (UPS)- X- ray photo electron spectroscopy (XPS) - Auger emission Spectroscopy (AES) - Transmission Electron microscopy (TEM) - Scanning Electron microscopy (SEM), Surface tunneling microscopy (STEM) - Atomic force microscopy (AFM).

UNIT IV

Mass spectroscopy – Ionization methods in mass spectroscopy – mass analyzer – ion collection systems, correlation of molecular spectra with molecular structure. Instrumentation design and application of Fourier transform mass spectroscopy (FT-MS)
Inductively coupled plasma mass spectroscopy (ICP-MS), Secondary Ion Mass Spectroscopy (SIMS) and Ion microprobe mass analyzer (IMMA). Radio chemical methods – Activation analysis, neutron activation analysis, isotope dilution analysis. Liquid scintillation system. Application of Radionuclides.

UNIT V

Thermal analysis: principles and instrumentations of thermogravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC), evolved gas detection, thermo mechanical analysis, dynamic mechanical analysis, Thermometric titrimetry and direct – injection enthalpimetry.

Text Books:

1. Instrumental methods of Analysis, Willard, Merritt, Dean and Settle, CBS Publishers and distributors, New Delhi, 7th edition, 1986.
2. Fundamentals of Molecular Spectroscopy, C.N Banwell and E.M. Mc Cash, Tata Mc Graw Hill, New Delhi, 1994.
3. Electron Beam Analysis of Materials, M.H. Loretto, Chapman and Hall, 1984.
4. Introduction to Mass Spectrometry, J.T. Watson, Raven, New York 1985.
5. Thermal Methods of Analysis, W. Wendlandt, John Wiley, New York, 1986.

Reference Books:

1. Surface Physics, m. Prutton, Clarenden press, Oxford, 1975.
2. Transmission Electron Microscopy of Materials, G. Thomas, J.G. Michael, John Wiley and Sons, 1979.
3. Instrumental methods in Chemical Analysis, Wing GW, Mc Graw Hill, 1975.

PH 806 - MATERIALS SCIENCE-II

Unit I

Dielectric polarization- Mechanism of polarization – electronic, ionic and orientational polarization – Lorentz Internal field - Clausius- Mossatti relation – Temperature dependence of static permitivity – Complex permitivity – dielectric loss – frequency dependence of polarization – Experimental determination of dielectric constant and dielectric loss by Scherring Bridge method Piezo and Pyro electricity- materials and applications– Ferroelectricity – dipole theory of ferroelectrics – ferro electric materials and applications.

Unit II

Optical properties

Optical constants – absorption of radiation in metals, semiconductors and insulators – edge absorption and excitons (elementary ideas) – Luminescence – Phosphorescence and fluorescence – photoluminescence in semiconductors and insulators – photoconductive devices – solar cells – electroluminescence – LED – Thermoluminescence, Cathodoluminescence- Luminescent materials – ZnS phosphors, Thallium activated alkali halides, lamp phosphors

Unit III

Magnetic properties

Classification of magnetic materials- Dia, Para , Ferro, antiferro and ferrimagnetic materials – domain theory and hysteresis – Weiss molecular field theory and Curie –Weiss law – Quantum mechanical theory for ferromagnetism- Outline of Heisenberg's exchange theory – magnetic anisotropy – Domain walls and Domain theory – Antiferro magnetism- Two sub lattice model- Ferri magnetism – soft and hard magnetic materials , and their applications- metals, alloys and ceramic materials – application of magnetic materials in data storage – magnetic bubble domains.

Unit IV

Super conductivity-I

Superconductivity – Transition temperature Tc – Critical field Hc- Isotope, pressure, magnetic field effects on Tc – Meissner effect – type I and type II super conductors – London equation – thermodynamics of superconductors – free energy – entropy – specific heat – BCS theory – Superconducting energy gap – DC and AC Josephson effects – Quantisation of flux – Quantum interference.

Unit V

Superconductivity II

High temperature superconductors – copper free oxide superconductors – preparation of Cuprates – Modern theories of HTSc – Qualitative ideas of RVB theory – application of superconductors – High field magnets, motors, generators – Magnetic Levitation and transportation – Nuclear magnetic resonance imaging – energy storage – superconducting power transmission - devises based on Josephson's effect – SQUID – memory elements – Signal Processing.

Text Book:

1. Introduction to Solid State Physics, S.O.Pillai, New Age International (2005)

Reference Books:

1. Solid State Physics, A.J. Dekkar, Mac Millan Student Ed. , 1986.
2. Introduction to Solid State Physics, 7th Edn., C. Kittel, Wiley & Sons, (1999).
3. Principles of Solid State Physics, H.V. Keer, Wiley Eastern, 1993.
4. Materials Science, J.C. Anderson & KDB Lever, ELBS fifth Edn., 2004.
5. Modern Materials Science, J. Granct, Printice Hall, 1980.
6. Electrical Engineering Materials, A. J. Dekker, Prentice Hall, 1983.
7. Physical Properties of Materials, M.C. Lovell etal, ELBS, 1984.
8. Physics of Magnetic Semiconductors, E.L. Nagaer, Mir Publishers, 1983.
9. Super conductivity, Mical. Cesnot, World University, Classic, 1992.
10. Introductory Solid State Physics, H.P. Mayers, Viva Book Publishers, New Delhi-1998.
11. Electronic Engineering Materials and Devices, J. Allison, Tata Mc Graw Hill, 1985, Fifth Edition.
12. Solid State Physics, J.S. Blackmore, Cambridge University Press, 1985.
13. Elementary Solid State Physics, M. Ali Omar, Addison Wesley, (2000)
14. Solid State Physics, Ashcroft & Mermin, Thomson Asia, Singapore, (2003)
15. Fundamentals of Solid State Physics, J. Richard Christman, John Wiley& Sons, (1988)
16. Science of Engineering Materials, 2nd Edn., C.M. Srivastava and C. Srinivasan, New Age International, (1997)

PH 807 - QUANTUM MECHANICS

Unit-I

Postulates of quantum mechanics-operator formalism-commutation relations-expectation values. Solution of Schroedinger's wave equation-three dimensional linear harmonic oscillator, one dimensional square well potential, Tunneling through a one dimensional potential barrier.

Unit-II

Matrix representation of quantum mechanics- application to one dimensional Simple harmonic Oscillator. Angular momentum- commutation relations-Eigen values and eigen functions of angular momentum - Ladder operator method – Matrix representation of angular momentum operators-combination of two angular momenta, Clebsch Gordon Coefficients. Hydrogen atom – solution of Schroedinger's wave equation for eigen values and eigen functions.

Unit-III

Time independent perturbation theory for non-degenerate and degenerate levels- application to one dimensional anharmonic oscillator, First Order Stark effect in hydrogen, Zeeman effect. Variation method- ground state energy of Helium atom, Heitler-London theory for Hydrogen molecule.

Unit-IV

First order time dependent perturbation theory – Transition probabilities – Fermi's Golden rule-Harmonic perturbation-interaction of electromagnetic radiation with matter, Einstein's coefficients- selection rules for harmonic oscillator and hydrogen atom (without rigorous derivations), Scattering Theory: Scattering cross section –Born's approximation, scattering by an attractive square well potential

Unit-V

Partial wave analysis-phase shifts-low energy scattering – scattering by an attractive square well potential. Identical particles and spin. Relativistic quantum mechanics –Klein Gordan equation-Pauli's Spin matrices and Dirac matrices.

Text Book

1. Quantum Mechanics , G. Aruldhas, Prentice Hall India, (2002)

Reference Books

1. A Text Book of Quantum Mechanics , P.M. Mathews and K. Venkatesan, Tata McGraw Hill Publishing Co., New Delhi (1985)
2. Quantum Mechanics , 4th Edn, Ajoy Ghatak and S. Lokanathan, MacMillan(1999)
3. Elements of Quantum Mechanics, Michael D. Fayer, (2001)
4. Quantum Mechanics L.I. Schiff, McGraw Hill, (1972)
5. Quantum Mechanics, L.M. Pauling and H. Wilson , McGraw Hill, (1935)
6. Introduction to quantum Mechanics, Dicke and Wittke, Addison Wesley (1963)
7. Introduction to Quantum Mechanics, Ajoy Ghatak, MacMillan India, (1996)
8. Quantum Mechanics, 7th Edn., S.L.Gupta, V. Kumar,H.V. Sharma and R.C. Sharma, Jai Prakash Natt & Co, Meerut, (1987)
9. Quantum Mechanics, L. Powell and Crasemann, Narosa Publishing House, (1988)

PH 815 - MATERIALS SCIENCE LABORATORY I

1. Band gap determination
2. Ultrasonic diffraction
3. Hall effect
4. Magnetic Susceptibility of liquids
5. Thermister Characteristics
6. Laser Experiments
7. Corrosion of Metals
8. Electrical Conductivity of Electrolytes / Crystals
9. Dielectric Constant of a Crystal, liquid – variation with frequency (LCR Circuit)
10. Guoy Balance – Paramagnetic Susceptibility.

CS 843 - PROGRAMING LABORATORY

FORTRAN

1. Sine series
2. Binomial coefficients
3. Transpose of a given matrix
4. Inverse of a given matrix
5. Diagonalisation of a matrix
6. Newton-Raphson method and other iteration methods

C – Language

7. Reading of data from Binary Ascii to data file – Elementary graphics and plotting
8. Curve fitting – least square, non least square
9. Numerical integration, Trapizoidal rule and Simpson's rule
10. Bisector
11. Solution of Ordinary differential equation Range – Kutta method
12. Advanced graphics: Ellipse, circle and colour filling.

PH 808 - NUCLEAR PHYSICS

UNIT I

Basic Nuclear Properties:

Nuclear mass. Charge, radius, size, magnetic moment, parity, statistics – Binding energy and stability of nuclei – variation of BE – Weizacker semiemperical formula, Nuclear instruments (G.M. Counter, Bubble Chamber and Cloud chamber). Rutherford scattering theory – interaction of charged particles with electromagnetic radiation.

UNIT II

Nuclear forces and Nuclear disintegration:

α - decay, Gamow's theory - β-decay, Fermi theory, selection rules - γ-decay, multipole emission – internal conversions. Nuclear isomerism – two body problem – ground state of deutron. Nucleon scattering, n-p scattering. Partial wave analysis. p-p scattering – charge independence of nuclear forces. Non central forces (tensor) forces. Exchange Forces (Different Types).

UNIT III

Nuclear reaction and Nuclear models:

Types of nuclear reaction – Breit – Wigner one level formula – Neutron Physics Diffusion theory – Neutron leakage – interaction with matter – diffusion and slowing down length. Slowing down of neutrons, Fermiage theory – microscopic and macroscopic cross section. Nuclear Models – liquid drop – shell model, deficiencies – collective model.

UNIT IV

Nuclear Fission and Reactor Theory:

Fission, chain reaction, neutron multiplication factors- deformation of nucleus – energy of fission – four factor formula for neutron multiplication. Classification of nuclear reactors – PWR, BWR, BHWR, Breeder reactor (fast, thermal and advanced reactors) – Nuclear reactors in India and abroad. Reactor materials – (Fuel, Moderator, Coolant and Control Materials) choice and processing. Fusion – thermonuclear reactions.

UNIT V

Elementary Particles:

Strong interaction – electromagnetic– weak interaction – Elementary particle physics – classifications - Hadrons-Leptons – quantum numbers – quark theory – quantum chromo dynamics (QCD). Electron weak theory, Gellman Nishijima formula – NCP-CPT invariance. Symmetry – unitary symmetry – SU(2) – SU(3).

Books:

1. Introductory Nuclear Physics, Samuel S. M. Wong, Printice Hall Advanced Reference Series Physical and life Sciences.
2. Introduction to Nuclear Physics - Elton, 1970.
3. Nuclear Physics, Irwing Kaplan - 1992.
4. Nuclear Physics, Enge, 1988.

PH 809 - Modern Materials

Unit-I Introduction to materials 10 hours

Classes of materials – Smart/intelligent materials – Functional materials – Diverse areas of intelligent materials – primitive functions of intelligent materials – Examples of intelligent materials – Materials responsive to thermal, electrical, magnetic, optic, stress fields, Bio-compatible materials and bio-Mimitics

Unit – II Novel Materials 10 hours

Amorphous and glassy materials – Structure – Preparation methods and novel properties – Shape memory alloys – working mechanism – pseudo elasticity – applications – Nickel-Titanium (Nitinol) alloys – Material characteristics of Nitinol – Introduction to Micro Electro Mechanical Systems (MEMS) – Silicon, porus Silicon and silicon oxide based MEMS –Fabrication of piezo-electric and piezo-resistive MEMS materials – Application to micro-actuators and micro-accelerometers.

Unit – III Nano-structured materials 10 hours

Definition – Types – preparation and characterization techniques – Size effects on various properties – Carbon nanotubes – silicon and silicon oxide nano wires –Mechanical (hardness, ductility, elasticity), optical and electrical properties of nano tubes and nano wires - quantum wires and quantum dots.

Unit – IV PZT, CMR & Ferro-fluid 10 hours

Structure of ABO_3 and AB_2O_4 materials – Synthesis and properties of piezo-electric ,ferro-electric perovskites and spinel structured materials - PZT thin films –preparation (different techniques-Sol-gel, PLD,MOVCD) and applications-Introduction to magnetoresistance (MR) – GMR and CMR materials – Applications-Preparation and properties of ferro-fluids – Electro-Rheological fluids – Applications.

Unit – V Modern Semi conducting materials 10 hours

Introduction to III – V and III - N Compounds – Synthesis techniques –CVD –VPE – Applications (White LED) – Technological importance of II – VI and I – III – VI_2 binary, ternary and quaternary semiconductors – Introduction to non linear optics (NLO) and NLO materials - Novel applications of ZnO and TiO_2 thin films.

Text Books

1. Mukesh V.Gandhi and Brian S.Thompson, *Smart materials and structures,* Chapman & Hall,London,1992.
2. T.W.Duerig, K.N.Melton, D.Stockel and C.M.Wayman, *Engineering aspects of shape memory Alloys,*Butterworth-Heinemann,1990
3. Sorab K. Gandhi, *Fabrication Principles of VLSI,* John Wiley,1996
4. Charles P.Poole and Frank J Owens, *Introduction to nano technology*, Wiley Interscience,2003.
5. Tapan Chatterji, *Colossal magnetoresistive manganites,* Kluwer Academic Publishers, 2004
6. Malcolm E.Lines and Alastair M.Glass, *Principles and applications of Ferroelectrics and Related materials,* Oxford University Press, 2001
7. A. Inoue and K.Hashimoto, *Amorphous and Nanocrystalline Materials:Preparation,Properties and Applications*, Springer Verlag
8. Review articles for recently developed materials

PH 810 - Electromagnetic Theory

UNIT-I: Electric field

Introduction to charge distribution-Coulomb's law and Gauss law, electric potential-Laplace and Poisson equations, electrostatic boundary conditions, derivation of the energy of a point charge and continuous charge distributions, conductors-properties and induced charges and surface charges, electric fields in matter-polarization, derivation of the field of a polarized object, Gauss law in presence of dielectrics, boundary conditions in presence of dielectrics, energy and forces in dielectric systems.

UNIT-II: Boundary value problems & Special techniques

Cartesian, cylindrical and spherical coordinate systems, Laplace and Poisson equation in different coordinate systems, boundary conditions and uniqueness theorems (without proof), conductors and second uniqueness theorem (without proof), solution of Laplace and Poisson equations in 3D in cartesian, cylindrical and spherical polar coordinate systems, boundary value problems with linear dielectrics, multipole expansion, origin of coordinates in multipole expansions, derivation of electric field of a dipole in cylindrical polar coordinate system.

UNIT-III: Magnetostatics and Electrodynamics

Lorentz force law and Biot-Savart law, scalar and vector potentials, multipole expansion of vector potential, calculation of field of a magnetized object, Amperes law in magnetized materials and auxiliary field H, magnetostatic boundary conditions, Faraday's law and Lenz's law, calculation of energy density in magnetic fields, Electrodynamics before Maxwell, Maxwell's correction of Amp`ere's law, derivation of Maxwell's equations in vacuum and in matter.

UNIT-IV: Electromagnetic waves

Electromagnetic waves in vacuum, wave equation for E and B, reflection-refraction of electromagnetic waves, Snell's law and Fresnel's law, Poynting theorem and its derivation, Electromagnetic waves in matter, propagation of E.M waves in linear media, reflection and transmission at normal and oblique incidence, absorption and dispersion of E.M waves, electromagnetic waves in conductors, reflection at a conducting surface, interference- diffraction and polarization.

UNIT-V: Potentials and Radiation

Potential formulation, Gauge transformations, Coulomb and Lorentz gauge, retarded potentials of continuous charge distribution, derivation of Jefimenko's equations, retarded potentials of point charges, Li´enard-Wiechert potential, fields of a moving point charge, electric dipole radiation, energy radiated by an oscillating electric dipole, radiation from moving charges-radiation fields, derivation of Larmor formula.

References

Griffiths D J (1999). Introduction to electrodynamics. Prentice Hall of India Private Limited, New Delhi, 3rd edition.

PH 811 - Laser Spectroscopy

Unit I

Laser as spectroscopic light source, fundamentals of laser- laser resonators, spectral characteristics of laser emission, realization of single-Mode lasers, wavelength tuning of single-Mode lasers- line width – tunable lasers – nonlinear optical mixing techniques.

Unit II

Nonlinear spectroscopy – linear- nonlinear absorption, saturation of inhomogeneous line profile, saturation spectroscopy, polarization spectroscopy, multiphoton spectroscopy – special techniques.

Unit III

Laser Raman spectroscopy – basic experimental techniques, non linear Raman spectroscopy, special techniques, CARS – applications.

Unit IV

New developments in laser spectroscopy – optical cooling – trapping of atom – spectroscopy of single ion, optical Ramsey fingers, atom interferometry, one atom Maser, squeezing, spectral resolution of natural line width, optical frequency measurement

Unit V

Application of Laser Spectroscopy - Application in chemistry – environmental – biological – medical – technological applications.

Textbooks

1. Laser Spectroscopy- Basic Concepts and Instrumentation, W. Demtroder, Springer, Third Edition, 2004. Chapters 5,7,8,11,14 and 15.

Reference Books:

1. 1. Laser Technology and Applications, S.L. Marshall, Mc. Graw Hill Book Co., 1980.
2. Laser in Industry, S.S. Charachan, Van Nostrand Reinhold Co., 1975.
3. Laser Electronics, by Joseph T. Verdeyen, PHI 1993.
4. Laser theory and applications, K. Thiagarajan and A. Ghatak, Me Millan, 1991.

PH 816 - MATERIALS SCIENCE LABORATORY II

1. Band gap determination (four probe method)
2. Ultrasonic diffraction (pulse echo method)
3. Thermolunimescence study of Alkali Halides
4. Determination of Specific Charge of an Electron (e/m Thomson's method)
5. Determination of Absorption coefficient of air and aluminiun using GM counter.
6. Determination of Rydberg constant using constant deviation spectrometer.
7. Error Analysis
8. Differential Thermal Analysis
9. Dielectric Constant of a Crystal– variation with temperature
10. Electrical conductivity study of ionic / semiconducting/ metallic compounds using two probe .

ME 950 - WORKSHOP PRACTICE

FITTING SHOP:

Study of hand tools like files, chisels, hammers, try square, calipers, hacksaw, marking gauge, punches, tapes, dies etc. use of vernier calipers and micrometers. Use of tools – cutting and filing of M.S. Strips to correct profiles – drilling and tapping

Welding Shop:

Study of welding, soldering and brazing making of lab, butt, of M.S. flats by gas and arc welding. Elementary practice of soldering and brazing (demonstration)

Metal Cutting:

Sand moulding exercises – two box types – demonstration – molten metal pouring and casting. Metal cutting – exercises on lathes – turning, joining, drilling and taper turning.

PH 817 - PHYSICS OF SEMICONDUCTOR DEVICE TECHNOLOGY

UNIT I

PN junction - Depletion Capacitance - Diffusion capacitance - Tunneling and Tunnel diodes - Junction break down – Schottky barriers – Ohmic contacts – UJT: Principle and operation- bipolar junction transistors (BJT): Principle of operation, doping profile – BJT as a switch – BJT in IC.

UNIT II

FET: Basic principle – Surface charge in metal oxide semi conductor capacitor – MOSFET: Principle and operation – Charge coupled device – Advanced MOS devices.

UNIT III

Photonic devices: Crystalline solar cells – Conversion efficiency – PN-Junction solar cells – Spectral response – Equivalent circuit – Amorphous silicon solar cells – Photo detectors – PIN Diode detectors – Electro luminescence of electromagnetic waves in two level systems – LEDs – Semiconductor lasers – Optical gain – Integrated Opto electronics – LCD – Seven segment displays.

UNIT IV

Transistor structures: Electron transport in short devices and compound semiconductor technology – Permeable Base Transistors – Planar doped barrier devices – Real space transfer – Super lattice devices – Resonant tunneling devices.

UNIT V

Wafer Preparation, Lapping, Etching, Polishing measurements on semi conductor material; Crystal orientation, Dislocation density, Resistivity. Transistor and Integrated circuits design theory, Fabrication techniques: MIS Devices – Thin film technology.

TEXT BOOKS:

1. Physics of Semiconductor Devices – Michael Shur, Prentice Hall India 1995.
2. Physics of Semiconductor Devices – S.M.Sze, Wiley Eastern Ltd., 1991.
3. Semiconductor Devices; An Introduction – Jasprit Singh, Mc.Graw Hill, 1994.

REFERENCE BOOKS:

1. Semiconductor Physics: An Introduction – K.Seegar, Springer – Verlag, Germany, 1985.
2. Physics of Technology of Semiconductor Devices – Andrew S.Grower.

PH 818 - CERAMIC MATERIALS

Unit I

Nature of Ceramic materials – crystalline ceramic materials – Silicates and clay minerals and spinal structures – Polymorphic transformations – glass and non-crystalline phases – structure and Composition of glass – Surface and Interface – wetting and phase distribution.

Unit II

Ceramic raw materials – clay materials – Silicate and Silicate minerals - Synthetic raw materials – Oxide (like Al_2O_3, ZrO_2, TiO_2, MgO) and non-oxide (like Si_3N_4, AlN, BN, SiC) raw materials. Synthetic techniques – Sol – gel processing, liquid – phase reaction and hydrothermal synthesis.

Unit III

Processing of Ceramics – powder pressing, extrusion, slip casting, firing- thermal treatment procedure – drying, sintering, annealing – Viscosity based transition points in glass – glass forming methods, glass- ceramics.

Unit IV

An outline of ceramic equilibrium diagrams – One component (SiO_2), two component (Al_2O_3, Cr_2O_3, MgO-CaO, MgO-Al_2O_3, Al_2O_3-SiO_2, Al_2O_3-BeO) and qualitative ideas of methods of representation of three component diagrams – Nucleation – grain growth.

Unit V

Mechanical properties of Ceramic materials – Elastic properties and strength – Griffith's theory – plastic and Viscous deformations – strengthening of glass.
Thermal properties – thermal expansion, heat capacity and thermal conductivity – thermal stresses.

Text Books:

1. L.H. Van Vlack – Physical Ceramics for Engineers – Addison Wesley, 1964.
2. F.H. Norton – Elements of Ceramics - Addison Wesley, 1974.

Reference Books:

1. W.D. Kingery, H.K. Bowen, D.R. Uhlmann – Introduction to Ceramics – 2nd edition, John Wiley & Sons, 1991.
2. D. Ganguli and M. Chatterjee – Ceramic powder preparation|: A hand book – Kluwer Academic Publishers, 1997.
3. David Segal – Chemical Synthesis of advanced Ceramic Materials – Cambridge University Press – 1989.
4. W.D. Kingery – Ceramic Fabrication Process – John Wiley 1960.

PH 919 - POLYMERS AND COMPOSITE MATERIALS

Unit I

Fundamental concepts of Polymers and Composites:

Introduction – classification of Polymers and composites – Types of Polymerization and Mechanisms – Molecular weight of Polymers – Number average and Weight average concepts – Degree of Crystallinity and Glass transition temperature of Polymers.

Unit II

Fabrication:

Compounding of plastics – injection, compression moulding – Preg moulding – Blow Moulding – calendaring and lamination techniques of plastics – Fabrication methods of composites – Molten metal infiltration, powder metallurgy, hot pressing, hot rolling, co-extrusions, fiber reinforced metals.

Unit III

Testing of Polymers and Composites:

Testing of Polymers – Chemical identification methods – tensile and bending strength – impart resistance – fatigue – dielectric strength – Testing of Composites – streee distribution and load transfer – prediction of strength of impurities – anisotrophy – failure criteria.

Unit IV

Properties of Polymers and Composites:

Properties of polymers – strength – plastic deformation – mechanical, optical and electrical properties with reference to important engineering plastics – LDPE, HDPE, PVC, Polyester, Phenol formaldehyde, alkyds, cellulose and elastomers – Properties of Composites – micro mechanics, inter phase band.

Unit V

Application of Polymers and Composites:

Application of Ploymers and plastic fibers – elastomers – coating adhesives – bio medical application - fiber reinforced plastic – conducting polymers.

Applications of Composites: Aircraft engineering – space hardware – wind turbine – marine craft – space structure – applications in surgery, sports equipments, vehicles .

Text / Reference Books:

1. Text Book of Polymer Science, Fred. W. BillMeyer, Jn. Wiley Interscience, 1984.
2. Introduction to Polymer Science, A.R. Gowarikar. etal, Tata McGraw Hill Book co., India.
3. The Science and Engineering of Materials, Donald R. Askeland, PWS –KENT Publishing Company, Boston, 1980.
4. An Introduction to Composite Materials, Derek Hull, Cambridge University Press, 1988.
5. Composite Materials: Engineering and Science, Mathews, F.L., Chapman & Hall, 1994.
6. Composite Materials Hand Book, M.M. Schwartz, McGraw Hill Book Co., 1984.

PH 820 - Thermodynamics

Unit I

System control volume, process cycles, homogeneous – heterogeneous system, quasi static process – continuum concept, zeroth law of thermodynamics – concept of temperature- pressure-volume diagram- $pv = c$, $pv^n = c$, $pv^\gamma = c$, ideal gas, temperature work and heat transfer, path and point function, work done in free expansion – zero work transfer, work transfer-heat transfer as a path function.

Unit II

First law of thermodynamics – system undergoing change of state, energy a property- specific heat at constant volume and constant pressure –PMMI, Second law of thermodynamics- cycle, difference between heat and work, efficiency of heat engine, Kelvin Planck, Clausius statement - refrigerator- heat pump- COP, equality of Kelvin Plank and Clausius statement, reversibility, irreversibility -causes, Carnot's cycle- Carnot's theorem, equality of thermodynamic scale and Kelvin scale of temperature.

Unit III

Entropy- Clausius theorem, entropy as a property, T-S diagram, Clausius inequality, change in entropy in irreversible process, entropy principle –application, maximum work obtainable, change in entropy with heat flow, change in entropy of closed system-open system, directional law of nature, entropy and disorder, available energy, quality of energy, maximum work done in reversible process with heat exchange, dead state.

Unit IV

Pure substance- gases and mixtures, P-V diagram of water and other substances, P-T diagram, PVT diagram, TS diagram, HS diagram (Mollier chart) dryness fraction, steam tables, saturation state-liquid vapour mixture, super heated liquid, Compressed liquid, thermodynamic properties chart, equation of state, ideal gas – specific heat at constant pressure, internal energy, enthalpy and entropy change of ideal gas, reversible adiabatic-isothermal process, change in entropy in poly tropic process, virial expansion, law of corresponding states.

Unit V

Mixture of gases-Daltons law of partial pressure, internal energy, enthalpy, specific heats at constant pressure and volume change in entropy of mixtures, Gibb's function, Maxwell's equations, TdS equation, $C_p - C_v$, C_p/C_v, energy equation, Joule Kelvin effect, Clausius Clapeyron equation, mixture of variable composition, equilibrium conditions of heterogeneous system, Gibbs phase rule-types equilibria, stability condition.

Text Book.

1. P.K. Nag, Engg. Thermodynamics Tata .Mc. Graw Hill 1995.

Reference books

1. Zemansky M.W., Heat and Thermodynamics, Mc. Graw Hill 1957.
2. Evelin Guha, Heat and Thermodonamics T.Mc. Graw Hill, 1998.
3. Arora C.P. Heat and Thermodynamics, Tata Mc. Graw Hill, 1998.
4. Huang F.F. Engg. Thermodynamics, Mac Millan, 1989.
5. Adrian Bejan, Advance Engg. Thermodynamics, John Wiley, 1988.

PH 821 - HIGH PRESSURE PHYSICS

Unit I

Introduction

Pressure: definition, types and Units - Generation of Static Pressure – Pistion Cylinder – Bridgman Anvil – Multi anvil devices – Diamond anvil cell – Measurement of High Pressure – Primary and Secondary Gauge – Thermocouple Pressure Gauge – Resistance Gauge – Fixed point pressure scale – Ruby Fluorescence – Equation of state.

Unit II

Devices and Techniques

X-ray and Neutron Diffraction – Electrical and Thermal Measurements – Spectroscopy studies – IR, Raman, NMR, Optical absorption – EXAFS – Generation of Ultra high pressure and Temperature.

Unit III

Physical Properties Under High Pressure

Compressibilities of solids and fluids – PVT relations in fluids – Properties of gases under Pressure – Viscosity – Thermo emf – Thermal and Electrical conductivity - Electronic and Structural Phase Transitions in Metals – Phonons – Superconductivity – Electronic structure of Metals and Semiconductors – magnetic properties – liquid crystals.

Unit IV

Mechanical Properties under Higher Pressure

Measurement of Elastic Constants – Tension and compression – Fatigue – Creep – Material Synthesis - Super-hard materials – Oxide and Other Compounds.

Unit V

Dynamic Pressures

Shock Waves – Generation – Measurements – Effect of Shock on metals – Application of Shock Waves.

Text Books:

1. The Physics of High Pressure, P.W. Bridgemann, G.Bell and Sons Ltd, London 1931.
2. High Pressure Science and Technology, Vol. I&II, B. Vodar and Ph. Marteam, Pergamom Press, Oxford, 1980.
3. Mechanical Behaviour of Materials under Pressure, H. L.D. Pugh, Elsevier Pub. Co. Ltd., New York 1970.
4. Solid State Physics, Vol. 13, 17 and 19, Frederick and Turnbull, Academic Press, New York, 1962.

PH 822 - SENSOR TECHNOLOGY

Unit I

Load cell – pressure transducers – Bourdow tubes – diaphram elements – Bell gauge – Electrical types, Mechanical types – Low pressure measurements – mechanical, electrical and thermal types – ionization gauges – differential pressure transducers.

Unit II

Sensors for displacement – velocity – acceleration and torque – electrical transducers for displacement – strain gauges – capacitance gauges – LVDT – Piezo electric transducers – measurement of quantities.

Unit III

Temperature Measurement: Solid and fluid expansion type – resistance thermometers – thermo emf – thermisters – radiation pyrometers – thermography – measurement of very high or Stellar temperature.

Unit IV

Flow and level measurements: Head types – Installation procedure – pitet tubes – area and mass flow meters – Positive displacement flow meters – electrical turbo magnetic and electromagnetic flow meters. Hot wire anemometers – open channel flow. Float type level measurement – displacement type – hydrostatic types – thermal effect type – electrical methods and magnetic methods.

Unit V

Materials for Transducers: Barium Titanate KDP, ADP, PDVE films, TaS, thermal sensors of ABO_3 type, Wurtzite etc.

Text / Reference Books:

1. Principles Industrial Instrumentation, D. Patranaris, Tata McGraw Hill, New Delhi, 1991.
2. Measurement Instrumentation and Experiment design in Physics and Engineering, M. Sayer and Abhai Mansingh, Printice Hall Pvt. Ltd, 2000.
3. Instrumentation and Devices, C.S. Rangan, G. Sharma and Mani , Tata McGraw Hill, New Delhi, 1985.
4. Physical Properties of Materials, Lovell, et al, ELBS, 1984.

PH 823 - Metallurgy

UNIT I

Defects in solids: Imperfections in solids – Point defects – vacancies – Frenkel and Schottky defects – dislocations – geometry of edge and screw dislocations – Burger vector – energy of a dislocation – stress to move a dislocation – critical resolution shear stress – slip systems in crystalline solids – dislocation multiplication – dislocation interactions with other defects – grain boundaries – stacking faults and twins.

UNIT II

Classification of alloys – Hume-Rothery rules – dendrites – constitutional super cooling – segregation and zone refining – formation of solid solutions – intermediate phases.

UNIT III

Phase diagrams : Free energy composition curves – Lever rule – Eutectic, peritectic and peritectoid systems – Solid state reactions – Industrially important equilibrium diagrams – Fe-C system – Copper alloys – Magnesium alloys – Titanium alloys – Experimental methods of determining equilibrium diagrams – Non-equilibrium structure – TTT diagram – Hyper eutectoid steels – effect of alloying.

UNIT IV

Critical temperature in steel – Banite and martensite transformations in steel. Hardness and hardenability. Hardenability test, Annealing, Normalising, Hardening, Spheroidising, Martempering and Austempering. Casehardening processes – Carburising, cyaniding and carbonitriding, nitriding, Flame hardening and induction hardening.

UNIT V

Categories of phase – Transformations – Transformation in the solid state – Spinodal decomposition – Recovery, recrystallization and grain growth – Powder metallurgy and sintering metallic glasses.

TEXT BOOKS

1. Van vlack, Elements of Materials Science, Addison & Wesley, 1964.
2. Raghavan, Physical Metallurgy – Principles and Practice, Prentice Hall India, 1993.
3. Raghavan, Materials Science and Engineering, Prentice Hall of India Private Limited, New Delhi, 2003.

REFERENCES

1. A.C. Guy and Hren, Elements of Physical Metallurgy, Oxford University Press, 1974
2. S.Clark and R.Varnery, Physical Metallurgy, Affiliated East Press, 1962
3. R.E.Reedhill, Physical Metallurgy Principles, Affiliated East West Press, New Delhi,1973
4. John Wulff et al., The structure & properties of Materials, Vol.II, John Wiley, 1964.
5. Irving Granet, Modern Materials Science, Reston Publishing Co., 1980
6. S.H.Avner, Physical Metallurgy, McGraw Hill, 1974.

PH 824 - CRYSTAL GROWTH AND CHARACTERISATION

Unit I: Materials Purification:

Distillation, Sublimation, Precipitation – liquid – liquid extraction, ion exchange, gas and liquid chromatography and Zone melting.

Unit II: Growth of Single Crystals:

Classification of growth processes, equilibria in Crystal growth – mono component solid state equlibria. The distribution coefficient phase diagrams, conservative and non conservative processes. Constitutional supercooling.

Unit III: Growth Kinetics:

Driving force, crystal morphology, possible types of interfaces. Nucleation – critical size of homogeneous and heterogeneous nuclei, rate of homogeneous nucleation, growth of solid – atomic mechanism, growth rate on diffuse interface and faceted interface.

Unit IV: Growth Technique:

Solid state equilibria: Strain and annealing, Sintering and polymorphic transition – Solid State Equilibria : Bridgmann- Stockbarger technique, Czochralski and Kyropolous – Zone melting and other crucible less techniques. Dendrite growth. – Vapour Solid Equilibria: Sublimation – condensation, sputtering, growth by irreversible reactions – Growth from solution: aqueous-solution growth, Hydro-thermal growth and molten salt growth – Gel growth.

Unit V: Crystal Characterization:

Review of crystal systems – orientations and planes. Orientation of crystals by optical and x-ray methods. Crystal cutting and polishing. Observation of defects in crystals (optical microscopy). Thermal , optical and mechanical properties of crystals (qualitative study).

Text Books:

1. Physical and Chemical Methods of Separation, Eugence W. Berg, Mc Graw Hill Co., 1963.
2. Methods of Experimental Physics, Marton L., (ed) Vol. 64, Academic Press 1959.
3. The Growth of Single Crystals, Laudise, R.A., Prentice Hall, 1970.
4. Phase Transformations in Materials, Jain, A.K. and Chaturvedi, Prentice Hall, 1972.
5. The Growth of Single Crystals from Liquids, J.C. Brice, North Holland, 1973.
6. Crystal Technology, W.L. Bond, John Wiley & Sons, New York, 1976.

Reference Books:

1. Instrumental Methods in Chemical Analysis, G.W. Wing, McGraw Hill Co., 1975.
2. Crystal Growth and Characteristation, R. Veda and J.B. Mullin (ed), North Hill, 1975.

PH 825 - CORROSION SCIENCE AND ENGINEERING

UNIT I

Importance of corrosion prevention in various industries: The direct and indirect effects of corrosion – The free energy and oxidation potential criterion of uniform corrosion – the pilling Bed work ratio and it consequences – the units corrosion rate – mdd and mpy – The importance of pitting factor – Pourbaix digrams of Mg, Al. and Fe – Their and limitations

UNIT II

Localized corrosion: The electro chemical mechanism Vs. The chemical mechanism – Galvanic corrosion – Area effect in anodic and cathodic metal coatings, Organic coatings of bimetallic systems – prediction using emf Series and Galvanic series – Crevice corrosion – Mechanism of differential oxygenation corrosion – Auto catalytic mechanism of pitting due to crevice or differential oxygenation corrosion –

Principles and procedures of cathodic protection: Sacrificial anodes and external cathodic current impression – stray current corrosion

UNIT III

Intergranular corrosion: Stainless steels – cause and mechanism (Cr- Depletion theory) – Weld decay and knife line attack – Stress corrosion and fatigue corrosion – Theory of critical corrosion rate in corrosion fatigue.

Cavitation damage – Fretting damage – Atmospheric corrosion – Bacterial corrosion – Marine corrosion – Control methods. High temperature Oxidation of metals – Ionic diffusion through protective oxides – Classification on the basis of kinetics or rates of oxidation.

UNIT IV

Kinetic aspects of corrosion: Over potential activation and concentration over potentials – Exchange current density – Mixed potential theory – corrosion rates of Fe. And Zn. In air – free acid – effect of oxidizing agents – Phenomenon of passivation – Theories – effect of oxidizing agents and velocity of flow on passivating metals – effect of galvanic coupling of Fe. and Ti respectively with Platinum – Noble metal alloying – anodic protection.

UNIT V

Corrosion in inhibition: Inhibiters of corrosion – passivators, adsorbing inhibiters, V.P. inhibiters. Prevention of galvanic crevice, inter granular, Stress and fatigue corrosion at the design stage and in service conditions – control of catastrophic oxidation and Hydrogen disease - control of Bacterial corrosion – Langelier saturation Index and its uses.

Corrosion prevention by Coatings – Surface pre- treatment – Hot dip, diffusion and cladded coatings – Phosphating and its uses.

TEXT BOOKS:

1. Fontanna, “Corrosion Engineering”, McGraw Hill, 1987.
2. Uhlig H.H, “Corrosion and its control”, Willey, 1985.
3. Fontanna, “Corrosion Engineering”, (Materials Science and Metallurgy series), third edition, McGraw Hill inter national Ed., 1987
4. Kenneth R. Trethewey and John Chamber lain, “Corrosion for Students of Science and Engineering”, Long Mann Scientific and Technical edition, 1988.

REFERENCE BOOKS:

1. Pludek, “Design and corrosion prevention”, McMillan, 1978.
2. Raj Narain, “Introduction to metal corrosion”, Oxford IBH, 1983.

PH 826 - Introduction to Nanotechnology

Unit-1: Introduction to Physics of Solid State

Intermolecular forces: thermodynamic aspects - Quantum Mechanical Treatment of the Many-Particle Problem - Potential Energy Surface - Pair Potential Approximation - Advantages and Limitations of the Pair Potential Approximation - Phenomenological Potentials - Pseudo-Potentials - Many-Body Potentials.

Unit - 2: Fundamentals of nanoscience

Size dependence of properties - Particle size determination - Bulk to nano transition - Semiconducting nanoparticles - Carbon nanostructures - Mechanical properties (hardness, ductility, elasticity) - Optical properties of nanotubes - Electrical properties of nanotubes.

Unit - 3: Preparation of nanosystems.

Introduction to nanolithography - Carbon nanotubes: preparation - Synthesis and preparation of nanomaterials (crystalline and thinfilm) - Physical and chemical methods - Control and stability (size, shape, composition).

Unit - 4: Characterization of nanosystems.

Thermal Stability - Basic Material Properties - Mean Values and Correlation Functions - X-ray diffraction - Scanning Electron Microscopy - Scanning Tunneling Microscopy - Electron Microscopy - X-ray absorption spectroscopy - Photoelectron emission spectroscopy.

Unit - 5 : Nano-Engineering: Applications

Nanotubes, nanowires, and nanodevices-introduction - Functional Nanostructures - Introduction to molecular electronics - Field emission and Shielding - Applications in Computers - Applications in fuel cells - Applications in chemical sensors - Applications in mechanical reinforcement - Microelectromechanical systems (MEMs) - Nanoelectromechanical systems (NEMs) - Molecular and Supramolecular Switches.

Text Books:

1. Charles P. Poole and Frank J Owens. *Introduction to nanotechnology*. Wiley Interscience, 2003. (US $ 80.00).
2. Crandall, B. C. and Lewis, James (Eds.) *"Nanotechnology: Research and Perspectives"* MIT Press, 1992.
3. P E J Flewitt, R K Wild. ***Physical Methods for Materials Characterization. 2nd Edition***, Institute of Physics Publishing, UK. 2004.
4. Gottstein, Günter. (2004) *Physical Foundations of Material Science*. Springer Verlag.
5. Cleland, Andrew N. (2003). *Foundations of Nanomechanics*: *From Solid-State Theory to Device Applications*. Springer Verlag.

References for further study:

1. J M Vail, Winnipeg. *Topics in the Theory of Solid Materials*. Institute of Physics Publishing, UK. 2004.
2. M W Barsoum. *Fundamentals of Ceramics*. Institute of Physics Publishing, UK. 2004.
3. A S Edelstein, R C Cammarata, *Nanomaterials: Synthesis, Properties and Applications*. IOP Publishing, UK, 1998. ($70.00)

4. Bhushan, Bharat (Ed.) (2004) *Springer Handbook of Nanotechnology* (With CD-ROM) ISBN: 3-540-01218-4 (EURO 200.00)
5. Awschalom, D.D.; Loss, D.; Samarth, N. (Eds.) (2002) *Semiconductor Spintronics and Quantum Computation*. Springer Verlag. ISBN: 3-540-42176-9 (EURO 70.00)
6. Vincenzo Balzani. *Molecular Devices and Machines : A Journey into the Nanoworld* Wiley VCH, 2003, ($92.00).
7. Peidong Yang. *Chemistry of Nanostructured Materials*. World Scientific, 2004. ($84.00)
8. Andrzej W. Miziolek et. al., *Defense Applications of Nanomaterials* American Chemical Society, 2004. ($150.00)
9. Liming Dai. *Intelligent Macromolecules for Smart Devices: From Materials Synthesis to Device Applications (Engineering Materials and Processes*. Springer Verlag 2004. ($150.00)
10. Michael Rieth. *Nano-engineering in Science and Technology: An Introduction to the World of Nano-Design*, World Scientific, 2003. ($26.00).
11. Hari Singh Nalwa. *Handbook of nanostructured materials and nanotechnology.* 5 volume set, 3583 pages; (US $ 1500.00). Academic Press, 2000.