Rs. 15/-

NORTH MAHARASHTRA UNIVERSITY
JALGAON - 425 001

SYLLABUS

FOR

M.Sc. [MATERIAL SCIENCE]

FROM JUNE, 1992.

SEMESTER I TO IV

DEPARTMENT OF PHYSICAL SCIENCES

SYLLABUS

for

M.Sc. [PHYSICS with MATERIAL SCIENCE specialization]

SEMESTER I

MS 101 : Mathematical Methods for Physical Sciences.

MS 102 : Classical Mechanics.

MS 103 : Quantum Mechanics.

MS 104 : Electronics.

MS 105 : General Laboratory I

SEMESTER II

MS 201 : Solid State Physics I

MS 202 : Electrodynamics.

MS 203 : Statistical Mechanics.

MS 204 : Computational Methods and Computer Programming

MS 205 : General Laboratory II.

SEMESTER III

MS 301 : Physics of Semiconductor Devices.

MS 302 : Atomic and Molecular Physics

MS 303 : Elements of Materials Science.

MS 304 : Special Laboratory I.

MS 305 : Project

SEMESTER IV

MS 401 : Solid State Physics II

MS 402 : Techniques in Materials Characterization

MS 403 : Physics of Thin Films

MS 404 : Special Laboratory II.

MS 405 : Project

MS 101 : MATHEMATICAL METHODS FOR PHYSICAL SCIENCES

1. LINEAR SPACES

Introduction to finite dimensional spaces, Linear dependence, basis and dimension, Subspace, Linear operators, Representation theory of operators, Eigen function and eigenvalues, Strum Liouville theory, Self adjoint differential equation, Hermitian operator, Schmidt Orhtogonalization, Inner product and normal spaces, Schwartz inequality.

2. MATRICES

Basic definitions of matrices, Eigenvalue equation, eigen vectors and eigen values, Hermitian, Unitary, Orthogonal, Inverse matrices and their properties, Similarity transformations, Diagonalisation, Pauli's spin matrices, Dirac matrices and their properties.

3. INTEGRAL TRNSFORMS

Fourier series, odd and even functions, half range Fourier Sine and Cosine series, Complex form of Fourier series, Parseaval's identity for Fourier series, Finite Fourier transform, Fourier integral, Fourier transform - sine and cosine transform, the convolution theorem, Parseval's identity for Fourier transform

Laplace transform : Definition, important theorems on Laplace transforms, Inverse Laplace transform, methods of finding inverse Laplace transform by partial fractions, convolution theorm,Applications of Laplace transform.

4. SPECIAL FUNCTIONS

Bessel functions, bessel differential equations, generating function, orthogonality of Bessel functions, properties of Bessel functions, intoduction to second kind Bessel function.

Hermite functions,Hermite differential equation, generating function, orthogonality of Hermite functions, properties of Hermite functions.

Legendre functions, Legendre differential equation, generating function, orthogonality of Legendre functions, properties of Legendre functions.
Dirac delta function and its properties.

5. TENSOR ANALYSIS :

Contravarient and covariant vectors and tensors, Mixed tensor, scalars, Kronecker delta, symmetric and skew symmetric tensors, fundamental operation with tensors, Metric tensor, raising and lowering of suffixes, Dyclics.

REFERENCES

1. Mathematical methods for Physicist
G. Arfken,Academic Press, 1985.
2. Mathematical Methods for Physics
J.Mathew and R.L.Walker, Benjamin (IBH), 1979.
3. Linear Algebra
Lipsuitz, Schaum's Series.
4. Mathematics for Physics and Chemistry, Vol.I
H.M.Margenau and G.M.Murphy, East-West Press.

MS 102 : CLASSICAL MECHANICS

1. Mechanics of a particle and system of particles - Applications and problems.

2. VARIATIONAL PRINCIPLE :

Configuration space, some techniques of calculus of variations, d-notation, applications of variational principle; equivalence of Lagrange's and Newton's equations, advantages of the Lagrangian-formulation, electromechanical analogies, Lagranges undetermined multipliers, Lagranges equation for non-holonomic systems, application of Lagrangian method of undetermined multipliers.

3. HAMILTON'S EQUATIONS AND ITS APPLICATIONS :

Hamilton's function and Hamilton's equation of motion, Properties of the Hamiltonian and Hamiltonian's equation of motion, Phase space and state space.

4. CANONICAL TRANSFORMATIONS AND THE POISSON BRACKET :

Gauss transformation, canonical transformation, condition for transformation to be canonical, generating functions, properties of canonical transformations, canonical transformation of the free particle, Hamiltonian, Poisson bracket-definition, some useful indentities, Poisson theorem, Jacobi-Poisson theorem, invariance of Poisson bracket under canonical transformation, Lagrange bracket.

5. HAMILTON-JACOBI THEORY :

Hamilton-Jacobi equation, separation of variables, Jacobi's theorem, connection with canonical transformation, applications of Hamilton-jacobi theory, action angle variables.

6. SMALL OSCILLATIONS :

Types of equillibria and the potential at equiilibrium, study of small oscillations using generalised coordinates, eigen vectors and eigen frequencies, orthogonality of eigen vectors small oscillations of particle on string.

7. RIGID BODY MOTION :

Euler's angles, moment of inertia tensor, its eigen value and principle axis transformation, method of solving rigid body problems and Euler's equations of motion.

REFERENCES

1. Classical Mechanics, Ed.II
   H.Goldstein, Addison Wesley, 1980.
2. Introduction to Classical Mechanics
   R.G.Takwale and P.S.Puranic, Tata McGraw Hill Company
3. Introduction to the Principles of Classical Mechanics
   Hauser, Addison Wesley.
4. Classical Mechanics
   N.C.Rana and P.S. Joag, Tata McGraw Hill Company, 1991
5. Classical Mechanics
   Y.R.Waghmare, Prentice Hall of India.

MS 103 : QUANTUM MECHANICS

1. GENERAL FORMULATION OF WAVE MECHANICS :

Fundamental postulates of wave mechanics, correspondance principle, eigenvalues, eigenfunctions, completeness and normalization of wavefunctions, closure property, expansion coefficients, eigen functions in momentum space, introduction to bra and ket notation and their properties.

2. OPERATORS IN QUANTUM MECHANICS :

Operators, their eigenvalues and eigenfunctions, Hermitian, Unitary, parity operators and their properties, Commutators- definition, commutator algebra, fundamental commutators in quantum mechanics, commuting operators and their physical significance. Solution of 1-D Harmonic Oscillator using ladder operators.

3. ANGULAR MOMENTUM

Angular momentum operator, Linear momentum operator as generator of translation, orbital angular momentum operator as generation of rotation, eigen values and eigenfunctions of L^2 and L_z using explicit forms of L^2 and L_z in spherical co-ordinates, Various commutation relations between L^2, L_x, L_y and L_z. determination of eigenvalue spectrum of J^2, J_z where J is any angular momnetum operator, Addition of two angular momenta : development of the necessary theory, Clebesch-Gordon coefficients.

4. MATRIX FORMULATION IN QUANTUM MECHANICS

Matrices in Quantum Mechanics, transformation theory, Unitary matrix, Projection operator.

5. APPROXIMATE METHODS IN QUANTUM MECHANICS

Variational mehtod : General characteristics of the method, application to estimation of energy of ground state and excited state.

Time independent perturbation theory : Stationary perturbation theory for degenerate and non-degenerate case; first order and second order perturbation, Applications to problems such as perturbation of an oscillator, Zeeman effect without electron spin, first order Stark effect in Hydrogen.

REFERENCES :

1. Quantum Mechanics
   L.I. Schiff, Mc Graw Hill, Koga Kusha, 1968.
2. A text book of Quantum Mechanics
   P.M.Mathew and K.Venkatesan, Tata Mc Graw Hill, 1981.
3. Quantum Mechanics, Vol.I
   A. Messiah, North Holland, 1972.
4. Quantum Mechanics,
   E.Merzbacher, Wiley Eastern, 1970.
5. Quantum Mechanics,
   A.K.Ghatak and S.Lokanathan, MacMillan India, 1979.
6. Quantum Mechanics,
   A.S.Davydov, Pergamon Press, 1976.

MS 104 : ELECTRONICS

1. DIODES AND CIRCUIT APPLICATIONS:

Forward bias and reverse bias I-V characteristics,ideal diode,diode large signal and small signal model.
Applications: Rectifiers, Clipping or limiting circuits,Clamping,Voltage multipliers,Amplitude demodulation, Diode logic gates.

2. BIPOLAR JUNCTION TRANSISTORS:

Transistor operation(p-n-p & n-p-n), characteristics (input, output & transfer),small signal and large signal models,common base,common emitter and common collector configurations,Biasing circuits:Fixed and self biasing,Design of Biasing circuit,load line(ac and dc),Transistor as an amplifier,Transistor as a switch.

3. FET and MOSFET:

Juction FET,I-V characteristics,JFET as an amplifier, Comparision with BJT, MOSFET (depletion and enhancement type),Biasing circuit for JFET and MOSFET.

4. FEEDBACK AMPLIFIERS AND OSCILLATORS:

Basic concept of feedback,positive feedback,negative feedback,Advantages of negative feedback,Effect of negative feedback on gain,input impedance,output impedance,bandwidth, noise and distortion.

Feedback configurations: shunt-shunt, series-series, series-shunt and shunt-series.

Oscillators: Sinusoidal oscillators, nonsinusoidal oscillators, RC oscillators and LC oscillators, Phase shift, Wien bridge, Colpitt, Hartley and tuned circuit, crystal oscillators.

5. OPAMP and Applications:

Ideal OPAMP parameters,Basic circuit block, input and output offset current and voltages,bias current,slew rate, Inverting amplifier, non-inverting amplifier, voltage follower, comparator, integrator and differentiator, logarithmic amplifier.

6. POWER SUPPLIES :

ERPS using IC 723, design of positive voltage regulator, concept of negative regulator. Extension to high voltage and high current. Concept of constant current source and DC to DC convertor. Three terminal regulators, 78XX and 79XX series voltage multipliers, SCR controlled power supplies. Programmable power supplies.

7. INTRODUCTION TO NUMBER SYSTEMS AND LOGIC GATES

Number systems: Binary, octal, hexadecimal, BCD, Gray, ASCII, EBCDIC, Excess- 3 code etc. and their interconversion.

Basic logic operations: NOT, OR and AND, Positive and negative logic,

logic gates: AND, OR, NOT, XOR, NOR, NAND, NAND and NOR as a universal building blocks, Standard TTL NAND gate,IC gates, Propagation delay, fan in, fanout, power dissipation etc.

8.FLIP FLOPS . MULTIVIBRATORS AND ARITHMATIC CIRCUITS:

SR latch,JK flip flop, JK master slave flip flop, D flip flop, T flip flop.

Multivibrator circuits: Monostable, astable and bistable, FF as a bistable multivibrator circuit, IC 555 as a timer, Multivibrator circuits using IC 741 and IC 555.

Arithmetic circuits: Binary addition and substraction, Half adder, Full adder and substractor circuits.

REFERENCES :

1. Electronic Principles,
   A.P.Malvino, McGraw Hill Company.
2. Electronic Fundamentals and Applications,Edition 5
   J.D.Ryder, Prentice Hall of India, 1981.
3. Integrated Electronics
   J.Millman and C.C.Halkias, Mc Graw Hill Company, 1981.
4. Electronic Devices and Circuits,
   A.Mottershead, Prentics Hall of India, 1981.
5. Operational Amplifiers,
   G.B.Clayton, Butterworth.
6. Digital Principles and Applications, Edition 4
   A.P.Malvino and D.P.Leach, McGraw Hill Company.

MS 105 : GENERAL LABORATORY I

PART- A

1. Electronically regulated power supply using IC 723 and measurements of performance with DMM.
2. Operational Amplifier - Characteristics and parameter measurements.
3. Differential Amplifier - Characteristics and parameter measurements.
4. Voltage to Frequency convertor using IC 741.
5. Design, build and test Wien bridge oscillator.
6. Design,build and test Phase shift oscillator using IC 741/transistor.
7. Study of Multivibrators.
8. Verification of De Morgan's theorem using logic gates.
9. Study of ADDER and SUBTRACTER circuits using logic gates.

PART - B

1. Resistivity of germanium at various temperatures using Four probe method.
2. Fermi level determination as a function of temperature.
3. Study of thermionic emission and determination of work function.
4. Measurements of ultrasonic velocity in liquids.
5. Study of the dispersion relation for the monoatomic lattice and diatomic lattice.
6. Energy band gap measurement of a semiconductor.
7. Ionic conductivity of NaCl.
8. Study of temperature to frquency convertor.
9. Determination of ultrasonic velocities in metals, polymers et

Note : Students are advised to complete at least 6 experiements from each part.

MS 201 : SOLID STATE PHYSICS I

1. THE CRYSTALLINE STATE

Miller Indices, Bravais lattices, interplanar distances, some simple crystal structures such as NaCl, CsCl, ZnS, Diamond, HCP etc. Wigner Seitz cell, The reciprocal lattice and its properties.

2. DIFFRACTION OF X-RAYS BY CRYSTALS

Crystal as a grating for X-rays, Bragg's diffraction condition- in direct lattice and in reciprocal lattice.. X-ray diffraction, geometrical structure factor, atomic structure factor for FCC, BCC and diamond structure. X-ray diffraction methods - Laue, rotating crystal and powder method, Analysis of cubic crystal by powder method.

3. PHONONS AND LATTICE VIBRATIONS

Vibrations of monoatomic lattice, Lattice vibrations of diatomic lattice, Optical and acoustic modes of vibrations, quantization of lattice vibrations, phonons, phonon momentum, inelastic scattering of neutrons by phonons, lattice heat capacity, Einstein's model of heat capacity, density of modes in one and three dimensions, Debye T^3 law, Anharmonic crystal interactions and thermal expansion, thermal conductivity, Umklapp processes.

4. FREE ELECTRON THEORY OF METALS

Free electron model, energy levels and density of orbitals in one dimension and three dimensions, Thermionic emission from metals, Field enhanced electron emission from metals, changes of work function due to adsorbed atoms, Hall effect in metals.

5. BAND THEORY OF METALS

Periodic potential, Bloch theorem, Kroning penny model,reduced zone scheme, effective mass of electron, nearly free electron model, origin of energy gap, tight binding approximation, Wigner-Seitz method, APW method, OPW and pseudo potential.

REFERENCES

1. Solid State Physics,
A.J.Dekkar, Mc Millan Students Ed.

2. Introduction to Solid State Physics,
C.Kittel, Wiley Eastern Ltd., Edition 5

3. Solid State Physics,
C.M.Kachhava, Tata Mc Graw Hill Edition.

4. Solid State Physics,
N.W.Ashcroft and N.D.Mermin, Holt- Saunders International Ed.

5. Solid State Physics,
L.Azzroff, Tata Mc Graw Hill Edition.

MS 202 : STATISTICAL MECHANICS

1. Specification of the state of system (classical as well as quantum), Phase space, Liouville's theorem, statistical ensemble, accessible states, postulate of equal a priori probability, density of states and its behaviour for ideal monoatomic gas in classical limit, statistical definition of entropy.

2. ENSEMBLES AND THERMODYNAMIC QUANTITIES :

   Microcanonical ensemble, canonical ensemble, Grand canonical ensemble, partition function, evaluation of thermodynamic quantities from partition function, application to ideal gas, Gibb's paradox.

3. FORMULATION OF QUANTUM STATISTICS :

   Density matrix, Liouville's theorem in quantum statistical mechanics, condition for statistical equilibrium, ensembles in quantum mechanics.

4. MAXWELL BOLTZMANN, BOSE EINSTEIN AND FERMI DIRAC STATISTICS :

   The various statistics in quantum mechanics, quantum distribution functions, the Boltzmann limit of Bose Einstein and Fermi Dirac gas, evaluation of the partition function, partition function of diatomic molecules, equation of state of an ideal gas.

5. IDEAL BOSE SYSTEM :

   Photon gas, Planck's law, Bose Einstein condensation, Ideal Fermi system : Fermi energy, mean energy of Fermion at T= o K, electron gas, Fermi energy as a function of temperature, electronic specific heat.

6. Boltzmann transport euation, electrical conductivity using Boltzmann transport equation.

REFERENCES :

1. Fundamentals of Statistical and Thermal Physics,
   F.Reif, Mc Graw Hill Company.
2. Statistical Mechanics,
   Kerson Huang, Wiley Eastern Ltd., 1963.
3. Introduction to Statistical Mechanics,
   B.B.Laud, Macmillan, India, 1981.
4. Statistical Mechanics,
   J.E.Mayer and M.G.Mayer, John Wiley, 1940.
5. Statistical Physics, Ed.II
   L.D.Landau and E.M.Lifshitz, Pergamon Press, 1958.
6. Statistical Physics,
   R.K.Pathria, Pergamon Press, 1972.

MS 203 : ELECTRODYNAMICS

1. MAXWELL'S EQUATIONS :

Electrodynamics before Maxwell, modification of Ampere's law, Maxwell's equations, magnetic charge, Faraday's law for moving media, Maxwell's equations for moving media.

2. ENERGY, FORCE AND MOMENTUM RELATION IN ELECTROMAGNETIC FIELD

Energy relations in quasi stationary current system, force on a current stystem, Inductance, Magnetic volume force, general expressions for electromagnetic energy-Poynting's theorem.

3. WAVE EQUATION FOR ELECTROMAGNETIC FIELDS :

The wave equations, plane waves, radiation pressure, plane waves in moving media, reflection and refractions at plane boundaries, the waves in conducting media, metallic reflection.

4. THE INHOMOGENEOUS WAVE EQUATION :

Scalar and vector potentials, Gauge transformations, Coulomb gauge and Lorentz gauge, the wave equation for potentials, solution by Fourier analysis, radiation fields, Hertz potential, electric dipole radiation.

5. COVARIANT FORMULATION OF ELECTRODYNAMICS :

Experimental basis for special relativity, the Lorentz transformations, law of velocity addition, the Lorentz transformation of Four vector, four velocity, four accelaration, four momentum, relation between energy momentum and mass, the Minkowski force, four vectors to charge and potential, electromagnetic field tensor, Lorentz force, invariance of Maxwell's field equations under relativistic (Lorentz's) transformation, covarience and tensor form of Maxwell's field equation, covarience form of Lorentz transformation.

REFERENCES

1. Classical Electrodynamics, Ed.II
   W.K.H. Panfsky and M.Philips, Addison-Wesley, 1962.
2. Classical Electrodynamics, Ed.II
   J.D.Jackson, Wiley Eastern Company Ltd.,1978.
3. Foundations of Electromagnetic Theory, Ed.II
   J.R.Reitz and F.J.Milford, Addison Wesley, 1967.
4. Introduction to Electromagnetic Fields and waves,
   D.R.Corson and P.Lorrain, Freeman, 1962.
5. Classical Electrodynamics, Ed.II
   Griffits, Prentice Hall of India.
6. Electromagnetics, Ed.II
   B.B.Laud, Wiley Eastern Ltd.

MS 204 : COMPUTATIONAL METHODS IN PHYSICAL SCIENCES

I. Some Computer Programming Topics :

Functions and Subroutines, Common Block and Equivalence declarations.

II. Numerical Mehtods in FORTRAN :

In the following topics on numerical methods, students are expected to be able to write programs, subprograms or program segments as well as perform numerical calculations using electronic calculators and mathematical tables.

1. ITERATIVE METHOD FOR SOLUTION OF ALGEBRAIC EQUATIONS

Newton Raphson method, iteration method, method of false position, rate of convergence, comparision of these methods, choice of an iterative method and implementation.

2. SOLUTION OF SIMULTANEOUS EQUATIONS

Directs methods - Cramer rule, Gauss elimination method, pivotal condensation, iterative methods, -Gauss Seidal method, Jacobi method.

3. INTERPOLATION

Lagrange and Newton interpolation methods, Finite differnece operators, interpolating polynomials using finite differences, differnece tables- central, forward, backward.

4. NUMERICAL INTEGRATION

Methods based on interpolation, methods based on undetermined coefficients, composite integration methods- Trapezoidal and Simpson's rules, double integration [derivation applications and errors in the formulae, comparison of two formulae].

5. NUMERICAL DIFFERENTIATION

Methods based on interpolation, finite differences and undetermined coefficients

6. SOLUTION OF DIFFERENTIAL EQUATIONS

Numerical methods-Euler's method, Modified Euler method, Single step methods- Taylor series method, Runge Kutta methods, Multistep methods, Stability analysis.

REFERENCES

1. Programming with FORTRAN 77, Ram Kumar, Tata Mc Graw Hill Company.

2. Introductory methods of Numerical Analysis, S.S.Sastry, Prentice Hall of India.

3. Numerical Mathematical Analysis, J.B.Scarborough, Oxford, 1964.

4. Computer Programming in FORTRAN IV, V.Rajaraman, Prentice Hall of India, 1974.

5. Computer Oriented Numerical Methods, V.Rajaraman, Prentice Hall of India.

MS 205 : GENERAL LABORATORY II

1. Draw the flow-chart and write a programme to find the root of the equation F(x) = 0 by Newton Raphson method.
2. Draw the flow-chart and write a programme to find the root of the equation F(x) = 0 by Iteration method.
3. Draw the flow-chart and write a programme to find the root of the equation F(x) = 0 by False position method.
4. Draw the flow-chart and write a programme to integrate the given function using Trapezoidal rule.
5. Draw the flow-chart and write a programme to integrate the given function using Simpson's 1/3 rule.
6. Draw a flow-chart and write a programme for fitting of a polynomial of degree n using Lagrange's interpolation formula.
7. Draw a flow-chart and write a programme to solve a given differential equation using Euler's simple and modified method.
8. Draw a flow-chart and write a programme to solve a given differential equation using Runge Kutta method.
9. Draw a flow-chart and write a programme to solve given set of simultaneous equations using Gauss elimination method.
10. Draw a flow-chart and write a programme to solve given set of simultaneous equations using Gauss Seidal elimination method.
11. Draw the flow-chart and write a programme to integrate the given function using Simpson's 3/8 rule.
12. Draw a flow-chart and write a programme for finding the inverse of a given matrix.
13. Write a programme for finding the transpose of a matrix.

MS 301 : PHYSICS OF SEMICONDUCTOR DEVICES

1. PROPERTIES OF SEMICONDUCTORS

Review of crystal structures and Energy bands of semiconductors (Ge, Si, GaAs, IV-V, III-V, II-VI compound semiconductors), charge carriers, minority and majority carriers, excess carriers and life time, diffusion of carriers and Einstein's relation, Intrinsic and extrinsic semiconductors, Position of Fermi level, degenerate and non-degenerate semiconductors, carrier concentration in degenerate and non-degenerate cases, current transport, internal field in a semiconductor with non-uniform doping.

2. MEASUREMENT OF ELECTRICAL PARAMETERS OF SEMICONDUCTOR

Resistivity, mobility, carrier concentration, carrier types by Hall effect, Haynes-Schockley experiment-mobility, diffusion constant and life time of minority carriers.

3. P-N JUNCTION DEVICES

The junction diode : Junction in equilibrium, junction with forward and reverse bias, current-voltage characteristic of junction diode, electron hole injection efficiency, the geometry of the depletion layer, depletion layer capacitance, diffusion capacitance, Small signal equivalent circuit of a P-N junction, switching characteristic, Breakdowns in P-N junctions.

Zener Diode : Reverse bias breakdown, principle of operation, device design for particular breakdown voltage.

Varactor Diode : Capacitance of p-n junction, principle of operation, equivalent circuit, power relation, applications.

Tunnel Diode : Degenerate semiconductors, principle of operation, circuit operation, applications as an oscillator.

P-I-N Diode : Intrinsic layer, principle of operation behaviour of forward and reverse bias, equivalent circuit, applications.

4. METAL-SEMICONDUCTOR JUNCTION DIODE

Structure, metal-semiconductor contact, energy band diagram for different cases, barrier formation, Schottky diodes-principle of operation, current transport theory and applications.

5. BIPOLAR JUNCTION TRANSISTOR

Structure, the principles of operation, the Ebers-Moll equations and large signal transistor model, the dependence of Ebers-Moll parameters on the structure and operating point, maximum transistor current, voltage and power rating, transistor as a switch.

6. FIELD EFFECT TRANSISTOR

JFET, Principle of IGFET, MOS capacitor, MOS transistor operation, charge coupled devices (CCD), MOS transistor as a memory elements.

7. **POWER SEMICONDUCTOR DEVICES**

General consideration, bipolar power transistor, thyristor family - the SCR , diac and triac.

8. **NEGATIVE CONDUCTANCE MICROWAVE DEVICES**

IMPATT devices - Read diode, principle of operation, applications, other structures.

GUNN devices - two valley semiconductors, transferred electron mechanism, formation and drift of space charge domain, applications in resonant circuits.

REFERENCES

1. Solid State Electronic Devices
   B. G. Streetman, Printice Hall of India

2. Semiconductor and Electronic Devices
   Adhir Bar-Lev,Printice Hall of India.

3. Physics of Semiconductor Devices
   S.M.Sze, Wiley Eastern Ltd.

4. Semiconductor Devices and Circuits
   Henry Zanger, John Wiley and Sons.

5. Physics of Microwave Semiconductor Devices
   and their applicatión
   H.A.Watson

MS 302 : ATOMIC AND MOLECULAR PHYSICS

1. ATOM MODEL FOR TWO VALENCE ELECTRONS

LL coupling, SS coupling. LS coupling, Pauli exclusion principle, coupling schemes for two electrons, factors for LS coupling, Lande interval rule, branching rule, selection rules, intensity relations.

Magnetic moment of the atom, Zeeman effect, intensity rules, calculation of Zeeman pattern, Paschen back effect LS and JJ coupling and Paschen back effect, Breits scheme for derivation of spectral terms, Paulis exclusion principle.

2. COMPLEX SPECTRA

Displacement law, alteration law of multiplicities, vector model for three more valence electrons, Lande interval rule, inverted terms, Hund's rule.

Zeeman effect and magnetic quantum nos. in complex spectra, magnetic energy and Lande g factor, Paschen back effect in complex spectra.

3. HYPERFINE STRUCTURE

Introduction, hyperfine structure, and Lande interval rule, nuclear interaction with one valence electron, hyperfine structure of two or more valence electrons, Zeeman effect in hyperfine structure, Back Goudsmit effect in hyperfine structure.

4. PURE ROTATION SPECTRA

Rotation of a linear system (classical and quantum mechanical), rigid rotator, rotational energy levels and their populations, interaction of radiation with rotating molecules, rotational spectra of rigid rotators, selection rules for linear molecules, determination of moment of inertia and bond length from rotational spectra, relative intensities of spectral lines, Stark effect in molecular rotational spectra, molecular rotation-nuclear spin coupling.

5. VIBRATIONAL SPECTRA

Vibrations of a single particle, vibrations of two particles connected by a spring (classical), Harmonic oscillator, vibrational energies of diatomic molecules, interaction of radiation with vibrating molecules, vibrational spectra of diatomic molecules, anharmonic oscillator, deduction of molecular properties from vibrational spectra of diatomic molecules.

6. ROTATION - VIBRATION SPECTRA

Diatomic vibrating rotator coupling of rotation and vibration, rotation-vibration spectra, selection rules and transitions for the vibrating rotator, intensities in rotation and vibration spectrum, Parallel and perpendicular bands of Linear molecules, Isotope effect-vibration, rotation.

7. **ELECTRONIC SPECTRA OF DIATOMIC MOLECULES**

Electronic energy, potential energy curves, stable and unstable molecular states, vibrational structure of electronic transitions, general formula, graphical representation, isotope effect, rotational structure of electronic spectra, the branches of band, band head formation, shading of bands: Fortrat diagram, isotope effect, intensities in electronic bands-vibrational structure- Franck condon principle, absorption and emission, rotational structure, transition.

REFERENCES

1. Atomic Spectra - White H.E.
(for topic 1 to 3)

2. Introduction to Molecular Spectroscopy - C.M.Barrow, M.Graw Hill, International Edition.
(for topic 4 to 6)

3. Spectra of diatomic molecules - Hersberg.
(for topic 7)

4. Atomic Structure and Chemical Bond - Manas Chanda. Mc.Graw Hill

MS 303 : ELEMENTS OF MATERIAL SCIENCE

1. **Classification of Materials**

   Selection of materials, Competetion among the different types of materials, Selecting an optimal metal, Modern material needs, Structure proper types processing relationships in materials.

2. **Properties of materials**

   Mechanical Properties: Mechanical fundamentals, isotropy and anisotropy, stress and strain, Hook's law and modulus of material, Poisson' ration, stress-strain relation, Important properties-strength, ductility, toughness, stiffness, malleatility, plasticity, hardness, brittleness, creep and fatigue.

   Electrical Properties:Resistivity, Conductivity, Ionic conductivity, Electronic conductivity, Factors affecting conductivity, Other electrical characteristics such as Superconductivity, Ferroelectricity and Piezoelectricity, dielectric behaviour.

   Magnetic Properties: Magnetization, classification of magnetic material, Magnetic domain, Magnetostriction, Paramagnetism, Ferromagnetism, Diamagnetism, Soft and hard material, Ferrites.

   Thermal Properties: Heat capacity, expansion, conductivity and stresses.

   Optical Properties: Electro-magnetic radiation, refraction, reflection, absorption, transmission, color.

3. **Diffusion**

   Classification of diffusion, mechanisms- vacancy, interstitial, direct interchange, Ficks first and second law, factor affecting diffusion coefficient, self diffusion, inter diffusion, diffusion couple, diffusion in oxides, ionic crystals, grain boundary of surface diffusion, activation of energy for diffusion, material processing and diffusion.

4. **Phase diagrams**

   Basic concepts, solid solution, Hume-Rotheley's rules, phase diagrams, phase rule, time temperature cooling curves, construction of phase diagram, interpretation of phase diagram, study of phase diagram for complete solid solution, eutectic diagram with no solid solution, eutectoid, peritectic diagram.Microstructural diagram developments. Study of Pb-Sn, Fe-C, Cu-Ni, Al_2O_3-SiO_2 systems.

5. **Polymers**

   Basic concept of polymer, chemistry of polymer, size of polymer, molecular weight, molecular shape, structure, configuration, crystality, mechanism of polymerization, structure verses properties of polymer, plastic and elastomers,deformation of polymer.

6. **Ceramics**

   Classification of ceramics, structure of ceramics, silicate structure, mechanical,thermal and electrical properties of ceramic phases, applications.

REFERENCES

1. Material Sciences and Process
   S.K.Hajra, Choudhary, Indian Book Distributing Co.
2. Material Science and Engineering
   V.Raghavan, Prentice Hall of India Pvt.Ltd.,N.Delhi.
3. Material Science and Engineering
   W.D.Callister,Jr. w
4. Introduction to Material Scince for Engineers-
   J.F.Shackelford, Macmillan Publishing Company
5. Elements of Material Scince and Engineering
   L.H. Van Vlack ,Addission Weston Publishing company.

MS 304 : SPECIAL LABORATORY I

1. Study of magnetic susceptibility in liquids.
2. Study of magnetic properties of MnSO4 (Guoy Method)
3. Determination of Hall coefficient of a given sample.
4. Study of phase diagrams by direct cooling curves.
5. Study of Electron Spin Resonance.
6. Study of thermoluminescence of F centres in alkali halide crystals.
7. To study the intensity of Beta rays as they pass through different thickness of alluminium and to determine the linear absorption coefficient.
8. Study the charasteristic of a GM tube and determination of its operating VOLTAGE.
9. Characteristic of solar cell Voc, Isc, Rs, dark/illuminated, temparature dependance,spectral distribution,CV measurement.
10. Refractive index measurement by Emursion technique.
11. Study of Haynes Schokley experiment for the determination of mobility and diffusion constant.
12. Determination of heat capacity.
13. Study of dielectric behaviour of $BaTiO_3$ sample.
14. Determination of Curie point of a Ferromagnetic material.
15. Seeback measurement and conductivity measurements.
16. Study Hysterisis curve.
17. Transmission of electromagnetic waves through aluminium.
18. To determine the stress strain properties of plastic samples on universal testing machine.
19. To determine tear strength of polymers.
20. To measure share hardness of plastics and rubber samples.

MS 401 : SOLID STATE PHYSICS II

1. FERMI SURFACES

Characteristics and construction of Fermi surfaces, Fermi surface and Brillouin zones, Fermi surfaces of metals such as aluminium, copper and gold. Effect of electric field on Fermi surfaces, De-Haas Van Alphan effect, Cyclotron resonance.

2. DIELECTRICS

Polarization, depolarization field, Lorentz field, dielectric constant and polarizability, Clausius Mossotti relation, atomic polarizability [electronic, ionic and dipolar], complex dielectric constant and dielectric losses,dielectric losses and relaxation time

3. MAGNETISM

Diamagnetism - classical and quantum theories, comparison with experiments, Paramagnetism - classical and quantum theories, Ferromagnetism, Weiss theory, Weiss molecular fields, Comparison of Weiss theory with experiments. Ferromagnetic domains, Antiferromagnetism - two sublattice model, superexchange interaction, Ferrimagnetism - structure of ferrites, saturation magnetization, elements of Neel's theroy.

4 DEFECTS IN SOLIDS

Lattice vacancies, Schottky defects, Frenkel defects, Diffusion, color centres, dislocations, effect of defects on mechanical, electrical and optical properties.

5. SUPERCONDUCTIVITY

Occurrence, Miessner effect, critical field, type-I, type II superconductors, Critical currents, thermodynamics of superconducting transitions, London equations, coherence length, London penetration depth, BCS theory of superconductivity, High T_c superconducting materials.

REFERENCES

1. Solid State Physics,
   A.J.Dekkar, Mc Millan Students Ed.

2. Introduction to Solid State Physics,
   C.Kittel, Wiley Eastern Ltd., Edition 5

3. Solid State Physics,
   C.M.Kachhava, Tata Mc Graw Hill Edition.

4. Solid State Physics,
   N.W.Ashcroft and N.D.Mermin, Holt- Saunders International Ed.

5. Solid State Physics,
   L.Azzroff, Tata Mc Graw Hill Edition.

MS 402 : TECHNIQUES IN MATERIALS CHARACTERIZATION

1. **CHARACTERIZATION TECHNIQUES**

Importance for characterization of materials, classification of characterization techniques, destructive and non-destructive techniques, electromagnetic spectrum, properties of electromagnetic radiation.

2. **INFRARED SPECTROSCOPY**

Range of IR absorption, requirements for Infrared radiation absorption, theory of IR absorption spectroscopy, Linear molecules, symmetric top molecules, asymmetric molecules, instrumentation- Single beam and double beam spectrophotometers, Application of IR spectroscopy, Limitation of IR spectroscopy.

3. **ULTRA VIOLET AND VISIBLE SPECTROSCOPY**

Color and light absorption, the chromophore concept, theory of electronic spectroscopy- orbitals involved in electronic transitions, laws of light absorption- Beer's and Lambert's laws, conventions, instrumentations - UV spectrometer, sample and reference cells vacuum ultraviolet, Applications of UV visible spectroscopy.

4. **X-RAY DIFFRACTION**

Crystalline state, x-ray diffraction processes, preliminary discussion of powder and single crystal pattern, and their information content, the production and monochromatization of x-ray diffraction, the use of method of recording diffraction patterns of materials, additional uses of x-ray diffraction data, structure determination particle size determination, crystallography by diffraction of radiation other than x-ray.

5. **RAMAN SPECTROSCOPY**

Characteristic properties of Raman Lines, differences between Raman spectra and infrared spectra, mechanism of Raman effect, instrumentation, intensity of Raman Lines, application of Raman spectroscopy, Laser Raman spectroscopy.

6. **MOSSBAUER SPECTROSCOPY**

Mossbauer effect, theory of Mossbauer spectroscopy, instrumentation, application of Mossbauer spectroscopy.

7. **PHOTOELECTRON SPECTROSCOPY**

Introduction, experimental techniques, theory, and applications.

8. INTRODUCTION TO Scanning electron microscopy and Transmission electron microscopy.

MS 403 : PHYSICS OF THIN FILMS

1. Various ranges ofvacuum,conductance, impedance, speed, pump-down time and their relations.

2. Pumps and Gauges for H.V. and U.H.V. Rotary diffusion, Getter pumps, evaporation, sputter ion, molecular drag, cryogenic and orbitron pump.
   Thermocouple penning (cold cathode ionization gauge), Hot cathode ionization gauge, triode ionization, Bayart Alpert gauge.

3. Thin Film deposition technology-
   Thermal evaporation, evaporation methods, resistive heating, Flash evaporation, arc evaporation, exploding wire technique, Laser evaporation, RF heating, electron bombardment heating.
   Cathode sputtering : sputtering proces, glow discharge sputtering pressure, deposition distribution, current and voltage dependance; cathode, contamination problem, deposition control.
   Low pressure sputtering : magnetic field, assisted (triode) sputtering, RF sputtering, Ion beam sputtering, reactive sputtering, sputtering of multicomponent materials.
   Chemical methods : electrodeposition, electrolytic deposition, electroless deposition, anode oxidation, Chemical Vapor Deposition (CVD)- pyrolysis, Hydrogen reduction, Halide disproportionation, transfer reaction, polymerization.
   Vacuum deposition apparatus : Vacuum system, substrate depositiom technology, substrate materials, substrate cleaning, uniform and non-uniform deposits, masks and connections, multiple film deposition.

4. Thickness measurments : optical interferance techniques, multiple beam interferometry, photometric method, gravimetric method.

5 Nucleation, growth and structure of films :
   Condensation process, Langmuir-Frenkel theory of condensation, theories of nucleation, capillarly theory, Atomic theory, various stages of growth, some aspects of the physical structure of films, crystallic size, surface roughness, density of thin films.

6 Mechanical properties: adhesion and its measurements with various methods, stress measurements.

7 Electrical properties: Boltzmann equation, Fuch- Sondhemir theory, TCR and its variation, resistance variation of very thin films, Hall effect.

8 Optical properties: reflection, refraction, Fresnels coefficients, complex refractive index, reflection and antireflecting films, ellipsometry.

9 Application of thin films: antireflection coating, infrared anti-reflection coating, filters, polarizers, resistors, capacitors, diodes, transistors, computer memory devices, thin film solar cell, thin film transducers.

REFERENCES

1. Thin Film Phenamenon, Mc.Graw Hill,1969
   K.L. Chopra
2. Hand Book of Thin Film Technology, Mc.Graw Hill,1970
   L.I. Maissel and R. Glang,
3. Thin Film Technology, Van Nostrand Reinhold, 1968

MS 404 : SPECIAL LABORATORY II

1. To determine the pumping speed of rotary pump.
2. Thin film deposition by evaporation method.
3. To study the kinetic of crystallization of polymers.
4. Study of corrosion of metals.
5. To study the deformation behaviour of FCC, HCP and BCC metals.
6. To determine the transition temperature and the heat of transition of the given sample of $BaTiO_3$ solid solution.
7. To study the following by etch technique :
   (a) dislocation in NaCl crystal
   (b) Grain and twin boundaries in alpha brass.
8. Crystal structure determination by X-ray diffraction technique.
9. Study of crystal growth.
10. Electroplating and study of adhesion, porosity and etching.
11. Study of photoelectrochemical solar cell.
12. Measurement of thickness of thin films.
13. Diffusion coefficient measurement using resistivity plots.
14. Schottky barrier determination for various semiconductor.
15. Synthesis of $Y_1Ba_2Cu_3O_{7-}$ bulk superconductor by solid state reaction method and the observation of Meissner effect.
16. Determination of transistion temperature of given superconductor by the method of low temperature resistivity measurement.
17. Determination of oxygen content in a 123 superconductor.
18. Study of Infrared spectra.
19. Study of ultra violet spectra.
20. To study the effect of molecular weight of polymers on viscosity.
21. Density measurement of polymer samples.
22. To determine the softening point of plastics.
23. Experiments on He-Ne Laser :
    i) Study of power distribution within Laser beam and determine the Laser beam quality.
    ii) Study of beam divergence and beam diameter.
    iii) Study of pointing stability.
    iv) Study of depth of focus of a lens.
    v) Study of focus spot size.