M.Sc. PROGRAMME IN PHYSICS UNDER

CREDIT AND SEMESTER SYSTEM

REVISED SYLLABUS
M.Sc. PHYSICS (MATERIAL SCIENCE)
(2013 admissions onwards)

POST GRADUATE AND RESEARCH
DEPARTMENT OF PHYSICS
CATHOLICATE COLLEGE
PATHANAMTHITTA

4.4 M.Sc. PHYSICS - MATERIAL SCIENCE

4.4.1 Course Code

The first two letters PH stand for Physics, and the letters C, P, E, D and V have the usual meaning. The letter M stands for Material Science. Here the core courses, Electives and Practicals are numbered from 1 to 4. The third character of the Code running from 1 to 4 indicates the semester concerned.
Course and Course code of M.Sc. Physics - Material Science are given in Table 4.3

SEM	NAME OF THE COURSE WITH COURSE CODE	No.of Hrs/ week	No. of credit	Total Hrs/ SEM
I	PH1MC1: APPLIED MATHEMATICS FOR PHYSICS- I	4	4	72
I	PH1MC2: BASIC QUANTUM MECHANICS	4	4	72
I	PH1MC3: CLASSICAL MECHANICS AND RELATIVITY	4	4	72
I	PH1MC4: CONDENSED MATTER PHYSICS	4	4	72
I	PH1MP1: GENERALPHYSICS PRACTICALS	9	3	162
II	PH2MC1: APPLIED MATHEMATICS FOR PHYSICS – II	4	4	72
II	PH2MC2: ELECTRODYNAMICS AND NON LINEAR OPTICS	4	4	72
II	PH2MC3: ADVANCED ELECTRONICS	4	4	72
II	PH2MC4: NUCLEAR PHYSICS AND PARTICLE PHYSICS	4	4	72
II	PH2MP2: ELECTRONICS PRACTICALS	9	3	162
III	PH3MC1: NUMERICAL METHODS IN PHYSICS	4	4	72
III	PH3MC2: STATISTICAL PHYSICS AND ASTROPHYSICS	4	4	72
III	PH3ME1: SOLID STATE PHYSICS	4	4	72
III	PH3ME2: CRYSTAL GROWTH TECHNIQUES	4	4	72
III	PH3MP3: COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS	9	3	162
IV	PH4MC1: ADVANCED QUANTUM MECHANICS	4	4	72
IV	PH4MC2: ATOMIC AND MOLECULAR SPECTROSCOPY	4	4	72
IV	PH4ME3: NANOSTRUCTURES AND CHARACTERIZATION	4	4	72
IV	PH4ME4: THIN FILM AND NANO SCIENCE	4	4	72
IV	PH4MP4: MATERIAL SCIENCE PRACTICALS	9	3	162
IV	PH4D05: PROJECT/ DISSERTATION	NIL	2	NIL
IV	PH4V06: VIVA VOCE	NIL	2	NIL

Table 4.3 Course and Course code of M.Sc. Physics - Material Science

SEMESTER – I

PH1MC1 APPLIED MATHEMATICS FOR PHYSICS- I

Unit I

Vector and Vector Spaces (18 hrs)

Differential Calculus: Gradient, Divergence, Curl - Successive applications of grad - Integral calculus: line, surface & volume integrals - Fundamental theorem for gradients, divergences and curls - Equation of continuity - Potential theory - Gauss's law and Poisson's equation Orthogonal curvilinear coordinates: Spherical & Cylindrical - Differential vector operators in orthogonal coordinates - Dirac delta function - its properties and integral forms. Linear vector spaces - Self adjoint, unitary & projection operators - Eigen values & Eigen vectors of self adjoint operators-inner product space - Schimdt orthogonalisation - Hilbert space - Schwartz inequality.

Unit II

Matrices (12 Hrs)

Direct sum and direct product of matrices, diagonal matrices, Matrix inversion (Gauss-Jordan inversion method) orthoganal, unitary and Hermitian matrices, normal matrices, Pauli spin matrices, Cayley-Hamilton theorem. Similarity transformation - unitary and orthogonal transformation. Eigen values and eigenvectors – Diagonalisation using normalized eigenvectors. Solution of linear equation-Gauss elimination method- Normal modes of vibrations.

Error analysis and Probability (6 Hrs)

Error analysis- Propogation of errors- Standard deviation- Binomial, Poisson and Gaussian distributions.

Unit III

Differential Equations and Special Functions (20 Hrs)

Gamma and Beta Functions (review of properties) – Dirac delta function – its property and integral forms. Bessel's differential equations – Legendre differential equations – Associated Legendre functions – Hermite differential equation – Laguerre differential equation – associated Laguerre polynomial – Generating Functions – recurrence relation –orthonormality – Rodrigue's formula – to be discussed for all equations.

Unit IV

Tensors (16 hrs)

Transformation of coordinates – contravariant, covariant and mixed tensor – symmetric and anti symmetric tensor – associated tensor – raising and lowering of indices – metric tensor – curvilinear coordinates – Riemannian Space – Covariant differentiation – Christoffel Symbols – geodesic.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press
2. Mathematical Physics, P.K Chattopadhyay, New Age International
3. Theory and problems of vector analysis, Murray R. Spiegel (Schaum's outline series)
4. Mathematical methods for Physics and Engineering, K.F. Riley, M.P Hobson, S. J. Bence, Cambridge University Press
5. An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements, John R. Taylor - Univ. Science Books
6. Mathematical Physics, B.S. Rajput, Y. Prakash 9th Ed, Pragati Prakashan
7. Introduction to Mathematical Physics, Charlie Harper, PHI
8. Vector analysis and tensors, Schaum's outline series, M.R. Spiegel, Seymour Lipschutz, Dennis Spellman, McGraw Hill
9. Tensor Calculus: Theory and problems, A. N. Srivastava, Universities Press
10. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
11. Advanced Engineering Mathematics, E. Kreyszig, 7th Ed., John Wiley
12. Introduction to mathematical methods in physics, G.Fletcher, Tata McGraw Hill
13. Advanced engineering mathematics, C.R. Wylie, & L C Barrett, Tata McGraw Hill
14. Advanced Mathematics for Engineering and Physics, L.A. Pipes & L.R.Harvill, Tata McGraw Hill
15. Mathematical Methods in Physics, J. Mathew & R.L. Walker, India Book House.
16. Mathematical Physics, H.K. Dass, S. Chand & Co. New Delhi.

PH1MC2 BASIC QUANTUM MECHANICS

Unit I

Basics of Quantum Mechanics (16 Hrs)

Stern - Gerlach experiment leading to vector space concept, Dirac notation for state vectors- ket space, bra space, inner products – algebraic manipulation of operators – unitary operators, eigenkets and eigenvalues – Hermitian operators- concept of complete set-representation of an operator by square matrix – matrix elements of an operator - expectation values of Hermitian and anti-Hermitian operators – generalized uncertainty product –– change of basis-orthonormal basis and unitary matrix, transformation matrixunitary equivalent observables-eigenkets of position-infinitesimal operator and its properties – linear momentum as generator of translation – canonical commutation relations – properties of wave function in position space and momentum space - relations between operator formalism and wave function formalism-momentum operator in position basis – momentum space wave function – computation of expectation values x, x^2, p and p^2 for a Gaussian wave packet.

Unit II

Quantum Dynamics (18Hrs)

Time evolution operator and its properties-Schrodinger equation for the time evolution operator - energy eigenkets - time dependence of expectation values - time energy uncertainty relation - Schrodinger picture and Heisenberg picture - behaviour of state kets and observables in Schrodinger picture and Heisenberg picture - Heisenberg equation of motion - Ehrenfest's theorem - time evolution of base kets - transition amplitude – energy eigenket and eigen values of a simple harmonic oscillator using creation and `annihilation operators

Unit III

Angular momentum (18 Hrs)

Infinitesimal rotations in quantum mechanics- representation of the rotation operator – rotation matrix-properties of the rotation matrix-orbital angular momentum as a rotation generator - fundamental commutation relations of angular momentum - commutation relations for J^2, J_Z - eigenvalues of J^2 and J_Z - matrix elements of angular momentum operators - rotation operator for spin ½ system - Pauli two component formalism - Pauli spin matrices - addition of angular momentum - Clebsch-Gordon coefficients

Unit IV

Approximation Methods (20 Hrs)

WKB approximation – WKB wave function –validity of the approximation - connection formula (proof not needed) potential well - barrier penetration variational methods – bound states – hydrogen molecule ion - stationary state perturbation theory – non degenerate case - anharmonic oscillator - degenerate case -applications – first order Stark effect and Zeeman effect in hydrogen

Reference Books:

1. Modern Quantum Mechanics, J.J. Sakurai, Pearson Education
2. Quantum mechanics, V.K. Thankappan New Age International 1996
3. Quantum Mechanics, G Aruldhas, PHI, 2002
4. A Modern approach to quantum mechanics, John S. Townsend, Viva Books MGH.
5. Basic Quantum Mechanics, A. Ghatak, Macmillan India 1996
6. Quantum Mechanics, an Introduction, W Greiner, Springer Verlag
7. Quantum Mechanics, E. Merzbacher, John Wiley, 1996
8. Introduction to Quantum Mechanics, D.J. Griffiths, Pearson.
9. Quantum Mechanics, L.I. Schiff, Tata McGraw Hill
10. A Text Book of Quantum Mechanics, P.M. Mathews & K. Venkatesan, TMGH.
11. Quantum Mechanics, Concepts and Applications, N. Zettily, John Wiley & Sons.
12. Fundamentals of Quantum Mechanics Y.R. Waghmare, S Chand & Co.
13. Advanced Quantum Mechanics, Satya Prakash. Kedar Nath Ramnath Publications.

PH1MC3 CLASSICAL MECHANICS AND RELATIVITY

Unit I

Hamiltonian Methods (18 Hrs)

Review of Lagrangian dynamics - applications of Lagrange’s equations to velocity dependent potentials - Hamilton's equations of motion – cyclic coordinates - conservation theorems - homogeneity of space and time- action for an arbitrary motion - variational principle and Hamilton’s equations - Physical significance of principle of least action –Proof-Physical significance- Canonical transformations – Lagrange brackets- Poisson brackets –Equation of motion in Poisson bracket form - Hamilton's characteristic function - Hamilton Jacobi theory - harmonic oscillator problem - action angle variables – Kepler problem- transition to Wave mechanics.

Unit II

Rigid Body Dynamics (12 Hrs)

Independent Coordinates – Orthogonal Transformations – Inertia Tensor – Euler’s Angles . Force free motion of rigid body - Cases of symmetric top - Heavy Symmetric top, fast top- Sleeping top - Precession of Charged bodies in magnetic field - Infinitesimal rotation - Coriolis Force and its effects.

Theory of Small Oscillations (8 Hrs)

Formulation of the problem – Eigen value equation – Coupled oscillators –Normal coordinates.Oscillations of linear triatomic molecules – monoatomic chain lattice – diatomic chain lattice.

Unit III

Continuous Systems and Fields & Perturbation Theory (16 Hrs)

Lagrangian formulation for continuous systems - sound vibrations in gas - Hamiltonian formulation for continuous systems - description of fields. Classical perturbation theory - time dependent perturbation - illustration case of simple pendulum with finite amplitude – Kepler problem and precession of the equinoxes of satellite orbits - time independent perturbation – first order with one degree of freedom.

Unit IV

The Special Theory of relativity (18 Hrs)

The postulates of Special Theory of relativity-Lorentz transformation – Velocity transformation - Length contraction-Time dilation - Mass in relativity - mass and energy -Relativistic Lagrangian and Hamiltonian of a particle-Lorentz co-variance - four vectors - Invariance of Maxwell’s equations under Lorentz transformations

- Electromagnetic field tensor - Principle of Equivalence- Precession of the Perihelion of planetary orbits.

Reference Books:

1. Classical Mechanics, Goldstein, Poole & Safko, 3rdEdn. Pearson.
2. Classical mechanics,G. Aruldas, Prentice Hall
3. Classical mechanics, N. C. Rana & P.S. Joag - TMGH
4. Classical mechanics, J.C. Upadhyaya, Himalaya.
5. Classical mechanics, Satyaprakash, Sultan Chand & Company.
6. Classical mechanics, Gupta & Kumar, Pragati Prakasan.
7. Classical Mechanics, A.K. Raychauduri, Oxford Univ. Press

PH1MC4 CONDENSED MATTER PHYSICS

Unit I

Lattice Vibrations (18 Hrs)

Vibrations of monatomic and diatomic lattices - acoustic and optical modes - Quantization of lattice vibrations - Phonon Momentum - Inelastic scattering of neutrons by phonons. Lattice Heat Capacity - Einstein model, Density of modes in one and three dimensions -Debye model of lattice heat capacity – Debye's T^3 law -Anharmonic crystal Interactions - Thermal Expansion - Thermal conductivity.

Unit II

Free Electron Theory and Band Theory (18 Hrs)

Energy levels and density of orbitals in one dimension - Free electron gas in three dimensions - Heat capacity of the electron gas - Electrical conductivity and Ohm's law - Motion in magnetic fields - Hall effect-Thermal conductivity of metals - Wiedemann-Franz law - Nearly free electron model- Wave equation of electron in a periodic potential - Number of orbitals in a band - Construction of Fermi Surfaces -Calculation of Energy Bands -Experimental methods in Fermi surface studies.

Unit III

Dielectrics and Ferroelectrics (10 Hrs)

Theory of Dielectrics: Polarisation - Dielectric constant - Local Electric field - Dielectric polarisability - Polarisation from dipole orientation - Dielectric losses - Ferroelectric crystals - Landau theory of ferroelectric phase transitions - Ferroelectric domain - Antiferroelectricity - Piezoelectricity - Applications of Piezoelectric Crystals.

Superconductivity (10 Hrs)

Meissner effect - Type I and Type II superconductors - Heat capacity- Energy gap - Isotope effect - Free energy of superconductor in magnetic field and the stabilization energy - London equation and penetration of magnetic field - Cooper pairs and the BCS ground state and BCS Hamiltonian - Flux quantization - Single particle tunneling - DC and AC Josephson effects - High Tc superconductors - Applications of Superconductivity.

Unit IV

Magnetic properties (16 Hrs)

Diamagnetism and Para magnetism: Langevin's diamagnetism equation - Quantum theory of diamagnetism of mononuclear systems - Quantum theory of paramagnetism - Hund's rule - Paramagnetic susceptibility of conduction electrons - Ferro, Anti and Ferri magnetism: Curie point and the exchange integral - Ferrimagnetic order - Curie temperature and susceptibility of ferrimagnets - Antiferromagnetic order - Weiss theory of ferromagnetism - Ferromagnetic domains.

Reference Books:

1. Introduction to Solid State Physics, C. Kittel, Wiley Eastern.
2. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall
3. Solid State Physics, A.J.Dekker, Macmillan, 1967
4. Solid State Physics, N.W.Ashcroft and N.D. Mermin, Cengage Learning Pub.
5. Elements of Solid State Physics, J.P. Srivastava, Prentice Hall of India (2nd Edition)
6. Solid State Physics-J.S. Blakemore, Cambridge University Press.
7. Solid State Physics, Gupta Kumar, Pragati Prakasan
8. Solid State Physics- Structure and Properties of materials, M.A. Wahab. Narosa.
9. Solid State Physics, S.O.Pillai, New Age International 6th Edn. 2010
10. Elementary Solid State Physics, M. Ali Omar, Pearson.

PH1MP1 GENERALPHYSICS PRACTICALS

(Minimum of 12 Experiments with Error analysis of the experiment is to be done)

1. Magnetic susceptibility - Quincke's method
2. Magnetic susceptibility - Guoys method
3. Y, n, σ Cornu's method, (a) Elliptical and (b) Hyperbolic fringes
4. Young's modulus and Poisson's ratio – Koenig's method
5. Michelson interferometer – λ and dλ/ thickness of mica
6. Absorption spectrum -$KMnO_4$ solution- telescope and scale arrangement- Hartmann's formula
7. e/m of electron – Thomsons method
8. Study of thermistor – computation of response equation
9. Determination of e/k – silicon transistor
10. Hydrogen spectrum – Rydberg constant
11. Ultrasonic – Acousto-optic technique- elastic property of a liquid.
12. Oscillating disc – viscosity of liquid
13. Determination of e – Milliken's method
14. Characteristics of a photodiode
15. B-H curve – Anchor ring
16. Mutual inductance – Carey Foster's bridge
17. Self and mutual inductance – Anderson's bridge
18. Arc spectrum of Iron, Copper and Brass
19. Absorption spectrum of Iodine- photographic method
20. Raman effect in liquids – plate measurement
21. Identification of elements by spectroscopic method
22. Dielectric constant of a non-polar liquid
23. Temperature dependence of a ceramic capacitor and verification of Curie Wiess law
24. Electrical and thermal conductivity of copper and determination of Lorentz Number
25. Silicon diode as temperature sensor
26. Verification of stephan's law and determination of Stephan's constant of radiation

SEMESTER – II

PH2MC1 APPLIED MATHEMATICS FOR PHYSICS – II

Unit 1

Complex Analysis (20 Hrs)

Functions of a complex variable - Analytic functions – Cauchy–Reimann equations - Laplaces equations - Cauchy's Integral Theorem - Cauchy's theorem for multiply connected domains - Cauchy's integral formula - Derivatives of analytic functions - Taylor & Laurent expansion - Singularities-poles and zeros - Residue theorem - Evaluation of definite integrals

Unit II

Group theory (18 Hrs)

Introduction to group theory- definition of group- cyclic groups - point groups – homomorphism and isomorphism- classes -reducible and irreducible representations – Schru's lemma- great orthogonality theorem – group character table C2v & C3v groups- generators of continuous groups- Rotation groups - applications in molecular and crystal physics - Lie group and Lie algebra - Poincare and Lorentz group - SU(2) and SU(3) - examples from particle physics.

Unit III

Integral transforms (18 Hrs)

Laplace & Fourier transforms– solution of differential equation, wrong L T Earth's mutation, LCR circuit, EM wave in dispersive medium – driven oscillator with damping – FT of square wave, full wave rectifier & finite wave train – momentum representation for hydrogen atom ground state & harmonic oscillator.

Unit IV

Partial Differential Equations (16 hrs)

Partial differential equation – characteristics - boundary conditions - classes of partial differential equations- heat equation- Laplace's equation - Poisson's equation - non linear partial differential equation and boundary conditions - separation of variables in Cartesian, circular cylindrical and spherical polar coordinates - non homogeneous equation - Green's functionsymmetry of Green's functions- forms of Green functions.

Reference Books:

1. Mathematical Methods for Physicists, G.B. Arfken &H.J. Weber 4th Edition, Academic Press.
2. Mathematical Physics, B.D. Gupta, Vikas Pub.House, New Delhi
3. Mathematical methods in Classical and Quantum Physics, T. Dass & S. K. Sharma, Universities Press (2009)
4. Introduction to Mathematical physics, Charlie Harper, PHI
5. Elements of Group Theory for Physicists, A.W. Joshi, New Age India
6. Mathematical Physics, Sathyaprakash, Sultan Chand & Sons, New Delhi.
7. Group theory- Schaum's series, Benjamin Baumslag & Bruce Chandler, MGH.
8. Mathematical Physics, H.K Dass & Dr. Rama Verma, S. Chand &Co.
9. Mathematical Physics, B.S Rajput, Pragati Prakashan
10. Advanced Engineering Mathematics, E. Kreyszig, 7th Ed., John Wiley
11. Introduction to Mathematical methods in Physics, G. Fletcher,Tata McGraw Hill
12. Advanced Mathematics for Engineering and Physics, L A Pipes & L R Harvill, Tata McGraw Hill
13. Mathematical Methods in Physics, J Mathew & R L Walker, India Book House

PH2MC2 ELECTRODYNAMICS AND NON LINEAR OPTICS

Unit I

Electrostatics and Magnetostatics (18Hrs)

Laplace's Equation – in one, two, three dimensions and its solutions. Boundary conditions and Uniqueness theorems - Conductors and the second Uniqueness theorem. Multipole expansion - Approximate Potentials at large distances - The Monopole and Dipole terms - Origin of coordinates in Multipole expansions - The electric field of a dipole. Linear Dielectrics - Susceptibility, Permittivity, Dielectric Constant - Boundary value problem with linear dielectrics - Energy in dielectric systems - Forces on dielectrics. Magnetostatics - The divergence and Curl of B - Straight line currents - Applications of Ampere's law - Comparison of magnetostatics and electrostatics. Magnetic vector potential - The vector potential - Magnetostatic boundary conditions- Multipole expansion of the vector potential - The auxiliary field H- Ampere's law in magnetized materials- A deceptive parallel - Boundary conditions.

Unit II

Electrodynamics and Electromagnetic Waves (20Hrs)

Maxwell's Equations - Electrodynamics before Maxwell - How Maxwell fixed up Ampere's law - Maxwell's equations - Magnetic charge -Maxwell's equations in matter- Boundary conditions. Conservation Laws –charge and energy - The continuity equation - Poynting`s theorem –Momentum - Newton's third law in Electrodynamics - Maxwell's StressTensor - Conservation of Momentum - Angular Momentum. Electromagnetic Waves - Waves in one dimension - Electromagnetic waves in vacuum - Electromagnetic waves ion matter - Absorption and Dispersion - Guided waves-Potentials and Fields -The Potential formulation - Continuous Distributions -Retarded Potentials – Jefimenko's equations - Point Charges - Lienard-Wichert Potentials.

Unit III

Radiation and Relativistic Electrodynamics (16Hrs)

Dipole radiation - Electric dipole radiation and Magnetic dipole radiation - Radiation from an Arbitrary source. Point Charges - Power radiated from a point charge - Radiation reaction - Abraham Lorentz formula. Relativistic Mechanics - Proper time and velocity-Relativistic energy and Momentum- Relativistic Kinematics- Relativistic dynamics. Relativistic Electrodynamics - Magnetism as a relativistic phenomenon – Transformation of the field -

Electromagnetic field tensor - Electrodynamics in tensor notation, Potential formulation of relativistic electrodynamics**.**

Unit IV

Non Linear Optics (18Hrs)

The self focusing phenomenon of light - Harmonic generation - Second
Harmonic generation – phase matching condition – third harmonic generation – optical mixing – parametric generation of light –- multi quantum photoelectric effect - two photon processes - three photon processes - parametric generation of light – frequency up conversion – phase conjugateoptics – generation of sum and difference frequencies.

Reference Books:

1. Introduction to Electrodynamics, David J Griffiths, PHI Learning,2009
2. Classical Electrodynamics, J.D. Jackson 3rd Ed. Wiley, 1993.
3. Lasers and Non Linear optics, B.B Laud, Wiley eastern.
4. Optical Electronics, Ajoy Ghatak & K. Thyagarajan, Cambridge 2003.
5. Contemporary optics, Ajoy Ghatak & K. Thyagarajan, Plenum, NewYork.
6. Introduction to Optics, Germain Chartier, Springer.
7. The Feynman Lectures in Physics,Vol 2, Feynamn, Leighton, Sands.
8. Quantum Electronics, Amion Yariv, Wiley.
9. Introduction to Classical Electrodynamics, Y K Lim, World Scientific.
10. Non Linear Optics, Robert W. Boyd, Academic Press.

PH2MC3 ADVANCED ELECTRONICS

Unit I

Op-amp with Negative Feedback (12 Hrs)

Differential Amplifier-Inverting Amplifier-Non Inverting Amplifier-Block Diagram Representations-Voltage series feedback-Negative feedback-Closed loop voltage gain-Difference Input voltage ideally zero-Input and output resistance with feedback-Bandwidth with feedback-Total output offset voltage with feedback-Voltage follower-Voltage shunt feedback amplifier-Closed loop voltage gain-Inverting input terminal at virtual ground-Input and output resistance with feedback-Bandwidth with feedback-Total output offset voltage with feedback-Current to voltage converter-Inverter-Differential amplifier with one Op-amps and two Op-amps.

The Practical Op-amp (6 Hrs)

Input offset voltage-Input bias current-Input offset current-Total output offset voltage-Thermal drift-Effect of variation in power supply voltages on offset voltage-Change in input offset voltage and input offset current with time-Noise-Common mode configuration and CMRR.

Unit II

General Linear Application (with design) (12 hrs)

DC and AC amplifiers-AC amplifier with supply voltage-Peaking Amplifier-Summing,Scaling and averaging amplifiers-Instrumentation Amplifiers using transducer bridge-Differential input and differential output amplifier-Low voltage DC and AC voltmeter-Voltage to current converter with grounded load -Current to voltage converter-Very high input impedance circuit-Integrator and differentiator.

Frequency Response of an Op-amp (6 Hrs)

Frequency response-Compensating networks-Frequency response of internally compensated and non compensated Op-amps-High frequency op-amp equivalent circuit-Open loop gain as a function of frequency-Closed loop frequency response-Circuit stability-Slew rate.

Unit III

Active Filters and Oscillators(with design) (12 Hrs)

Active filters-First order and second order low pass Butterworth filter-First order and second order high pass Butterworth filter-Wide and narrow band pass filter-Wide and narrow band reject filter-All pass filter-Oscillators: Phase shift and

Wien bridge oscillators-Square triangular and saw-tooth wave generators-Voltage controlled oscillator.

Comparators and Converters (6 Hrs)

Basic comparators-Zero crossing detector-Schmitt Trigger-Comparator characteristics-Limitations of Op-amps & comparators-Voltage to frequency and frequency to voltage converters-D/A and A/D converters.

Unit IV

Communication Systems (18 hrs)

Introduction to communication systems-Modulation-Bandwidth requirements-Review of amplitude modulation-- Theory of frequency band-Phase modulation-Generation of FM - Pulse communications-Pulse modulation-Pulse width , Pulse position-Pulse code modulation-Digital communication-Digital codes-Error detection and correction-Modem classification-Modem interfacing.

Reference Books

1. Op-amps and linear integrated circuits: R.A.Gayakwad.
2. Electronic communication systems: Kennedy and Davis (4^{th} Edn).
3. Electronic Devices (Electron Flow Version 9.1 Thomas L Floyd Pearson.
4. Electronic Communications: Dennis Roddy and John Coolen 4^{th} Edn Pearson.
5. A text book of Applied Electronics, R.S. Sedha, S. Chand & Co.
6. Principles of Electronics, V.K.Mehta and Rohit Mehta S. Chand &Co.
7. Basic Electronics, B.L. Theraja, S. Chand & Co.
8. Integrated Electronics, J. Millman and C.C. Halkias, MGH

PH2MC4 NUCLEAR PHYSICS AND PARTICLE PHYSICS

Unit I

Nuclear Structure and Models (18 Hrs)

Basic properties of nuclei - Masses and relative abundances - mass defect - size and shape, nuclear binding energy - nuclear stability - nuclear angular momentum and parity - nuclear electromagnetic moments - magnetic dipole moment and electric quadrapole moments - Liquid drop model - Semiempirical mass formula of Weizacker - Shell model - Shell model potential - Magic numbers - Valence nucleons - Collective structure - nuclear vibrations - nuclear rotations.

Unit II

Nuclear Decay and Nuclear Reactions (18 Hrs)

Beta decay - energy release - Fermi theory - experimental tests - angular momentum and parity selection rules - Comparative half lives and forbidden decays - neutrino physics - non conservation of parity -Types of reactions and conservation laws - energetics of nuclear reactions – isospin - Reaction cross sections - Coulomb scattering - nuclear scattering - scattering and reaction cross sections - compound-nucleus reactions - direct reactions - heavy ion reactions.

Unit III

Nuclear Interactions, Fission and Fusion (18 Hrs)

Nuclear forces - Two body problem - Ground state of deuteron, nucleon-nucleon scattering, Proton-proton and neutron-neutron interactions, Characteristics of fission - energy in fission - fission and nuclear structure, Characteristics of nuclear force - Spin dependence, charge independence and charge symmetry - Isospin formalism Controlled fission reactions - Fission reactors. Fusion processes, Characteristics of fusion, Controlled fusion reactor.

Unit IV

Particle Physics (18 Hrs)

Types of interactions between elementary particles - Hadrons and leptons masses, spin, parity and decay structure. Quark model, confined quarks - coloured quarks, experimental evidences for quark model, quark-gluon interaction. Gell-Mann-Nishijima formula - symmetries and conservation laws - C, P and T invariance, applications of symmetry arguments to particle reactions - parity non-conservation in weak interactions. Grand unified theories.

Reference Books:

1. Introductory Nuclear Physics, K. S. Krane Wiley
2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House
3. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)
4. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, NewDelhi, (1983).
5. The particle Hunters - Yuval Ne'eman & Yoram kirsh CUP, (1996)
6. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).
7. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).
8. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
9. Nuclear Physics, I. Kaplan, 2nd Edn, Narosa, New Delhi, (1989).
10. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).
11. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi, (1981).
12. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company
13. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York, (1971).
14. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison-Wesley, Tokyo, (1995).
15. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.
16. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer (2002)
17. Elementary Particles and Symmetries, L.H. Ryder, Gordon and Breach, Science Publishers, NY, 1986

PH2MP2 ELECTRONICS PRACTICALS

(Minimum of 12 Experiments should be done)

1. RC coupled CE amplifier – two stages with feedback – frequency response and voltage gain
2. Differential amplifier – using transistors – constant current source – frequency response
3. Active filters – low pass and high pass – first and second orders – frequency response and roll of rate
4. Band pass filter using single op-amp
5. Voltage controlled oscillator using transistors
6. Voltage regulation using op-amp with short circuit protection
7. UJT characteristics
8. Relaxation oscillator using UJT
9. RF amplifier- frequency response and band width
10. Op – amp monostable multivibrator , square wave generator
11. IC 555 monostable multivibrator and astable multivibrator
12. IC 555 pulse width modulation and linear RAMP generator
13. Voltage controlled oscillator using IC 555
14. Shift registers Binary sequence generator
15. Synchronous counters and divide by N counters
16. Op – amp mathematical operations
17. Op – amp Wein bridge oscillator
18. Amplitude modulation using transistors
19. Precision rectifiers – measurement of rectifier efficiency at different frequencies
20. Op- amp triangular wave generator with specified amplitude
21. Analog to digital and digital to analog converter ADC0800 & DAC0800
22. RC phase shift Oscillator using op amp
23. Crystal Oscillator
24. Solving differential equation using IC741
25. Solving simultaneous equation using IC741

SEMESTER – III

PH3MC1 NUMERICAL METHODS IN PHYSICS

Unit I

Interpolation and Curve fitting (18 Hrs)

Errors in Polynomial Interpolation – Finite differences(Forward differences, Backward differences, Central differences) - Detection of errors by use of difference tables-Differences of a polynomial – Newton's formulae for interpolation - Central difference interpolation formulae (Gauss central difference formulae, Stirlings formulae, Evretts formula) - Interpolation with unevenly spaced points (Lagrange's interpolation formulae, Error in Lagrange's interpolation formulae, Hermite's interpolation formulae)

Unit II

Numerical Differentiation and Integration (16 Hrs)

Numerical differentiation – Errors in Numerical differentiation – Trapezoidal rule-Simpson's 1/3 rule - Simpson's 3/8 rule - Romberg Integration-Gaussian Integration – Monte Carlo evaluation of integrals - Double Integration -Newton-cotes integration formulae.

Unit III

Numerical Solution of Ordinary Differential Equations (20Hrs)

Euler method - modified Euler method and Runge - Kutta 4^{th} order methods - adaptive step size R-K method, predictor - corrector methods - Milne's method, Adam-Mouton method.

Numerical Solution of System of Equations

Gauss-Jordan elimination Method, Gauss-Seidel iteration method, Gauss elimination method and Gauss-Jordan method to find inverse of a matrix. Power method and Jacobi's method to solve eigenvalue problems.

Unit IV

Numerical Solutions of partial differential equations (18 Hrs)

Finite difference approximations to derivatives - Laplace equation-Jacobi's method – Gauss Seidal method - Successive over relaxation - The ADI method – Parabolic equations - Iterative methods for the solution of equations – Hyperbolic equations

Reference Books:

1. Mathematical Methods, G. Shanker Rao, K. Keshava Reddy, I.K. International Publishing House, Pvt. Ltd.
2. Introductory Methods of Numerical Analysis, S.S. Sastry, PHI Pvt. Ltd.
3. An Introduction to Computational Physics, Tao Pang, Cambridge University Press
4. Numerical methods for scientific and Engineering computation M.K Jain,S.R.K Iyengar, R.K. Jain, New Age International Publishers
5. Computer Oriented Numerical Methods, V. Rajaraman, PHI, 2004.
6. Numerical Methods, E. Balagurusami, Tata McGraw Hill, 2009.
7. Numerical Mathematical Analysis, J.B. Scarborough, 4^{th} Edn, 1958

PH3MC2 STATISTICAL PHYSICS AND ASTROPHYSICS

Unit I

Quantum Statistical Mechanics and Ideal Gas Systems (18 Hrs)

The postulates of Quantum statistical mechanics – indistinguishability of particles - exchange degeneracy - Density matrix - Ensembles in Quantum statistical mechanics - statistical distribution – The ideal gas in quantum mechanical micro canonical and other quantum mechanical ensemble – Partition functions and other thermodynamic quantities of monatomic and diatomic molecules. Thermodynamic behaviour of an ideal Fermi gas – Pauli Para magnetism - Thermodynamic behavior of a Bose gas – Bose Einstein condensation — Theory of white dwarf stars.

Unit II

The Canonical and Grand Canonical Ensemble (18 Hrs)

Equilibrium between a system and heat reservoir – a system in the canonical ensemble – thermo dynamical relations in a canonical ensemble – the classical systems – energy fluctuations in the canonical ensemble: correspondence with micro canonical ensemble – equilibrium between a system and a particle energy reservoir – a system in the grand canonical ensemble – physical significance of statistical quantities – density and energy fluctuations in the grand canonical ensemble: correspondence with other ensembles.

Unit III

Fluctuations and Phase Transitions (18 Hrs)

Energy fluctuations in canonical ensemble - Density fluctuation in grand canonical ensemble - one dimensional random walk problem – Brownian motion and Random walk- correlation functions- Spectral analysis of fluctuations: Wiener-Khintchine theorem - Fokker Planck equation. Phase transitions - First and second order phase transition – Bragg–Williams approximation - critical phenomena - critical exponents - scaling hypothesis - Ising model and its solution for a linear chain – equivalence of Ising model to other models - lattice gas and binary alloy- solution of one dimensional Ising model – Liquid crystals and Liquid Helium.

Unit IV

Astrophysics (18 Hrs)

Stellar spectrum - stellar types - electromagnetic radiation from stars - measuring temperature and distances - excitation and ionization - application of Saha's Equation - Hertz Sprung Russell diagram- star formation - life of a star - Virial theorem- stellar energy and nuclear reactions - stellar structure - final stages of stellar evolution - white dwarfs – neutron stars - black hole - pulsars.

Reference Books:

1. Fundamentals of Statistical Mechanics, B. B. Laud, New Age International.
2. Elements of Statistical Mechanic, Kamal Singh, S P. Singh, S. Chand & Co.
3. Statistical mechanics, Kerson Huang, John Wiley and Sons.
4. Statistical mechanics, R..K. Pathria, Butterworth-Heinemann
5. Statistical Mechanics, B.K. Agarwal and M. Eisner, Wiley Eastern.
6. Introduction to Statistical Mechanics, S.K. Sinha, Alpha Science International.
7. Statistical Mechanics, Tung Tsang, Rinton Press.
8. Introductory Statistical Mechanics, R. Bowley & M. Sanchez, 2^{nd} Edn. Oxford University Press
9. Statistical Mechanics, Gupta, Kumar, Pragati Prakasan.
10. Astrophysics: Stars and Galaxies, K D Abhyenkar, Universities Press.
11. Introduction to Astrophysics, Baidyanath Basu, PHI.

PH3ME1 SOLID STATE PHYSICS

Unit I

Optical Properties (16 Hrs)

Lattice vacancies – diffusion – colour centres – F-centre and other centres in alkali halides – ionic conductivity – colour of crystals – excitons in molecular crystals – model of an ideal photoconductor – traps – space charge effects – experimental techniques – transit time excitation and emission Aicalf mechanism – model for thallium activated alkali halides - electroluminescence.

Unit II

Mechanical Properties (18 Hrs)

The Stress – Strain curve- Characteristics of elastic deformation – Atomic Mechanism of elastic deformation – Elastic deformation of an isotropic material- Plastic deformation – Dislocation and stress –strain curves – Strengthening Mechanism – Work Hardening – Grain Boundary Hardening – Dispersion Hardening-Plastic theory of an isotropic material- The tensile test – Compression and hardness test – Fatigue and Creep testing – Fracture – Griffith's theory – Fatigue and Creep.

Unit III

Semiconductor crystals and Lasers (20Hrs)

Classification of materials as semiconductors - band Gap - band structure of Silicon and germanium - equations of motion - intrinsic carrier concentration - impurity conductivity- Thermoelectric effects in semiconductors – semimetals - amorphous semiconductors - p-n junctions.

Lasers: Properties of laser beams - temporal coherence - spatial coherence – directionality – single mode operation - frequency stabilization – mode locking - Q-Switching - measurement of distance - Ruby laser - four-level solid state lasers - semiconductor lasers - Neodymium lasers (Nd:YAG, Nd:Glass) .

Unit IV

Imperfections and Dislocations (18 Hrs)

Types of imperfections in crystals - thermodynamic theory of atomic imperfections – experimental proof – diffusion mechanisms – atomic diffusion theory – experimental determination of diffusion constant – ionic conduction – shear strength of single crystals - slip and plastic deformations. Dislocations - Burgers vectors – edge and screw dislocations – motion of dislocation – climb - stress and strain fields of dislocation – forces acting on a dislocation – stress and strain fields of dislocation – forces acting on a dislocation – energy of dislocation

– interaction – between dislocation densities – dislocation and crystal growth – Dislocation – Frank – Read mechanism - point defects - twinning.

Reference Books:

1. Crystallography and crystal defects, A. Kelley, G.W. Groves & P. Kidd, Wiley
2. Crystallography applied to Solid State Physics, A.R. Verma, O.N. Srivastava, NAI
3. Solid State Physics, A.J.Dekker, Macmillan, (1967).
4. Lasers Theory and Applications, K.Thyagarajan, A.K. Ghatak, Plenum Press
5. Lasers and Non-Linear Optics, B B Laud, New Age International.
6. Solid State Physics, S.L. Gupta and V.Kumar, Pragati Prakashan.
7. Introduction to Theory of Solids, H.M. Rosenberg, Prentice Hall.
8. Solid State Physics,J.S. Blakemore, W.B.Saunders & Co. Philadelphia.
9. Solid State Physics, N.W. Ashcroft & N.D. Mermin, Brooks/ Cole(1976).
10. Crystal Defects and Crystal Interfaces, W. Bollmann, Springer Verlag.
11. A short course in Solid State Physics, Vol. I, F.C Auluck, Thomson Press,India, Ltd.
12. Crystalline Solids, Duncan Mc Kie, Christine Mc Kie, Wiley

PH3ME2 CRYSTAL GROWTH TECHNIQUES

Unit I

Crystal Growth phenomena (18 Hrs)

The historical development of crystal growth – significance of single crystals - crystal growth techniques - the chemical physics of crystal growth. Theories of nucleation - Gibb's Thompson equation for vapour, melt and solution- energy of formation of spherical nucleus- heterogeneous nucleation - kinetics of crystal growth, singular and rough faces, KSV theory, BCF theory - periodic bond chain theory- The Muller- Krumbhaar model.

Unit II

Crystal Growth from Melt and Solution Growth (20Hrs)

Growth from the melt - the Bridgmann technique – crystal pulling - Czocharalski method- experimental set up - controlling parameters advantages and disadvantages.- convection in melts – liquid solid interface shape - crystal growth by zone melting - Verneuil's flame fusion technique. Low temperature solution growth - methods of crystallization - slow cooling, solvent evaporation, temperature gradient methods - crystal growth system - growth of KDP, ADP and KTP crystals - high temperature solution growth, gel growth.

Unit III

Vapour Growth (16Hrs)

Physical vapour deposition - chemical vapour transport – definition, fundamentals, criteria for transport, Specifications, STP, LTVTP & OTP - advantages and limitations of the technique, hydrothermal growth, design aspect of autoclave – growth of quartz, sapphire and garnet.

Unit IV

Materials for Semiconductor Devices (18Hrs)

Semiconductor optoelectronic properties - band structure - absorption and recombination, semiconductor alloys - group III-V materials selection - binary compounds, ternary alloys, lattice mismatch - lattice mismatched ternary alloy structures - compositional grading, heteroepitaxial ternary alloy structure - Quarternary alloys.

Semiconductor Devices - Laser diodes, light emitting diodes (LED), photocathodes, microwave Field-Effect Transistors (FET).

Reference Books:

1. The Growth of Single Crystal, R.A. Laudise, Prentice Hall, NJ.
2. Crystal Growth: Principles and Progress , A.W. Vere, Plenum Press, NY.
3. Crystal Growth Processes and methods, P.S. Raghavan and P.Ramasamy, KRU Publications.
4. A Short course in Solid State Physics, Vol. I, F.C. Auluck, Thomson Press India Ltd.
5. Crystal Growth, B.R. Pamplin, Pergamon, (1980)
6. Crystal Growth in Gel, Heinz K Henish, Dover Publication

PH3MP3 COMPUTATIONAL AND ADVANCED ELECTRONICS PRACTICALS

(Minimum of 12 Experiments should be done)
(Experiments from 1 to 15 are C++ programs)

1. Motion of a spherical body in a viscous medium
2. Projectile motion and motion of a satellite
3. SHM – damped and forced
4. Formation of standing waves
5. Young's double slit – interference
6. Diffraction due to a grating
7. Polarisation and birefringence
8. Electric field due to a point charge and equipotential surface
9. Motion in electric and magnetic fields – cyclotron
10. Circuit analysis using Kirchoff's laws – LCR circuit with AC & DC sources
11. Solution of Schrodinger equation for harmonic and anharmonic potential
12. Finding the roots of a non-linear equation by bisection method
13. Solving an ordinary differential equation
14. Numerical integration of a function
15. Integration by using Monte Carlo method
16. RF oscillator above 1 MHz – frequency measurement
17. Pulse width modulator
18. Microprocessor – multiplication of two 8 bit binary numbers
19. Microprocessor – Sorting of data in ascending and descending order
20. Microprocessor – measurement of analogue voltage
21. Microprocessor – stepper motor control
22. Microprocessor - digital synthesis of wave form using D/A converter
23. Fullwave controlled rectifier
24. Frequency modulation and demodulation
25. OPAMP – Inverting amplifier
26. OPAMP – Low distortion sine wave generator
27. OPAMP – Difference amplifier
28. JK flip flop – four bit binary counter
29. JK flip flop – shift register
30. Pulse amplitude modulation
31. Attenuators
32. Half adder and full adder

SEMESTER – IV

PH4MC1 ADVANCED QUANTUM MECHANICS

Unit I

Time Dependent Perturbation Theory (16 hrs)

Time dependent potentials - interaction picture - time evolution operator in interaction picture - time dependent perturbation theory - Dyson series – transition probability - constant perturbation - Fermi-Golden rule – harmonic perturbation - interaction with classical radiation field - absorption and stimulated emission - electric dipole approximation - photo electric effect – energy shift and decay width - sudden and adiabatic approximation.

Unit II

Scattering (18 hrs)

Differential Scattering cross section & Total Scattering cross section - Scattering amplitude - The Born approximation - Yukawa potential- Rutherford Scattering - Method of Partial waves-Scattering by a perfectly rigid sphere & by a square well potential - Ramsaur-Townsend effect.

Unit III

Relativistic Quantum Mechanics (18 hrs)

Need for relativistic wave equation - Klein-Gordon equation – Probability conservation - covariant notation - derivation of Dirac equation – conserved current representation - large and small components – approximate Hamiltonian for electrostatic problem - free particle at rest -plane wave solutions - gamma matrices - bilinear covariant – relativistic covariance of Dirac equation - angular momentum as constant of motion.

Unit IV

Elements of Field Theory (20 hrs)

Euler-Lagrange equation for fields - Hamiltonian formulation – functional derivatives -conservation laws for classical field theory - Noether's theorem - Non relativistic quantum field theory - quantization rules for Bose particles, Fermi particles - relativistic quantum field theory - quantization of neutral Klein Gordon field - canonical quantization of Dirac field – plane wave expansion of field operator - positive definite Hamiltonian

Reference Books:

1. Advanced Quantum Mechanics, J.J. Sakurai, Pearson Education
2. Quantum mechanics - V.K. Thankappan, New Age Int. Publishers
3. A modern approach to Quantum Mechanics, Townsend
4. Introduction to Quantum Mechanics, David J. Griffiths
5. Field Quantization, W Greiner , J Reinhardt, Springer, (Chapter 2, 3,4 & 5)
.
6. Quantum Field Theory, Lewis H. Ryder, Academic Publishers, Calcutta,1989
7. Quantum Field Theory, Claude Itzykson & Jean Bernard Zuber, MGH, 1986
8. Introduction to Quantum Field Theory, S.J. Chang, World Scientific, 1990
9. Quantum Field Theory, Franz Mandl & Graham. Shaw, Wiley 1990

PH4MC2 ATOMIC AND MOLECULAR SPECTROSCOPY

Unit I

Atomic Spectra (18 hrs)

Vector atom model-electron spin-Stern-Grelach experiment-LS and jj coupling schemes-spectroscopic terms-Pauli's exclusion principle-spin-orbit interaction-interaction energy-interaction energy in LS and jj coupling schemes-selection rule- Hund's rule- Lande interval rule- normal and anomalous Zeeman effect Paschen- Back effect and Stark effect in one electron systems-hyperfine structure-width of spectral lines.

Unit II

Resonance Spectroscopy (18 hrs)

ESR-theory-relaxation process-experimental setup-hyperfine structure applications. NMR-classical and quantum theories-relaxation process-experimental technique-chemical shift-spin-spin coupling-applications. Mössbauer effect-theory-experimental technique-chemical isomer shift-magnetic hyperfine interactions-electric quadrapole interaction-applications

Unit III

Microwave and Infrared Spectroscopy (18 hrs)

Rotational spectra of rigid diatomic molecules - isotopic effect- intensity of rotational lines-non rigid rotator-linear polyatomic molecules-symmetric top molecules -microwave spectrometer- informations from rotational spectra. Vibrating diatomic molecules as harmonic and anharmonic oscillators - diatomic vibrating rotator-breakdown of Born-Openheimer approximation - vibrational spectra of polyatomic molecules- overtones and combinations influence of rotation on the spectra of linear and symmetric top molecules- IR spectroscopic analysis- FT- IR spectroscopy.

Unit IV

Raman Spectroscopy (9 hrs)

Raman effect, theory, rotational Raman spectra-linear molecules-symmetric top molecules-vibrational Raman spectra-rotational fine structure-Raman activity-mutual exclusion principle-structure determination using Raman and IR spectroscopy-laser Raman spectrometer, basic idea of nonlinear Raman effects, stimulated Raman effects, Hyper Raman effect, inverse Raman effect and CARS.

Electronic Spectroscopy (9 hrs)

Electronic spectra of diatomic molecules - progressions and sequences- Frank Condon principle- rotational fine structure of electronic vibration spectra-the Fortrat parabola-dissociation-pre dissociation-fluorescence and phosphorescence.

Reference Books:

1. Introduction of Atomic Spectra, H.E. White, Mc Graw Hill
2. Spectroscopy (Vol. 1 & 2), B.P. Straughan & S. Walker, Science paperbacks 1976
3. Fundamentals of molecular spectroscopy, C N Banwell and E M McCash.TMH
4. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.
5. Raman Spectroscopy, D.A. Long, Mc Graw Hill international, 1977
6. Introduction to Molecular Spectroscopy, G.M. Barrow, Mc Graw Hill
7. Molecular structure and spectroscopy, G. Aruldhas, PHI
8. Elements of Spectroscopy, Gupta, Kumar & Sharma, Pragathi Prakshan
9. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.
10. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India.

PH4ME3 NANOSTRUCTURES AND CHARACTERIZATION

Unit I

Low Dimensional Structures (18hrs)

Preparation of quantum nanostructures - size and dimensionality effects - size effects - potential wells - partial confinement - conduction electrons and dimensionality - Fermi gas and density of states - properties dependent on density of states - excitons - single-electron tunneling - applications - infrared detectors - quantum dot lasers - superconductivity.

Microelectromechanical Systems (MEMS) - Nanoelectromechanical Systems (NEMS) –Fabrication of nanodevices and nanomachines - Molecular and Supramolecular Switches.

Unit II

Carbon Nanostructures (18hrs)

Carbon Molecules - Nature of the Carbon Bond - New Carbon Structures - Carbon Clusters -Small Carbon Clusters - Carbon Nano tubes - Fabrication - Structure – Electrical Properties - Vibrational Properties – Mechanical Properties - Applications of Carbon Nano tubes - Computers - Fuel Cells - Chemical Sensors - Catalysis – Mechanical Reinforcement - Field Emission and Shielding. Solid Disordered Nanostructures - Methods of Synthesis - Failure Mechanisms of Conventional Grain sized Materials – Mechanical Properties – Nano structured Multi layers -Electrical Properties – Porous Silicon - Metal Nano cluster - Composite Glasses.

Unit III

Thermal, Microscopic and Infrared Analysis (18 Hrs)

Thermal analysis – DTA, DSC and TGA – methodology of DTA, DSC and TGA and Instrumentation.

Microscopy - Electron microscopy – Principles and instrumentation – resolution limit–scanning tunnelling microscopy – principles – scanning tunnelling microscope - SEM & TEM. Atomic force microscope–Instrumentation.

IR spectrophotometers –Theory and Instrumentation- Applications. Fourier transform techniques – FTIR principles and instrumentation. Raman spectroscopy –Principles, Instrumentation and Applications. Microwave Spectroscopy - Instrumentation and Applications

Unit IV

Mass Spectrometry, Resonance Spectroscopy (18 Hrs)

Mass Spectrometry - Principle – Instrumentation – Types of ions produced in a Mass spectrometer - Interpretation of Mass spectra – Applications. NMR – Principles and Instrumentation – Chemical shift - Spin-spin coupling - Applications of NMR - Electron spin resonance spectrometry – Theory of ESR – Instrumentation - Interpretation of ESR spectra - Applications.

Reference Books:

1. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley, (2003)
2. MEMS/NEMS: micro electro mechanical systems/nano electro mechanical systems Volume 1, Design Methods, Cornelius T. Leondes, Springer, (2006).
3. Instrumental methods of Chemical Analysis, G. Chatwal & Sham Anand, Himalaya
4. Introduction to Infrared and Raman spectroscopy, Norman D Colthup, Lawrence H Daly and Stephen E Wiberley, Academic press, NY.
5. Instrumental methods of analysis, H.H. Willard, L.L. Merrit, J.A. Dean & F.A. Settle, CBS Pub.
6. Principles of Instrumental analysis, Skoog and West – Hall – Sanders Int.
7. Instrumental methods of chemical analysis, G W Ewing, MGH
8. Scanning Tunnelling Microscopy, R. Wiesendanger & H.J. Guntherodt, Springer
9. Thermal Analysis, Wesley W.M. Wendlandt , Wiley.

PH4ME4 THIN FILM AND NANO SCIENCE

Unit I

Thin Film (18 Hrs)

Nucleation – Langmuir theory of condensation – Theories of nucleation – Liquid like coalescence and growth process – Epitaxial growth – Structural defects in thin films – Electrical conduction in metallic, semiconducting and insulator films. Optical properties of thin films.

Unit II

Deposition of Films (18 Hrs)

Production of Vacuum, Different types of vacuum pumps, Measurement of Vacuum Gauges, Working principle, Deposition of thin films, Various deposition techniques, Thickness measurement – optical methods, thickness monitors - Thin film applications.

Unit III

Nano materials and Applications (18 hours)

Nano structured Crystals -Natural Nano crystals -Crystals of Metal-Nano particles –Nano particle Lattices in Colloidal Suspensions –Photonic Crystals.

Synthesis and purification of carbon nanotubes, Single-walled carbon nanotubes and multiwalled carbon nanotubes, Structure-property relationships, physical properties, applications.

Overview of different nano materials available, Potential uses of nano materials in electronics, robotics, computers, sensors in textiles, sports equipment, mobile electronic devices, vehicles and transportation. Medical applications of nano materials.

Unit IV

Synthesis of Nano materials (18hrs)

Top-down techniques: photolithography, other optical lithography (EUV, XRay, LIL), particle-beam lithographies (e-beam, focused ion beam, shadow mask evaporation), probe lithographies, Bottom-up techniques: selfassembly, self-assembled mono layers, directed assembly, layer-by-layer assembly. Combination of Top-Down and Bottom-up techniques: current state-of-the-art.

Pattern replication techniques: soft lithography, nano imprint lithography. Pattern transfer and enhancement techniques: dry etching, wet etching, pattern growth techniques (polymerization, directed assembly).

Reference Books:

1. Thin film phenomena, K.L Chopra, McGraw Hill, New York
2. Thin film fundamentals, A. Goswami, New Age International
3. Vacuumm deposition of Thin films, L. Holland, Chapman Hall, London
4. Handbook of thin film Technology, L.I Maissel and R Glang, McGraw Hill
5. Optical Properties of Thin Films, O. S. Heaven, Dover Publications
6. Nano: the essentials, T. Pradeep, TMH, 2007
7. Nanoscale Materials, L.M. Liz-Marzán & P.V. Kamat, Kluwer Academic Pub. (2003)
8. Nanoscience, Nanotechnologies and Nanophysics, C. Dupas, P. Houdy & M. Lahmani, Springer-Verlag , (2007).
9. Nanotechnology 101, John Mongillo, Greenwood Press, (2007).
10. What is What in the Nanoworld A Handbook on Nanoscience and Nanotechnology, Victor E. Borisenko and Stefano Ossicini , WILEY-VCH Verlag, (2008).
11. Introduction to Nanotechnology, Charles P. Poole, Jr. and Frank J. Owens, Wiley
12. Semiconductor Nanostructures for Optoelectronic Applications, Todd Steiner, ARTECH HOUSE, (2004).
13. Nanotechnology and Nano-Interface Controlled Electronic Devices, M. Iwamoto, K. Kaneto, S. Mashiko Elsevier Science, Elsevier Science, (2003).
14. Semiconductors for Micro and Nanotechnology—An Introduction for Engineers Jan G. Korvink and Andreas Greiner, WILEY-VCH Verlag, (2002).

PH4MP4 MATERIAL SCIENCE PRACTICALS

(Minimum of 12 Experiments should be done)

1. Ultrasonic Interferometer – Young's modulus and elastic constant of solids
2. Ultrasonic Interferometer – calculate wada's constant
3. Thermal conductivity of a liquid and air by Lee's Disc method
4. Photo conductivity of a semiconductor material.
5. Study of colour centres and thermo luminance of alkali halides (Metal Oxides)
6. Optical constants of dielectrics and metal films
7. Measurement of optical properties of a glass plate by laser – Fizean Interferometry
8. Characterisation of Solar Cell
9. Determination of dielectric constant
10. Determination of forbidden energy gap
11. Study of variation of magnetic properties with composition of a ferrite Specimen
12. Four probe method – energy gap of a single crystal
13. Band gap energy of Ge or Si
14. Hall effect (a) carrier concentration (b) mobility & (c) Hall coefficient
15. Young's Modulus using strain Gauge
16. Measurement of thickness of a thin film
17. Study of dielectric properties of a thin film
18. Study of electrical conductivity with temperature for a thin film by two probe method
19. Determination of ac electrical conductivity of thin film (J-V characteristics using four probe)
20. Determination of lattice constant of a cubic crystal with accuracy and indexing the Bragg reflections in a powder X-ray photograph of a crystal
21. Observation of dislocation – etch pit method
22. X-ray diffraction – lattice constant (plate measurement)
23. Optical absorption coefficient of thin films by filter photometry
24. Temperature measurement with sensor interfaced to a PC or a microprocessor
25. ESR spectrometer – determination of g factor
26. Beam profile of diode laser
27. Track width of a CD using laser beam
28. He – Ne laser- verification of Malus law, measurement of Brewster

angle, refractive index of a material

29. Determination of Fermi energy of copper
30. Study of ionic conductivity in KCl / NaCl crystals
31. Thermo-emf of bulk samples of metals (aluminium or copper)
32. Study of physical properties of crystals (specific heat, thermal expansion, thermal conductivity, dielectric constant)
33. Study of variation of dielectric constant of a ferro electric material with temperature (barium titanate)
34. Thermal Conductivity of a metal by Forbe’s method.
35. Velocity of sound using Standing wave tube.
36. Blackbody radiator- emissivity
37. Zeeman effect set up- measurement of Bohr magnetron and Lande g-factor