SCHOOL OF PURE & APPLIED PHYSICS

MSc PHYSICS SYLLABUS

MATHEMATICAL PHYSICS-I

UNIT I Vector spaces and vector analysis (10 hours)

Linear vector spaces, Schmidt orthogonalisation, linear operators, dual space, ket and bra notation, Hilbert space, Metric space, Function spaces, Riesz –Fisher theorem (no proof),basis, orthogonal expansion of separable Hilbert spaces, Bessel inequality, Parsevals formula, Orthogonal curvilinear coordinates-gradient, divergence, Curl and Laplacian. Evaluation of line, surface,volume integrals.

UNIT II Differential geometry (15hours)

Definition of tensors, Metric tensor, One-form, metric tensor as a Mapping of vectors into one form. Covariant, Contravariant, and mixed tensors. Differentiable manifolds and tensors, Riemannian transport, geodesics, Christoffel symbols and curvature, Riemann curvature tensor, Ricci tensor and Ricci scalar: their definitions and properties , Bianchi identities.

UNIT III Sturm-Liouville theory, special functions and their differential equations (15 hours)

Frobenius method for solving second order ordinary differential equations with variable coefficients. Bessel ,Legendre, Hermite equations. Recurrence relations, generating functions and Rodrigues formulae for the Bessel, Legendre and Hermite functions. Linear differential operators, adjoint operators, Greens identity, eigen values and eigen functions, Sturm-Lioville operators and eigen values and eigen functions

UNIT IV Greens functions (20 hours)

Dirac delta functions-properties and representations, Definitions and physical significance of Greens functions, Translational invariance, eigen function expansion of Greens function, Greens function for ordinary differential operators, first order linear differential operators and second order linear differential operators.(Eg. Forced harmonic oscillator)

Greens functions for partial differential operators, Laplace diffusion equation and wave equation operators, solution of boundary value problems using greens function for Laplace, Poisson and wave equations.

References

1. Mathematical methods in classical and quantum physics- T. Das and S.K. Sharma, University Press(1998)
2. Theory and problems of vector analysis- M. Spiegel, Schaum Out line series, McGraw Hill Book company.
3. A first course in general relativity- B.F.Schutz, Cambridge university press(1985)
4. Mathematical methods for physicists- G.B. Arfken and ,H.T.Weber

BASIC ELECTRONICS

UNIT I Operational amplifiers & Power devices (20 hours)

Basic operational amplifier applications- Differential DC amplifier- instrumentation amplifier- integrators and differentiators – Analog computation- Active filters- comparators- sample and holed circuit- precesion Ac/Dc converters- Logarithmic amplifiers- waveform generators- Regenerative comparator- voltage regulators. Thyristors- SCR & Triac- characteristics and ratings- power control using thyristors- power MOSFETs, IGBT- switch mode DC power supplies.

UNIT II Digital Electronics (16 hours)

Binary adders- Decoder & encoder- multiplexer & demultiplexer- JK flipflop- shift registers- Ripple counter- synchronous counter- A/D and D/A converters- 555 timer- phase locked loop.

UNIT III Microprocessors (20 hours)

Architecture of 8085 microprocessor- instruction set of 8085- simple programs using 8085- interfacing memory & I/O devices- 8085 interrupts-8255 programmable peripheral interfaces- operating modes of 8255- interfacing using 8255.

UNIT IV Communication Electronics (16 hours)

Amplitude modulation- single side band techniques- frequency modulation & demodulation techniques- Bandwidth requirement- pulse communication- pulse width, pulse position , pulse code modulation- Digital communication- error detection & corruption- frequency & time division multiplexing.

References

1. Milman & Halkias " Integrated electronics" TMH.
2. Roddy & Coolen " Electronic communications" PHI
3. Kennedy and Davis " Electronic communications" TMH
4. M. Ramamoorthy " An introduction to Thyristors and their applications".
5. A.P. Mathur " Introduction to microprocessors" TMH
6. Gaonkar " Microprocessor Architecture, programming & applications with 8085".
7. K C Shet and K M Hebbar " Microprocessors",

CLASSICAL MECHANICS

UNIT – I Lagrangian and Hamiltonian formulation (20 hours)

Review of Newtonian and Lagrangian dynamics- application of Lagrange's equations to velocity dependent potentials- Hamilton's equations of motion- cyclic coordinates- conservation theorems – homogeneity of space and time- variational principle and Hamilton's equations- physical significance of principle of least action. Canonical transformations- Poisson brackets- Hamilton's characteristic function- Hamilton-Jacobi theory- harmonic oscillator problem- action-angle variables- transition to wave mechanics.

UNIT – II Fluid Mechanics (18 hours)

Equation of state- equation of continuity- Bernoullli's thorem- interepretation- flow around bodies of simple shapes- aerodynamic lifting forces- Kelvin's theorem – Helmholtz theorem -flow of imperfect fluids- Navier-Stokes equation, Lagrangian formulation for continuous systems- sound vibrations in gas

UNIT – III Perturbation Theory (17 hours)

Classical perturbation theory- time dependent perturbation- 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- Euler angles(elementary ideas only)- Free vibrations of a linear triatomic molecule

UNIT – IV Chaotic Dynamical Systems (15 hours)

Classification of dynamical systems- conservative systems- integrable systems- KAM theorem (qualitative idea) nonlinear perturbation- Hamiltonian-chaos. Dissipative systems- continuous systems- Duffing oscillator- discrete systems- Logistic map- fixed points- period doubling- limit cycles- chaotic attractors – Lyapunov characteristic exponent- fractal dimensions- fractals - Koch curve.

References

1. Classical Mechanics- N.C. Rana & P.S Joag
2. Classical Mechanics- H. Goldstein
3. Classical Mechanics- A.K. Roy Chaudari.
4. Chaos and integrability in Nonlinear Dynamics – M Tabor
5. Chaos in Classical and Quantum Mechanics – M C Gutzwiller
6. Chaotic Dynamics- An Introduction – G L Baker and J P Gollub
7. Deterministic Chaos – N Kumar, University Press

<u>CLASSICAL ELECTRODYNAMICS</u>

UNIT I Electrostatics & Magnetostatics (18hours)
Coulomb's law, electric field, Gauss' law, differential form of Gauss' law, another equation of electrostatics and the scalar potential, approximate potentials at large distances (ref2). Simple ideas about a) Poisson and Laplace equations and b) the energy density of the electrostatic field, Elementary treatment of electrostatics with ponderable media. Biot and Savart law , differential equations of magnetostatics and Amperes law ,vector potential, magnetic fields of a localized current distribution, magnetic moment

UNIT II Time dependent fields (18 hours)
Faradays law of induction, energy in the magnetic field, Maxwell's displacement current, Maxwell's equations, vector and scalar potentials, gauge transformations, Lorentz gauge, Coloumbs gauge, derivation of the equations of macroscopic electromagnetism (final equation alone), Poyntings theorem, transformation properties of electromagnetic quantities under rotations, spatial inversions and time reversal

UNIT III Electromagnetic radiation & Guided waves (20hours)
Plane waves in a non conducting medium, energy and momentum of electromagnetic waves(Ref.2), reflection and refraction at a plane interface between two dielectrics, electromagnetic waves in conductors(Ref.2), the frequency dependence of ε,μ and σ(Ref.2), Waves guides, Modes in a rectangular wave guide. Retarded potentials, The Lienard-Wiechert potentials, the field of a system of charges at large distances, electric and magnetic dipole radiation. Magneto hydrodynamic equations.

UNIT IV Relativistic Electrodynamics (16 hours)
Lorentz transformation equation, Lorentz invariance of the Maxwell's equation, electrodynamics in tensor notation, potential formulation of relativistic electrodynamics, Four potential of a field, equations of motion of a charge in a field, the vector potential and quantum mechanics(the Aharanov - Bohm effect)

References

1. Classical Electrodynamics(2nd edn)- J.D Jackson, Wiley Eastern.
2. Introduction to Electrodynamics(2nd edn)- D.J.Griffiths, Prentice Hall of India.
3. The Classical theory of Fields(4th edn) L D Landau and E M Lifshitz, Pergamon
4. The Feynman Lectures on Physics Vol II -R Leigthton, M Sands, Narosa publishing House.
5. Introduction to Relativity -R Resnick.

MATHEMATICAL PHYSICS – II

UNIT I Complex Analysis (18 hours)

Functions of a complex variable – The derivative and Cauchy Reimann differential equations – Line integrals of complex functions – Cauchy's integral theorem - Cauchy's integral formula – Taylor's series – Laurent's series – Residues – Cauchy's residue theorem – Singular points of an analytic function – The point at infinity – Evaluation of residues – Evaluation of definite integrals by contour integration - Method of steepest descent (Sterlings formula)- summation of series using residue theorem.

UNIT II Group theory (20 hours)

Definition of groups (eg.)– matrix groups- transformation groups- cosets- congugacy classes- Lagrange theorem – invariant subgroup- factor group- homomorphism-homomorphism theorem- isomorphism- direct product of groups. Representation of groups: matrix, faithful, UNITary, reducible and irreducible representations- Schur's lemma- orthogonality theorem- characters- character table- group algebra and regular representations- representation on function spaces. Lie groups and Lie algebras: Defention of Lie groups with examples- O(3), SO(3), SU (2) groups- representation of SU(2), SO(3)

UNIT III Fourier series, Fourier transforms, Laplace transforms (14 hours)

Fourier series – Dirichlet's conditions – Fourier series of even and odd functions – Complex form of Fourier series – Fourier integral and it's complex form – Fourier transforms – Fourier sine and cosine transforms – Convolution theorem and Parseval's identity. Laplace transform of elementary functions – Inverse Laplace transforms – Methods of finding Inverse Laplace transforms – Heaviside expansion formula – Solutions of simple differential equations

UNIT IV General theory of Relativity (20 hours)

Principle of equivalence (weak and strong)- Einstein – Hilbert action- Einstein equations from the action- Newtonian limit of Einstein's equations. Centrally symmetric gravitational fields. Schwaarzschild solution- singularities – motion in a centrally symmetric gravitational field with application to the perihelion shift of mercury- conserved quantities – types of orbits – binary pulsar. Gravitational deflection of light – gravitational radiation- weak gravitational waves – propogation of gravitational waves- effect on fluid particles. Simpifying assumptions of cosmology- the Robertson – walker metric

References

1. Mathematical methods in classical and quantum physics, T Dass & S K Sharma
2. Mathematical methods for physicists- G F Arfkan & Weber
3. A first course in general relativity- B F Schutz
4. Classical theory of fields- L D Landau & E M Lifshitz

STATISTICAL PHYSICS

UNIT I Thermodynamics and Statistical theory (18 hours)

Laws of thermodynamics and their consequences. Thermodynamic potentials and Maxwell's relations. Chemical potential. Phase equilibriam. The macroscopic and microscopic states – contact between statistics and thermodynamics – the classical ideal gas – entropy of mixing and the Gibb's paradox – Phase space of a classical system – Liouville's theorem and it's consequences – The micro canonical ensemble – quantum states and phase space – The equi partition theorem-The Virial theorem

UNIT II The Canonical and grand canonical ensemble (16 hours)

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 Quantum statistics (18 hours)

Quantum mechanical basis – statistical distribution – an ideal gas in quantum mechanical micro canonical ensemble and other quantum mechanical ensemble – Partition functions and other thermodynamic quantities of monatomic and diatomic molecules. Thermodynamic behavior of a Bose gas – thermodynamics of Black body radiation – Bose Einstein condensation – Thermodynamic behavior of an ideal Fermi gas – Pauli Para magnetism – electron gas in metals and thermionic emission

UNIT IV Theory of Phase transition and fluctuations (20 hours)

Problem of condensation – Theory of Yang and Lee – Bragg – Williams approximation – comparison with experiment near transition temperature - Ginzburg – Landau theory – Ising model and it's solution for a linear chain – equivalence of Ising model to other models – Lattice gas and binary alloy. Fluctuations – Brownian motion – Langevin equation – random walk problem – Einstein's relation for mobility – the Fokker Planck equation – Spectral analysis of fluctuations: Wiener- Khintchie theorem

References

1. Statistical mechanics - R K Pathria
2. Statistical mechanics - K Huang
3. Statistical mechanics and properties of matter – E S R Gopal
4. Statistical thermodynamics - M C Gupta
5. An introduction to thermodynamics- Y V C Rao

OPTICAL PHYSICS

UNIT I Light Propagation and Vectorial Nature (15 hours)

Electromagnetic wave propagation, Harmonic waves, phase velocity, group velocity, energy flow – Poynting vector. Different polarizations –Matrix representation, Jones calculus. Ray vectors and ray matrices. Theory of partial coherence-visibility of fringes-coherence time and coherence length-coherence line width-temporal and spatial coherence-multiple beam interference- fabry perot interferometer - theory of multi layer films-applications

UNIT II Theory of Diffraction & Crystal Optics (24hours)

Kirchoff's theory of diffraction-Fresnel -Kirchoffs formulae-Fresnel diffraction at a straight edge-Babinets principle-Fraunhoffer diffraction at single , multiple and circular aperture-resolution of patterns -Fourier transform in diffraction theory-Frauhnhoffer diffraction -apodization-spatial frequencies and spatial filtering. Propagation of light in isotropic dielectric media-dispersion -Sellmeir's formulae-propagation of light in crystals-ray velocity-wave vector surface-susceptibility tensor of an optically active medium Nonlinear polarization and nonlinear wave equation. Second harmonic generation and phase matching

UNIT III Laser Optics (15 hours)

Laser action: absorption, spontaneous and stimulated emission; Einstein A and B coefficients – amplification of light – threshold condition, three- and four-level rate equation analysis, line broadening. Laser media and laser systems; solid-state lasers, gas lasers, dye lasers, semiconductor lasers, fibre lasers. Theory of laser resonators and modes. Q switching and Mode locking (Qualitative ideas)

UNIT IV Holography and Fibre Optics (18 hours)

Theory of holography, reconstruction of images. Volume holograms- off-axis holograms. Fourier holograms. theory of cylindrical wave guides, modes-step index fibre-graded index fibre- Ray theory of transmission-acceptance angle-numerical aperture -single mode fibres- cut-off wavelength. Transmission characteristics in optical fibres, attenuation and scattering loses-non-linear loses-optimum wavelength for transmission. Material dispersion-wave guide dispersion- intermodal dispersion. Optical communication (General ideas)

References

1. Introduction to Modern Optics- G R Fowles
2. Quantum Electronics-A Yariv
3. Optical Electronics-Ghatak & Thyagarajan
4. Modern Optics-R d Guenther
5. Laser Fundamentals-W T Silfvast
6. Introduction to fibre optics- Ghatak & Thyagarajan

QUANTUM MECHANICS –I

UNIT I Postulates of Quantum Mechanics (15 hours)

Definition of Hilbert space using Dirac Bracket notation- Postulates of quantum mechanics- principle of superposition- observables as hermitian operators- expectation values- projective evolution – time dependent schrodinger equation- generalized Heisenberg uncertainty relations- free particle, matrics representation of operators, one dimensional oscillator- postion and momentum representations - algebraic representation – eigen functions and eigen values using commutation relations.

UNIT II Representations and stationary states (15 hours)

Schrodinger , Heisenberg and interaction representation – Ehrenfests theorem- time dependent Schrodinger equation and continuity equation- Time independent Schrodinger equations – spherically symmetric potentials - particle in a three dimensional box, three dimensional isotropic harmonic oscillator and Hydrogen atom- energy eigen values and eigen functions.

UNIT III Approximation methods (22 hours)

Time independent perturbation theory (degenerate and nondegenerate cases):Wave function and correction to energy to second order- (e.g.) anharmonic oscillator- degenerate case: secular equation- corrections to eigen values and eigen functions in the first and second approximations for a double degenerate level- first and second order Stark and Zeeman effect in hydrogen. Time dependent perturbation theory: Transitions under perturbations acting for a finite time- (eg) uniform electric field applied to a charged oscillator in the ground state – ionization of Hydrogen atom under a sudden jolt- transition under periodic perturbation. WKB approximation (Quasi classical case): Boundary conditions in quasi classical case- Connection formula- quasi classical motion in a centrally symmetric field- penetration through a potential barrier.

UNIT IV Angular momentum (20 hours)

Commutation relations of angular momentum operator- Generalised angular momentum operators - eigen values and eigen functions of angular momentum operator-spherical harmonics- matrix representation –pauli spin matrices- operators for infinitesimal and finite rotations- addition of angular momenta - Clebsch –Gordon coefficients for $j_1= ½, j_2 = ½$

References

1. Quantum Mechanics- Landau & Lifshitz
2. Quantum Mechanics- Greiner
3. Quantum Mechanics- G Aruldas
4. Quantum Mechanics-Schiff
5. Quantum Mechanics-Mathews & Venkatesan

Theoretical Physics I

Unit I Global Symmetries-Galilean, Poincare and Conformal group. (20 hours)
Poisson brackets; Galilean group-transformations, generators; graded poisson brackets, fermionic oscillators, Lie bracket, Lie Algebra, Lie group, Lorentz group , Poincre group and Conformal group – algebra and transformations, invariants and conservation laws, light-cone coordinates, Charge conjugation, Parity and Time reversal transformations and their combinations, Matrix representations of Lie groups; Determinants in terms commuting and anticommuting integrals; Classical groups – classification and definitions; Tensor notation; coordinate representations; Differential forms and their integration; Young tableaux; Standard model group – color and flavor; Covering group**.**

Unit II Spin. (18 hours)
Spinor representation of lorentz group; 2 component notation – 3-vectors, rotations, spinors, indices, Lorentz transformations, Dirac spinors, Chiral spinors, chirality and duality; Field equations for massless particles and their solutions; Dimensional reduction, Field equations for massive particles, Stuckleberg formalism, Foldy-Wouthuysen transformation; Twistors; Helicity ; Supersymmetry algebra; Supercoordinates, Superconformal groups, supertwistors.

Unit III Local Symmetries(18 hours)
Functional differentiation and integration; Action functional and its properties- bosonic fields and fermionic fields; Field equations; Gauge transformations – global and local, Abelian and Non-abelian, Gauge fixing; Constrained Hamiltonian systems, First class and Second class constraints; Free particles, particles coupled to gauge fields, conservation laws, pair creation; Yang-Mills theories- light cone gauge, plane waves , self duality, twistors, instantons, ADHM and Monopoles.

Unit IV Hidden Symmetries(16 hours)
Spontaneous breakdown of symmetry – Higgs mechanism and Goldstone theorm; Sigma models, Coset spaces, Chiral symmetry, Stuckelberg fields; Standard model – Chromodynamics, Electroweak dynamics, Salam-Weinberg theory, families, grand Unified theories; Chiral Supersymmetriy, Supersymmertric actions- covariant derivatives, prepotentials, gauge fields; Supersymmetry breaking; Extended Supersymmetry.

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Text and Reference Books

Fields, W. Seigel
Quantum theory of fields Vol.1, S.Weinberg
An introduction to quantum field theory, M.E.Peskin and D.V.Schroder
An introduction to quantum field theory, G. Sterman
Quantum field theory-A modern introductiom, M.Kaku
Classical theory of fields, Landau and E.M.Lifshitz
Quantum field Theory, C.Itzykson and J.Zuber
Quantum Field theory and critical phenomenon, J.Zinn-Justin

Theoretical Physics II

Unit I Quantisation (20 hours)

Path integrals, Semiclassical expansion, Propagators– particles, properties, generalizations, Wick rotation; Smatrix – path integrals, semiclassical expansion, Feynman rules, semiclassical unitarity, cutting rules, cross sections, singularities.

Unit II Quantum Gauge theory (18 hours)

Quantisation of constrained Hamiltonian systems using BRST method.- Using Hamiltonian, Nakanishi-Lautrup fields, gauge fixing, for particles and fields; Gauges – Radial, Lorentz, Massive, Gervais-Neveu, Spacecone, Background field, Nielsen-Kallosh ; Scattering- Yang-Mills, Recursion relations, Fermions, masses.

Unit III Loops(18 hours)

Dimensional renormalisation, Momentum integrations, Modified subtractions, optical theorem, power counting, infrared divergences; Tadpoles, Effective potential, Dimensional transmutation, Massless propagators, Massive propagators, renormalisation group, overlapping divergences; Improved perturbation, Renormalons, Borel summation, 1/N expansion.

Unit IV Gauge loops(16 hours)

Propagators- Fermion, photon, Gluon, Bosonosation; Schwinger model; JWKB approximation, Axial anomaly, Anomaly cancellation, $\pi \rightarrow 2\gamma$, Vertex corrections. Nonrelativistic JWKB; conformal anomaly, $e^+e^- \rightarrow$ hadrons, Parton model.

Text and Reference Books

Fields, W. Seigel
Quantum theory of fields Vol.2, S.Weinberg
An introduction to quantum field theory, M.E.Peskin and D.V.Schroder
An introduction to quantum field theory, G. Sterman
Quantum field theory-A modern introductiom, M. Kaku
Quantum field Theory, L.Ryder
Quantum field Theory, C.Itzykson and J.Zuber
Quantum Field theory and critical phenomenon, J.Zinn-Justin

COMPUTATIONAL PHYSICS

UNIT I COMPUTATIONAL METHODS (15 hours)

Methods for the determination of zeroes of linear and nonlinear algebraic equations and transcendental equations, -convergence of solutions
Solution of simultaneous linear equations, Gaussian elimination, pivoting, iterative method, matrix inversion
Eigenvalues and eigenvectors of matrices, Power and Jacobi method

UNIT II (15 hours)

Finite differences, Interpolation with equally spaced and unevenly spaced points, Curve fitting, Polynomial, least squares, and spline fitting
Numerical differentiation and integration, Newton-Cotes formulae, Error estimates, Gauss method

UNIT III (18hours)

Random variate, Monte Carlo evaluation of integrals, Methods of importance sampling, Random walk and Metropolis method
Numerical solution of ODE's, Euler and Runge Kutta methods, Predictor and corrector method, Elementary ideas of solutions of partial differential equations

UNIT IV PROGRAMMING (24 hours)

Elementary information about digital computer principles, Compilers, Interpreters and Operating systems, C++ PROGRAMMING Constants and variables, simple data types, I/O operators, arrays, conditional statements, Boolean expressions, true and false values, relational and logical operators, 'while', 'for', and 'do-while' loops, switch statements, simple algorithms, Reference variables, passing arguments to functions by reference and constant reference, Literal strings, I/O for strings, Structures -user defined types, accessing members of a structure, Modularity -modular programmes, header files, local, global and static variables, Classes -public and private members

REFERENCES

Numerical Algorithms E.V.Krishnamuirthy & S.K.Sen
Numerical Methods E.Balaguruswamy
Introductory Methods of Numerical Analysis Sastry
Numerical Analysis Rajaraman
Numerical Recipes Press, Flannery, Teukolsky, Vetterling
Programming with C++ J.R.Hubbard Schaum's Outline Series
C++ Primer Plus Stephen Prata 1992 Galgotia Publications New Delhi
Object Oriented Programming with C++ E.Balguruswamy

Quantum Mechanics II

UNIT I. Scattering Theory. (20 hours)

Collisions in 3-D and scattering; Laboratory and CM reference frames; Scattering amplitude; Differential scattering cross section and Total scattering cross section; Scattering by spherically symmetric potentials; Partial wave and phase shifts; Scattering by a perfectly rigid sphere and by square well potential; Complex potential and absorption; Partial wave analysis of scattering from standard simple potentials; Optical theorem. Born Approximation.

UNIT II Many particles. (18 hours)

Identical particles; Symmetric and antisymmetric wave functions; Collision of identical particles; Spin function for a many electron system; Slater determinants; spin and statistics; Differences in collision process between classical and quantum identical particles; Occupation number representation; Second quantisation of fermions; Second quantisation of bosons. Hamiltonian for 1 particle and 2 particle interactions in second quantised formalism.

UNIT III (18 hours)

IIIa. Approximate methods

Variational method. Semiclassical theory of radiation; Transition probability for absorption and induced emission; Electric dipole and forbidden transitions; Selection rules; Magnetic dipole transitions; Stimulated emission; Higher order transitions.

IIIb. Relativistic quantum mechanics

Klein-Gordon equation; Difficulties with Klein-Gordon equation; Dirac equation; Plane wave solution; Non-relativistic limit of Dirac equation; Spin and orbital angular momentum of electron from Dirac equation.

UNIT IV. Quantum Field theory (16 hours)

Lagrangian and Hamiltonian formalism of classical field theory; Canonical quantisation; Second quantisation of real scalar field; Second quantisation of complex scalar field; Second quantisation of Dirac field; Second quantisation of Electromagnetic fields; Gupta-Bleular formalism.

Text and Reference Books

Quantum Mechanics, L.D.Landau and E.M.Lifshitz
Quantum Mechanics, P.M.Mathews and Venkatesan
Quantum Mechanics, L.I. Schiff
Quantum Mechanics. P.M. Thankappan
Quantum Mechanics, A.P. Messiah
Quantum Mechanics, B.Crasemann and J.D.Powell
Modern Quantum Mechanics, J.J. Sakurai
Relativistic Quantum Mechanics, P.Strange
Quantum Field Theory, L.Ryder
Quantum Field Theory, C.Itzykson and J.Zuber

ASTROPHYSICS I

UNIT I (15 hours)
Coordinate systems - sidereal, solar, universal, standard and ephemeris times. Parallax, precession, nutation, aberration. Proper motion -radial and transverse velocities, space velocity. Units of distance -AU, light year and parsec. Magnitude scale -magnitudes and luminosities (apparent and absolute), colour indices, surface temperature. Distance modulus -distances and radii of stars, double stars and the masses of stars

UNIT II (15 hours)
Solar structure - photosphere, chromosphere and corona. Activity in the sun -sunspots, flares, solar oscillations, helioseismology. The solar system -general characteristics, origin of the solar system, orbits of planets, satellites and comets

UNIT III (21 hours)
Concepts of sensitivity, resolving power and signal to noise ratio. Optical telescopes - parts, different focii and mountings. Radio telescopes -interferometers, synthesis telescopes, VLBI. Xray astronomy -detection and collimation. IR, gamma ray, neutrino, and gravity wave detectors. CCD's as detectors.

UNIT IV (21 hours)
Radiation mechanisms – Lienard-Wiechert potentials and fields for a point charge, total power radiated by a point charge, Larmor formula and relativistic generalization. Black body, bremsstrahlung, cyclotron, synchrotron, curvature, plasma and inverse Compton radiation. The 21 cm line of H. Transmission through an ionized medium -Faraday rotation. Interstellar extinction, Doppler, cosmological and gravitational redshifts

REFERENCES
Astrophysics, B. Basu
The Physical Universe, F.H.Shu
Astrophysics: Stars and Galaxies, K.D.Abhyankar
The New Cosmology, Albrecht Unsold
Radio Astronomy, J.D.Kraus
Theoretical Astrophysics, T.Padmanabhan

ASTROPHYSICS II

UNIT I (18 hours)

Correlations between stellar properties -M-L relation, HR diagram. Physical state of the stellar interior -hydrostatic equilibrium, distribution of mass, estimates of central temperature and pressure. Energy generation equations -energy transport by radiation and by convection. Equations of stellar structure -equation of state for stellar interiors - perfect gas, degenerate gas. Sources of opacity

UNIT II (18 hours)

Nuclear reactions -H burning, CNO cycle, Helium burning, neutrinos, solar neutrino experiments. Structure of main sequence stars. Qualitative account of premain sequence evolution, early post main sequence evolution, turn off and the ages of stellar clusters. Advanced evolutionary stages, degenerate stars.

UNIT III (18 hours)

The Galaxy - structure, stellar populations and the formation of the Galaxy. The ISM -H II regions, supernovae, HI in the Galaxy, Giant Molecular Clouds and star formation. Determination of the rotation curve of the Galaxy -its implications regarding dark matter. Classification of Galaxies. Hierarchy of structures (groups, clusters, superclusters). Active Galactic Nucleii and quasars -the redshift controversy.

UNIT IV (18 hours)

What is cosmology? Olber's paradox, the uniformity of the CMB. The seeds of structure formation, the origin of the anisotropies in the CMB. The contents of the universe -dust and radiation, Hubble's law. Fundamental assumptions -homogeneity and isotropy, the FRW metric, density evolution, critical density, cosmological constant. Conditions in the early universe – big bang nucleosynthesis, formation of light elements, observational constraints on their primordial abundances

REFERENCES

Astrophysics, B. Basu

The Physical Universe, F.H.Shu

Astrophysics: Stars and Galaxies. K.D.Abhyankar

The New Cosmology, Albrecht Unsold

Theoretical Astrophysics, T.Padmanabhan

APPLIED ELECTRONICS I

UNIT I (hours)
Architecture OF TYPICAL 16 BIT MICROPROCESSORS(Intel 8086)- Memory address space and data organization- segment registers and memory segmentation-generating a memory address- I/O address space- Addressing modes- comparison of 8086 and 8088- Basic 8086/80888 configuration- Minimum mode- maximum mode.

UNIT II (hours)
Instruction set of 8086/8088 microprocessors- Data movement instructions-Arithmetic and logic instructions- program control instructions- programming examples- assembly language program development on IBM PC – study of DEBUG utility.

UNIT III (hours)
Memory devices, address decoding, 8088/8086 memory interface, Dynamic RAM controllers, Basic I/O interface, I/O port address decoding, The 8255 programmable peripherial interface, The 8279 programmable keyboard/Display interface, 8254 Programmable Intervel timer. Interrupt processing, Hardware interrpts, expanding the interupt structure, 8259 programmable interrupt controller.

UNIT IV (18 hours)
Introduction to microcontrollers- comparison with microprocessors- study of microcontroller(MC 51 family)- Architecture, instruction set, addressing modes and its programming.

REFERENCES

1. YU-Cheng Liu & Glenn A Gibson , "Microprocessor system, Architecture programming & Design.
2. Bre, "The Intel Microprocessors –" PHI
3. Douglas V Hall ,"Microprocesors & Interfacing" – TMH
4. Avtar Singh, "IBM PC/8088 assembly Language Programming"
5. Scott MacKeinz "The 8051 Microcontroller, 3/E" Prentice Hall Inc.

CONDENSED MATTER PHYSICS -1

UNIT I

Crystal structure and diffraction from crystals

Two and three dimensional lattices- point groups and space groups- reciprocal lattice. The Ewald construction- X-ray diffraction from an atom, array of atoms and from a crystal – Structure factor- systematic absences- factor affecting the intensity- Larence and polarization factors, Debye-Waller factor- absorption cross-section

Powder diffraction methods- multiplicity and factors affecting the intensity – indexing of powder data for simple systems, structure determination from single crystal and power data (qualitatively)- Neutron diffraction- electron diffraction

UNIT II

Lattice vibrations

Quantisation of lattice vibrations- phonon momentum- vibrational modes of a diatomic lattice- inelastic scattering of neutrons by phonons- density of modes in three dimensions Debye theory of heat capacity- lattice thermal conductivity- thermal resistivity- Normal and umklapp process

UNIT III

Free electron theory and band theory

Free electron gas in three dimension- heat capacity of metals- Fermi momentum, energy and temperature

Kroning-Penny model- wave equation of electrons in a periodic potential – Bloch electrons in electric and magnetic fields – effective mass tensor- elementary ideas of fermi surface- evaluation of band structure- deHass –van Alphen effect- tight binding approximation

UNIT IV

Superconductivity

The of zero resistance – Type I and Type II superconductors- destruction of superconductivity by magnetic fields- Meissner effect- heat capapcity- energy gap-entropy change – isotopic effect-

Thermodynamics of superconduction transition- London penetration depth – Ginzburg London equations. B C S theory- ground state and excited state- flux quantisation- AC-DC Josephson effect- superconduction materials and devices-Oxide upper conductors- atomic arrangment and properties.

SPECTROSCOPY

Unit I Atomic Spectroscopy
Quantum states of electrons in atoms- Spectroscopic terms and selection rules- spin orbit interaction- fine structure –Landau g factor – Equivalent and nonequivalent electrons- Zeemen effect and Paschen Back effecting one electron system-LS and JJ coupling schemes- Hunds rule- Derivation of interaction energy-Examples of LS and JJ coupling- Llande intervel rule- Stark effect- hyperfine structure- width of spectral lines.

Unit II Microwave and IR spectroscopy
Linear, systematic top and asymmetric top molecules- rotational spectra of diatomicmolecules- intensity of spectral lines- Isotopic substitution- nonrigid rotator- roatational spectra of polyatomic molecule- stark modulation spectrometer
Diatomic molecules as harmonic and anharmonic oscillations- diatomic vibrating rotator- Born - Oppenheimer approximation – vibrations of polyatomic molecules- overtones and combination frequencies- IR analysis techniques- IR spectrometer- FTIR spectroscopy.

Unit III Raman and Electronic spectroscopy
Pure rotational Raman spectra- Linear and symmetric top molecules- vibrational Raman spectra-Raman activity of vibrations- Mutual exclusion principle- rotational fine structure- structure determination from Raman and IR spectroscopy- Laser Raman spectrometer- Nonlinear Raman effect- Hyper Raman effect- Stimulated Raman effect- Inverse Raman effect- CARS. Electronic structure of diatomic molecules- Intensity of spectral lines- Frank-Condon principle- dissociation energy and dissociation products- rotational fine structure of electronic vibrational transitions- Fortrat diagram- predissociation

Unit IV Spin Resonance Spectroscopy
NMR- quantum mechanical and classical treatment – Bloch equations- relaxation processes- chemical shift- spin - spin coupling- CW and FTNMR spectrometer- Applications- Theory of ESR- Thermal equilibrium and relaxation experimental techniques – g factor- hyperfine structure- applications- Mossbauer effect- recoilless emission and absorption- experimental methods- hyperfine interaction- chemical isomer shift- magnetic hyperfine interactions- electric quadrapole interaction- applications

References

1. Introduction to atomic spectra- HE White
2. Molecular spectra and molecular structure Vol. 1, 2 & 3 G Herzberg
3. Molecular structure & Spectroscopy G Aruldas
4. Fundamentals of molecular spectroscopy C Banwell
5. Raman spectroscopy D A Long
6. Introduction to molecular spectroscopy G M Barrow
7. Molecular spectroscopy J M Brown
8. Modern spectroscopy J M Holias

Condensed Matter Physics-II

Unit-1-Ferroelectrics, Diamagnetism & Paramagnetism 20hrs

Polarizability- Ferroelectric crystals and their properties- ferroelectric domains-thermodynamics of ferroelectric transitions-application of ferroelectrics. Landau diamagnetism equations- quantum theory of paramagnetism- magnetic properties of rare earth ions-crystal field splitting-quenching of orbital angular momentum-magnetic cooling-paramagnetic susceptibility of conduction electrons.

Unit-11-Ferromagnetism,Antiferromagnetism and Ferrimagnetism 18hrs

Ferromagnetic order-Weiss molecular field theory-Curie Weiss law-Magnons and their dispersion relation-magnons specific heat-Bloch wall- Neutron magnetic scattering-Ferrimagnetic order-Neels theory-structure of ferrites- antiferromagnetic order.

Unit-III-Crystal growth and defects in crystals 16Hrs

Crystal nucleation and growth-growth from melt-Chokralsky-Kyroplorous –zone refining. Crystal defects-point defects-line defects-colour centers inalkali halides-frenkel defects-Schtkey defects-dislocations-Grain boundaries-plane and stacking faults-Burgers vector.

Unit-IV- Less ordered solids 18Hrs

Amorphous materials-Glasses-the glass transition-factors determining glass transition-glass forming systems-structure of glassy materials. Liquid crystals-isotropic nematic and choledsteric phases-Smetic-A andC- Hexatic phases-Iyotropic liquid crystals-one and two dimensional order in three dimensional materials-incommensurate structures Quasicrystals-the icosaedral symmetry-magnetic order-fractals-penrose tiling.

References:

1. Introduction to Solid state Physics. C.Kittel (7thEdn) John Wiley.
2. Solid state Physics. A.JDekker -McMillian.
3. Introduction to solids. I.V.Azaroff, Tata MacGraw Hill.
4. Principles of Condensed Matter Physics, P.M.Chaikin&T.C.Lubensky,Cambridge University press.
5. Liquid crystals. S,Chandrasekhar.
6. Solid state Physics, G.Burns, Academic press.
7. Solid state Physics, S.O.Pillai, New age intl.pub.1999.
8. Solid state Physics,N.W.Aschrot and N.D.Mermin, H Rinchart Wriston Inc. Philaelphia.
9. Crystal growth, B.R.Pamplin, Pergamon Press,1975.

Materials Science I.

Unit I -Crystal growth: Nucleation and growth. Thermodynamics of crystal nucleation and growth. Solution growth, Gel growth. Bridgman, Czochralski, Kyropoules and Verneul methods. Floating zone method, Zone melting method, Growth from Vapour phase. Macromolecular crystal growth. Defects and imperfections in crystals- Frenkel defects and Schotkey defects, edge and screw dislocations, multiplication of dislocation during deformation, work hardening and metals, creep, color centers in alkali halides, plastic deformation and creep in crystalline materials. [15 hrs]

Unit II -Atomic arrangement in solids: bonding in solids, HCP and CCP, Interstetial sites, NaCl, CsCl, ZnS, Fluorite, Wurzite structure, Diamond structure, Cristobalite, Perovskite structure, Corundum Structure, Rutile structure, Spinel Structure, Graphite, Silicate structures, Pyrosilicates, Coordination number and Packing fraction, Fullerenes. [10 hrs]

Unit III -Diffraction theory: Basic ideas about crystalline and amorphous materials. Symmetry in crystals. Real lattice and the concept of reciprocal lattice. Point groups and space groups, Diffraction of X-rays from an electron, an atom, 1D lattice and a crystal. Atomic scattering factor and structure factor. Intensity of scattering from an hkl plane and various factors affecting the intensity. Importance of X-ray photographic methods: Laue, oscillation, rotation and Weissenberg methods. [15 hrs]

Unit IV -Structure Determination methods: Determination of symmetry and space group from single crystal data. Fourier transform and calculation of electron density. Structure determination from single crystal X-ray data. Phase Problem in crystallography, Elementary ideas about Heavy atom method, Equal atom method and Molecular replacement methods of structure solution. [20 hrs]

References:

1. Crystal growth, R.L. Laudise
2. Crystal Growth, B.R.Pamplin
3. Fundementals of X-ray crystallography, M.M.Woolfson.
4. Elements of X-ray crystallography, L.A.Azaroff.
5. X-ray Crystallograpgy, Stout & Jensen.
6. Structure Determination from Powder Diffraction Data Ed By W.I.F. David , K.Shankland, L.B.McCusker andCh. Baerlocher
7. Electron beam analysis of materials, M.H.Loretto
8. Science of Engineering materials, Srivastava and Srinivasan
9. The Science and Engineering of materials, Askeland.

Materials Science II.

Unit I -Material characterization methods: Diffraction of x-rays from powder samples. Factors that determine the intensity of scattered x-rays from powder samples. Identification of symmetry, indexing and structure solution from powder diffraction data. Rietveld analysis, The Le Bail method, The Pawley method, Direct methods in powder diffraction, Electron Diffraction and Neutron diffraction, IR, NMR, Raman, Mossbauer. Thermal characterization methods, DSC, TGA, DTA. [18 hrs]

Unit II -Amorphous materials: Ceramics and Glasses, Glass transition temperature, Preparation of glasses and ceramic materials, Melt spinning, Sputtering. Structural studies of glasses: RDF analysis. EXAFS analysis, Properties of ceramics and glasses. [7 hrs]

Unit III -Electron Microscopy: TEM: principle and working, HRTEM lattice imaging, contrast mechanisms, Applications.EELS, STEM Basic principles, Imaging with high energy electrons, theoretical background. High resolution BF and DF STEM imaging. Size measurement and distribution of nanoparticles, Coherent electron nano diffraction. Formation and emission of secondary electrons, Imaging with secondary electrons, Imaging with auger electrons.Nanoanalysis by EELS and XEDS. Principle and use of AFM technique. [20 hrs]

Unit IV -Synthesis and Characterization of Nanomaterials: Methods, of Synthesis. Nano structures, Symmetry in nano materials. Characterization of nanomaterials and their Properties using X-ray diffraction, Microscopy, Auger spectroscopy, X-ray spectroscopy etc …. . [15 hrs].

References:

1. Fundementals of X-ray crystallography, M.M.Woolfson.
2. Elements of X-ray crystallography, L.A.Azaroff.
5. Characterization of nanophase materials ed by Zhong Lin Wang

10. Structure Determination from Powder Diffraction Data Ed By W.I.F. David , K.Shankland, L.B.McCusker andCh. Baerlocher
11. Electron beam analysis of materials, M.H.Loretto
12. Basic Solid State Chemistry, A.R.West.
13. Science of Engineering materials, Srivastava and Srinivasan
14. The Science and Engineering of materials, Askeland.
11. Nanophysics and Nanotechnology, Edwarld L Wolf (Wiley-VCH)