Department of Physics
University of Kerala

M.Sc. Syllabus

Course Details

Semester I		
Course Code	**Credits**	**Subject**
PHY 511	**4**	**Mathematical Physics-I**
PHY 512	**4**	**Classical Mechanics**
PHY 513	**4**	**Electrodynamics and Plasma Physics**
PHY 514	**4**	**Electronic Devices and Circuits**
PHY 515	**5**	**LAB: Electronics**
Semester II		
PHY 521	**4**	**Mathematical Physics- II**
PHY 522	**4**	**Quantum Mechanics- I**
PHY 523	**4**	**Thermal and Statistical Physics**
PHY 524	**4**	**Atomic and Molecular Physics**
PHY 525	**5**	**LAB: Advanced Physics**
Semester III		
PHY 531	**4**	**Quantum Mechanics- II**
PHY 532	**4**	**Condensed Matter Physics**
PHY 533	**4**	**Nuclear and Particle Physics**
PHY 534	**4**	**Computational Methods and Programming (Elective)**
PHY 535	**4**	**Electronics – I (Elective)**
Semester IV		
PHY 541	**4**	**Electronics- II (Elective)**
PHY 542	**4**	**Electronics III(Elective)**
PHY 543	**5**	**LAB: Advanced Electronics**
PHY 544	**4**	**Project**

Semester I

PHY511: Mathematical Physics I

Unit I

Vector Spaces and Matrices

Postulates – lineqar independence-subspace- ordered dimensions- Euclidian vector space- reciprocal basis- Hilbert space- linear equations- eigen value problem- orthogonal matrices – Hermition matrices and Unitary matrices – diagonalization of matrices – eigen vector and eigen values – normal modes of vibration – singular matrices- inverse of matrix

Curvilinear Coordinates

Orthogonal curvilinear coordinates – Differential vector operator- Gradient, divergence, curl and Laplacian in cicrcle cylindrical and spherical polar coordinates.

Partial Differential Equations

Linear second order partial differential equations – solutions of partial differential equations- separation of variables- solution of wave equations.

Unit II

Gamma, (Γ), Beta (β) and Delta (δ) functions – Gqamma functions – Gqauss λ functions, values of Γ1/2 – β functions- connection between β and Γ functions- Error function – Dirac delta function – representation of δ function – properties

Legendre differential equations – Series solution – Rodrigues formula for Pn(x)- Generating function for Pn(x) – Orthogonality of Legendre polynomials – Orthogonality of associate Legendre polynomial

Bessels equation

Series solution- Bessel function of second kind – Generating function for Jn(x) – Bessel's integral representation – Recurrence formula for Jn(x) – Orthogonality of Jn(x) – Spherical Bessel function

Hermite differential equation

Series solution – Rodrigues formula for Hermite polynomial Hn(x) – recurrence relation for Hermite polynomial- Generating function – Orthogonality of Hermite equation.

Laguerre's differential equation

Series solution – generating function - L_n^m (x)- Rodregues formula- Associate Luguerre function of integral order.

Unit III

Fourier series and Integrals – Periodic series and integrals – Periodic functions – Fourier series – Euler Fourier series- Convergence of Fourier series and Dirchenet condition, half range Fourier series – change of interval – identity- integration and differentiation of Fourier series – Fourier integrals and Transforms – Application of the solution in one dimension – alternative form of Fourier sine and cosine series.

Laplace Transform – Definition – Existence – derivatives- elementary functions – periodic function – functions defined by integrals

Reference

Mathematical Methods for Physicists 4th Edn by Arfken & Weber, Academic Press

Mathematical Physics, Eugine Butkov, Addison Wesley

Applied Mathematics for Engineers and Physicists- L.A. Pipes and L. R. Harvill, McGraw-Hill Kogakusha

Mathematical Physic, Rajputh

Mathematical Physics- Ajay Ghatak

PHY 512 : Classical Mechanics

Unit I

Review of Newtonian Formulation

Space, Time, Reference frames – inertial, non-inertial, Galilean transformation, System of particles, Conservation laws, Limitations of Newtonian formulation.

Lagrangian Formulation of Mechanics

Generalize coordinates – constraints, virtual displacement, principle of virtual work, D'Alembert's principle, Lagrng's equation of motion, simple applications of Lagrange's equation, Generalized momenta, Cyclic coordinates, Routhe's procedure, Symmetric properties and conservation laws, Hamilton's principle, Lagrange's equations from Hamilton's principle, Nonconservative systems- Rayleigh dissipation function, Nonholonomous system – Lagrange's method of undetermined multipliers.

Unit II

Hamiltonian Dynamics

Description of motion in phase space, Hamiltonian of a dynamical system, Hamilton's equations, Integrals of Hamilton's equations, Cannonical transformations, Generating function, Poisson bracket, phase space and Liouville's theorem

Hamilton- Jacobi formulation

Hamilton-Jacobi equation- Harmonic oscillator as an example- separation of variables in Hamiltion-Jacobi equation – Action-angle variable- Kepler problem.

Two-body Central Force Problem

Two body problem and reduced mass, general properties of central force motion, effective potentials and classification of orbits, inverse square law of force – Kepler's laws of planetary motion, Newton's laws of gravity from Kepler's ;aws, Stability of circular orbits, Hyperbolic orbits and Rutherford's scattering

Unit III

Linear Oscillations

Potential energy and equilibrium , Stability expression of potential energy function in a power series, Oscillations of a system with one degree of freedom, Normal coordinates, Coupled harmonic oscillator, Linear symmetric triatomic molecule, General ides of transition from discrete to continuous system, The wave equation.

Motion of Rigid Bodies

The independent coordinates of a rigid body, Eulerian angles, rotational kineti energy and angular momentum, Euler's equation of motion, motion of a torque free symmetric top , motion of heavy symmetric top with one point fixed.

Reference

Goldstein: Classical Mechanics (Wiley/Narosa)
Rana and Jog: Classical Mechanics (TMH)
Bhatia: Classical Mechanics (Narosa)
Landaue and Lifshitz: Mechanics (Oxford: Pergamon)
Guptha, Kumar Sharma: classical Mechanics (Pragati Prakashan)
G Aruldhas: Classical Mechanics (PHI)

PHY513 : Electrodynamics and Plasma Physics

Unit I

Electrodynamics

Maxwell's equations – integral form- boundary conditions-scalar and vector potentials- Gauge transformations- Wave equations and their solutions- source free wave equations – time harmoinc fields- phasors – Helmhotz equations

Plane Electromagnetic Waves

Plane waves in Lossless media- TEM weaves- Polarization of plane waves- plane waves in lossy media, flow of electromagnetic power- Poynting's vector

Normal incidence at plane conducting boundary – Oblique incidence at a plane conducting boundary – normal incidence at a plane dielectric boundary- Oblique incidence at a plane dielectric boundary

Unit II

Waveguides and Cavity Resonators

Waves between parallel plates – TE, TM and TEM waves – Rectangular wave guides- TE and TM modes in rectangular wave guides – Circular wave guide – dielectric wave guides – cavity resonators

Radiation Theory

Dipole radiation – electric dipole radiation – magnetic dipole radiation – radiation from an arbitrary source

Relativistic Electrodynamics

Magnetism as a relativistic problem – transformation of the fields – electric field of a point charge moving uniformly – electromagnetic field tensor – electrodynamics in tensor notation – potential formulation of relativistic electrodynamics

Unit III

Motion of a charged particle in an electromagnetic field

Uniform E and B fields – non uniform fields – time varying E and B fields

Plasma Physics

Plasma Concepts – derivation of moment- equations from Boltzmann equation – Plasma oscillations – Debye Shielding – Plasma parameters – Electrodynamic description of plasma- Magneto plasma – Plasma confinement – fundamental hydrodynamical equations – Wave phenomena in magneto plasma – hydromagnetic waves and Alfven waves.

Reference

David K Cheng, Field and Wave Electromagnetics, Second Edition, Adison-Wesley (1999) Indian Edition

David J Griffiths, Introduction to Electrodynamics, 3rd edition Pearson Education, Indian Edition

F F Chen, Elements of Plasma Physics and Controlled Fusion Vol I Plams physics Second Edition, Plenum Press 1984.

Nannepaneni NarayanaRao, 'Basic Electromagnetic with Applications', PHI P\rivate Ltd. New Deljhi 1974 Indian Edition

John D Krouse, Electromagnetics, 4th Edition, McGraw Hill
Internationsl J.D. Jackson, Classical Electrodynamics, John Weily and Sons

PHY 514: Electronic Devices and Circuits

Unit I

Frequency response of amplifiers

Review of frequency response of CR circuits – Cut off frequencies – band width – Bode plots – single pole and two pole transfer functions – Dominant pole – gain round off- Frequency response of BJT amplifiers- Series capacitance and low frequency response – Shunt capacitance and high frequency response- high frequency characterstics of transistors.

Field Effect Transistor

Biasing of FET, small signal model, analysis of common souse and common drain amplifiers, high frequency response – FET and VVR and its appiactions, CMOS logic and logic packages

Power Amplifiers

Types of power amplifiers, series fed class A amplifier- series fed transformer coupled Class B

– Push-Pull circuits- harmonic distortion in amplifiers- Class C and D amplifiers- Design considerations.

Unit II

Operational Amplifier Circuits

Differential amplifier, Ideal op-amp – inverting, noninverting, voltage follower, differential configuration, real op-amp- inverting configuration, noninverting configuration, op-amp parameters, effect of Offset, frequency response, op-amp applications, Buffer amplifier, Mathematical operations- summing, differentiator, integrator, log amplifier, antilog amplifier, active filters – low pass, high pass, band pass, band reject filters, analogue computations, comparators – zero crossing detector, Schmitt trigger, wave form generators- phase shift oscillator, twin-T oscillator, astable multi vibrator, monostable multi vibrator, bistable multi vibrator, triangular wave generator, sample and hold circuit, voltage regulators.

Monolithic timers and their applications

RS flip flop, basic timing concept, 555 functional diagram and pin configuration, astable multi vibrator, monostable multi vibrator, free running ramp.

Unit III

Microwave and Optoelectronic Devices

Tunnel diode, Transfer electron device (Gunn diode) – optical fibre as a wave guide- mode theory of circular wave guides- wave guide equation – modes in step index fiber – graded index fiber – single mode fiber – mode characteristic and cut off frequencies.

Optical sources – LEDs, Device configuration and efficiency – LED structures – Heterojunction LED, surface emitting LED, edge emitting LED, Junction Laser,- Operating principle – Heterojunction Laser.

Photodetectors, photoconductors, Pin photo diode, heterojunction diodes, avalanche photodiodes, basic idea of photo transistors

References

1. Millmann J and Halkias C C, Integrated Electronics (Mc Graw Hill 1991)
2. Robert Boylestad and Luis Nashelsky : Electronic Devices and Circuit theory (PHI, 1989)
3. Ramakant A Gayakwad : Op-amps and Linear Integrated Circuits (PHI 2006)
4. John D Ryder Electronic Fundamentals and Applications (PHI, 1983)
5. Pallabh Bhattacharya: Semiconductor Optoelectronic Devices (PHI 1995)
6. Gerd Keiser Optical Fiber Communications (Mc Graw Hill, 2000)
7. John M Senior: Optical Fiber Communications (PHI 1992)

Semester II

PHY521: Mathematical Physics II

Unit I

Complex Variables

Functions of a complex variable-derivatives-Cauchy-Reimann equations- Cauchy-Reimen equations in polar form-harmonic functions-trigonometric hyperbolic and logarithmic functions- line integrals of complex functions- Cauchy-Gourasat theorem- Cauchy's integral formula- derivatives of analytic functions- Taylor series- Laurent series- singular points of an analytical function- poles –removable singularity- essential singularity- point at infinity-residues- calculation of residues- the residue theorem – evaluation of residues- evaluation of definite integrals – miscellaneous definite integrals.

Unit II

Tensor analysis

Transformation of co-ordinates in linear space- summation convention- contravariant and covariant tensors- properties of Kronecker delta- addition, multiplication and contraction of tensors – metric tensor- conjugate metric tensor – associated tensor- tensor calculus- Christoffel symbols – Christoffel symbols in rectangular, cylindrical and spherical polar coordinates-covariant differentiation – tensor form o0f gradient, divergence, curl and Laplacian.

Green's function

Green' function in one dimension – motion of a particle in a resisitive medium- motion of a damped harmonic oscillator – Green's function in three dimensions – solution of Poisson's equation.

Unit III Group

theory

Definition of a group – elementary properties of group- sub groups – cosets and classes – cyclic group – homomorphism and isomorphism – representation of finite groups – invariant subspace – properties of representations' – reducibility of a representation – irreducible representations – orthogonally theorem – characters of representations – orthogonally of characters – reduction of reducible representations – the groups C_{2v} and C_{3v} as examples – continuous groups – Lie groups – SO(2) and SO(3) groups – generators of SO(2) – special unitary groups – SU(2) and SU(3) groups and their representations.

Probability

Laws of probability – discrete probability distributions – theory of combinations and permutations – Stirling approximation for the factorial – continuous distributions – moments and standard deviations – Binomial distribution – Poisson distribution – normal distribution – distribution of a sum of normal variates – applications to experimental measurements.

References

Complex Variables and Applications, 5th Edn by Churchill & Brown, Mc Graw Hill
Vector Analysis by Speigal, Schaum series
Mathematical Methods for Physicists 4th Edn by Arfken & Weber, Academic Press
Mathematical Physics, Eugine Butkov, Addison Wesley
Matrices and Tensors in Physics, by A. W. Joshi, New Age International Publishers Elements of Group Theory for Physicists, by A. W. Joshi, New Age International Publishers Group Theory in Physics, by Wu-Ki Tung, World Scientific
Applied Mathematics for Engineers and Physicists- L.A. Pipes and L. R. Harvill, McGraw-Hill

PHY 522: Quantum Mechanics I

Unit I

- **The physical basis of Quantum Mechanics**
  Inadequacy of Classical Physics - significant experimental results, Max Planck's quantum hypothesis, Neil Bohr's application of quantum postulate to hydrogen atom, stationary states, energy levels, Bohr frequency rule. Limitations of old-Quantum Theory - practical and conceptual difficulties, quantum-mechanical view point. De Broglie's hypothesis of matter waves, the uncertainity principle, concept wave function, principle of superposition, wave packets.
- **The Schrödinger Wave Equation**
  Development of the wave equation- travelling harmonic waves. Need for a wave equation, the one dimensional wave equation, extension to three dimensions, inclusion of forces, operators for energy and time. Interpretation of the wave function - statistical interpretation, normalization of ψ, probability current density, expectation value, Ehrenfest's theorem.
- **Stationary states and energy eigen functions**
  Energy eigen functions - separation of the wave equation - The Time-Independent Schrödinger Equation, significance of the separation constant E, stationary states. Boundary conditions at great distances, continuity conditions, Degeneracy, orthogonality of eigen functions.
- **Eigen value problems in one dimension**
  Particle in an infinite square well potential, finite square well, rectangular potential barrier, quantum mechanical tunnelling-Alpha emission, The periodic potential - Bloch's theorem, Krönig-Penny model. Linear harmonic oscillator
- **Eigen value problems in three dimension**
  Spherically symmetric potentials in three dimensions, parity, angular momentum. Three-dimensional square well potential. Two-particle system – rigid rotator - The Hydrogen atom.

Unit II

- **The Mathematical Formulation of Quantum Mechanics**
  Matrix Algebra, Hermitian and Unitary matrices, transformation and diagonalisation of matrices, eigen values, matrices of infinite rank. Linear vector spaces, completeness, Hilbert space, orthonormal functions – Fourier series as an outstanding example of Hilbert space, linear operators, eigen values and eigen functions of operators – Eigen value problem – degeneracy. Dirac's ket and bra vectors, inner products. Hermitian operators - real eigen values and orthonormalcy of eigen functions of Hermitian operators, Dirac Delta function, closure property using Dirac Delta function, physical meaning of matrix elements. Commuting operators, compatibility – removal of degeneracy, The uncertainty principle – general uncertainty relationship. Postulates of Quantum Mechanics. Momentum representations – operators for position and momentum in momentum representation. Matrix representation of operators and wave function. The Equations of Motion – Schrödinger picture, Heisenberg picture, Interaction picture. Linear harmonic oscillator problem in the matrix mechanics, linear harmonic oscillator problem by operator method.

Unit III

- **Invariance principles and conservation laws**

  Symmetry and conservation laws. Space-time symmetries – translation in space : conservation of linear momentum, translation in time : conservation of energy, rotation in space : conservation of angular momentum, space inversion : parity conservation, time reversal invariance

- **Approximation methods for stationary states**
  - **Stationary Perturbation theory for discrete levels**.

  Non-degenerate case - first and second order perturbations, unharmonic oscillator – cubic and quartic perturbations. The degenerate case – removal of degeneracy, effect of electric field on the energy levels of H_2 atom – Stark effect in the ground and first excited state of hydrogen atom, Zeeman effect in hydrogen atom.

  - **The Variation Method**

  The principle of variation method – variation method for ground and excited states – Application to the linear harmonic oscillator, ground state of hydrogen and helium atom.

  - **The WKB Approximation**

  The WKB method – connection at the turning point, criterion for the validity of the Approximation, Applications to bound states, tunnelling through a barrier, α -emission.

References

1. Leonard I.Schiff : Quantum Mechanics (third edition, McGraw-Hill Book Company, 1955)
2. P..M..Mathews and K.Venkatesan : A text book of Quantum Mechanics (Tata McGraw-Hill, 1976)
3. P.A.M.Dirac : The Principles of Quantum Mechanics (fourth edition, Oxford University Press, 1958)
4. G.Aruldhas : Quantum Mechanics (Prentice-Hall of India Pvt. Ltd., 2002)
5. V.K.Thankappan : Quantum Mechanics (Wiley Eastern Limited, 1985)
6. Schaum's outline of theory and problems of Quantum Mechanics (Tata McGraw-Hill Publishing Company Limited, 2004)
7. E.Merzbacher: Quantum Mechanics (John Wiley, 1997)
8. Ajoy Ghatak : Introduction to Quantum Mechanics (Macmillan India Ltd., 1996)
9. Ajoy Ghatak and Lokanathan : Quantum Mechanics (fourth edition, Macmillan India Ltd., 1999)
10. W.Greiner : Quantum Mechanics an Introduction (third corrected edition, Springer, 1994)
11. Y.R.Waghmare : Fundamentals of Quantum Mechanics (Wheeler Publishing, 1997)
12. L.Pauling and E.B.Widson : Introduction to Quantum Mechanics (McGrqw-Hill Book Co., New York, 1935)
13. Nourdine Zettili : Quantum Mechanics – Concepts and Applications (John Wiley and Sons Ltd Publication)

Additional References

1. Satya Prakash and Swati Saluja : Quantum Mechanics (Kedar Nath Ram Nath & Co)

2. Satya Prakash : Advanced Quantum Mechanics (Kedar Nath Ram Nath)

PHY 523: Thermal and Statistical Physics

Unit I

Thermal Physics

Laws of thermodynamics- thermodynamic functions of an ideal gas – thermodynamic potentials- Maxwell's relations – Entropy of ideal gas- TdS equations – Entropy and disorder – Heat capacity of equatiions

Classical Statistics

Phase space- density of distribution in phase space – Liouville's theorem- statistical equilibrium – microcanonical ensemble – Maxwell Boltzmann distribution law- Evaluation of Maxwell Boltzmann constants- Maxwell's law of distribution of velocities – mean values – principles of equipartition of energy- grand canonical ensemble.

Unit II

Quantum Statistics

Indistingushibility of similar particles – probability of eigenstates-Bose Einstein statistics, Fermi-Dirac Statistics-Maxwell Boltzmann statistics – comparison of three statistics – Number of eigen states in an energy range – Eigen states and the Maxwell-Boltzmann equation.

Applications of Bose-Einstein Statistics

Bose-Einstein system- gas-degeneration-Bose-Einstein statistics and radiation-Bose-Einstein condensation.

Applications of Fermi-Dirac Statistics

Fermi-Dirac system – Extreme gas degeneration-electron gas in metals – therminic emission of electrons from metals.

Statistical Thermodynamics

Entropy and probability-Entropy and number of eigen states- thermodynamic functions of a monatomic gas – partition function – entropy and free energy- energy and heat capacity- effect of zero energy level – separation of partition function-translational partition function-translational thermodynamic functions-rotational partition function-nuclear spin effects-vibrational partition function.

Phase transitions

Phase diagram of a simple substance- Clausius – Clapeyron's equation- phase diagram of Helium – Classification of phase transitions- superconducting phase transition.

References

M.W. Zemensky: Heat and Thermodynamics

R K Pathria Statistical Mechanics

A B Pippard The elements of classical thermodynamics

K Haung Statistical Physics

F Mandl Statistical Physics

F Rief Statistical Physics

M N Saha and B N Srivastava a treatise on Heat

H B Callen Thermodynamics

Samuel Glasstone: Theoretical Chemistry

PHY 524: Atomic and Molecular Physics

Unit I

Electronic Spectra of Atoms

Quantum state of an electron system in an atom, electronic wave functions – The shape of atomic orbitals-Hydrogen atom spectrum- Electronic angular momentum-orbital angular momentum-electron spin angular momentum- total electronic angular momentum- the fine structure of hydrogen atom.
Stern-Gerlach experiment- Spin-orbit coupling- relativistic correction- Spectroscopic terms – selection rules – exchange symmetry of wave functions-Pauli's exclusion principle

Many electron atoms- Building principle- the spectra of Li and hydrogen like elements, The L-S and j-j coupling schemes- total angular momentum – term symbols- The spectra of helium
Zeeman effect – The magnetic moment of atom, Launde's g factor- The normal Zeeman effect-Emitted frequencies in anomalous Zeeman transitions- Nuclear spin and Hyperfine structure

Unit II

Rotation of Molecules

The rotation of molecules – Rotational spectra of diatomic molecules – Rigid Rotator- The intensities of spectral lines – The effect of isotopic substitution – The non-rigid rotator, The spectra of non-rigid rotator – rotational spectra of linear and symmetric top molecules-experimental techniques of MW spectroscopy- structure determination.

Vibration of Molecules

Origin of infrared transitions- Experimental techniques of IR spectroscopy- the simple harmonic oscillator- the anharmonic oscillator- the diatomic vibration- rotation of diatomic molecules-selection rules- the vibration rotation spectrum of carbon monoxide- the interaction of rotations and vibration- the vibrations of the polyatomic molecules – the influence of rotation on the spectra of poly atomic molecules

Raman Spectroscopy

Classical theory of Raman effect- experimental techniques-Pure rotational Raman spectra-vibrational Raman spectra – Rule of mutual exclusion- Raman spectrometer, Structure determination from Raman and infrared spectroscopy- Basic ideas of surface enhanced Raman spectroscopy- Non linear Raman spectroscopy- theory – hyper Raman effect

Unit III

Electronic Spectra of Diatomic molecules

The Born-Oppenheimer approximation- vibrational coarse structure- Frank Condon principle-Dissociation and predissociation- rotational fine structure of electronic vibration transitions-Fortrat diagram-Electronic structure of diatomic molecules- Electronic angular momentum – Molecular hydrogen spectrum

NMR spectroscopy

Nuclear magnetic resonance spectra- basic principle- experimental techniques – idea of chemical shift and spin orbit coupling – applications

ESR spectroscopy

Electron spin resonance spectra – basic principle- experimental techniques – idea of hyperfine structure- hydrogen applications.

Mossbauer spectroscopy

Principle- Applications – Structural methods- Quadrupole effects – The effect of magnetic fields.

References

Colin N Banwell and Elaine M Mac Coah, Fundamentals of Molecular Spectroscopy, 4th Edition Tata Mc Graw Hill New Delhi 2001
Straughen and Walker Spectroscopy Vol I
H E White – Introduction to Atomic Spectroscopy
G Aruldhas- Molecular Structure and Spectroscopy. PHI India 2006

Semester III

PHY 531: Quantum Mechanics II

Unit I

- **Theory of Angular momentum**

The angular momentum operators – fundamental commutation relations of angular momentum. Eigen values and Eigen functions of L^2 and L_Z. Spin – general angular momentum – Eigen values and Eigen vectors of J^2 and J_Z, matrices for J_+, J_-, J_X and J_Y. Spin – (1/2) systems – Pauli's spin matrices, - Eigen vectors and Eigen values of spin – (1/2) systems. Addition of angular momenta , Eigen value of the total angular momenta – Clebsh-Gordan coefficients – recursion relations – construction procedure – some particular coefficients for cases (j_1: ½, 1, 1 and j_2: ½, ½ and 1 respectively only).

- **Time – dependant Perturbation**

Time – dependant perturbation theory – Harmonic perturbation – transition probability. Transition to continuum states – Transition probability per unit time – Fermi's golden rule. Interaction with classical radiation field – absorption and stimulated emission – electric dipole approximation, Einstein's A and B coefficients, selection rule for emission and absorption of light radiation, sudden and adiabatic approximation.

Unit II

- **Collision Theory**

Elastic scattering – differential and total scattering cross-sections, the scattering amplitude. Method of partial waves – expansion of a plane wave in terms of partial waves – scattering by a central potential – phase shift – Optical theorem, scattering by a hard sphere, low energy scattering – s-wave scattering by a square well: Ramsauer-Townsend effect, scattering of neutrons by protons, resonance scattering – Briet-Wigner formula. Zero energy scattering – scattering length. Green's function technique of solving inhomogeneous differential equation – First Born approximation, validity of Born approximation. Applications: Scattering amplitude in the case of spherically symmetric potential, Screened Coulomb potential leading to Rutherford scattering formula.

- **Many electron atoms**

Identical particles – indistinguishability and exchange symmetry – Fermion and Boson assemblies. Symmetric and anti-symmetric wave functions – construction from unsymmetrized functions, The exclusion principle – Slater determinant. Spin angular momentum – spin matrices and Eigen functions – spin functions for two electrons, The Helium atom, spin functions for three electrons, the He atom. Central field approximation – Hartree-Fock equation
– direct term and exchange term.

Unit III

- **Relativistic wave equations**

The Schrödinger relativistic theory and it's failures. Dirac's relativistic equation – free-particle equation, Position probability density, expectation values, matrices for α and β, free-particle solutions and energy spectrum – existence of states with negative energy, spin of the Dirac particle, Significance of negative energy states – Dirac particle in electromagnetic fields, Spin-orbit interaction, Dirac's equation for a Central field – the Hydrogen atom, Lamb shift. Relativistic co-variance – Covariance of the Dirac equation – Zitterbewegung, Theory of positron.

Elements of Field Quantization – Quantization of the non-relativistic Schrödinger equation – systems of bosons and fermions. Relativistic fields – quantization of the electro-magnetic field.

References

1. Leonard I. Schiff : Quantum Mechanics (Third edition, McGraw-Hill Book Company)
2. P.A.M.Dirac : The Principles of Quantum Mechanics (Fourth edition, Oxford University Press)
3. G. Aruldhas : Quantum Mechanics (Second Edition, Prentice Hall of India Pvt Ltd)
4. V.K. Thankappan : Quantum Mechanics (New Age, New Delhi)
5. J.J. Sakurai : Modern Quantum Mechanics (Addison Wesley, Reading)
6. J.J. Sakurai : Advanced Quantum Mechanics (John Wiley)
7. P.M. Mathews and K. Venkatesan : A Textbook of Quantum Mechanics (Tata McGraw-Hill Publishing Company Ltd)
8. Nourdine Zettili : Quantum Mechanics – Concepts and Applications (John Wiley and Sons Ltd Publication)
9. L.P. Landau and H.M. Lifshitz : Quantum Mechanics – Non Relativistic Theory (Pergamom Press)
10. B.H. Bransden and C.J. Joachain : Introducton to Quantum Mechanics (Longman Group UK Ltd)
11. Y.R. Waghmare : Fundamentals of Quantum Mechanics (Wheeler Publishing)
12. B.K. Agarwal and Hari Prakash : Quantum Mechanics (Prentice Hall of India Pvt Ltd)
13. Walter Greiner : Quantum Mechanics – An Introduction (Third edition, Springer-Verlag Heidelberg)
14. E. Merzbaker : Quantum Mechanics (Second edition, John Wiley and Sons)
15. A. Ghatak and S. Lokanathan : Quantum Mechanics – Theory and Application (Third edition, MacMillan India Ltd)
16. J.L. Powell and B. Crasemann : Quantum Mechanics (Narosa, New Delhi)
17. Schaum's Outline of Theory and Problems of Quantum Mechanics (Tata McGraw-Hill Publishing Company Ltd)

Additional References

Satya Prakash and Swati Saluja : Quantum Mechanics (Kedar Nath Ram Nath & Co)

Satya Prakash : Advanced Quantum Mechanics (Kedar Nath Ram Nath)

PHY532: Condensed Matter Physics

Unit-I

Crystal Physics

Periodicity in crystals - unit cell- Wigner Seitz cell - point group - space group - Number of lattice points per unit cell - symmetry elements - Bravais lattice in two dimensions-Bravais lattice in three dimensions- Miller indices-interplanar spacing- density of atoms in a crystal plane-structures of Diamond, ZnS, NaCl and CsCl. Bonding in solids - Cohesive energy-ionic bonding - evaluation of Madelung constant for NaCl - covalent bonding - Matallic bonding - Hydrogen bonding - Van der Waals bonding. Diffraction of X-rays by crystals - reciprocal lattice- structure determination by powder method, Laue method and Rotating crystal method.

Lattice vibrations. Vibrations of Monatomic and diatomic linear lattices-acoustical and optical phonons - phonon momentum - lattice specific heat of Einstein and Debye model

Free electron theory

Electron motion in one dimensional potential well- three dimensional potential well - Density of energy states - Fermi Dirac distribution - electronic specific heat - electrical conductivity and Ohm's law - thermal conductivity - Brillouin zone in two and three dimensions - Fermi surface.

Unit-II

Band theory of solids

Nearly free electron model - origin of energy gap - Bloch theorem-Kronig-Penney model effective mass of an electron - reduced zone - Tight binding approximation

Semiconductor

Conductors, semiconductors and insulators- Intrinsic semiconductors - carrier concentration in intrinsic semiconductor - Fermi level - electrical conductivity of semiconductors - Band gap - Extrinsic semiconductor - carrier concentration - variation of carrier concentration with temperature - conductivity of extrinsic semiconductor earner transport n semiconductors -Hall effect - Applications of Hall effect.

Dielectric Properties of materials

Various polarization processes - Clausius - Mosotti releation - Dielectric loss - Applications of dielectric materials Ferro electricity - Pyroelectric material and their applications - Ferroelectric domain – Antiferroelectricity and Ferrielectricity

Unit- III

Magnetic properties

Classification of magnetic materials - Langevin's theory of diamagnetism - Quantum theory of paramagnetism - paramagnetism of free electrons - Ferromagnetism - Weiss molecular field theory - curie-Weiss law-spin waves - magnons - Dispersion relation for magnons - magnon specific heat - Blockwall - Ferromagnetic domains - Antiferromagnetism - two sublattice model - Ferromagnetism. Applications of different magnetic material

Superconductivity

Meissner effect - Type I and Type II superconductors - Thermal properties - Isotope effect - London equations - London penetration depth - coherence length BCS theory flux quantisation - Josephson effect - Applications of Superconductors.

References

Introduction to solid state Physics, C.Kittel
Introduction to solids, Azaroff
Solid state Physics, A J Dekker
Solid State Physics Ali-Omar
Superconductivity, Lynton
Solid State Physics, J S Blackmore

PHY 533 : Nuclear & Particle Physics

Unit 1
Nuclear Interactions & Nuclear Reactions

Characteristics of inter-nucleon potential: charge independence, charge symmetry. Spin dependence, saturation, short range, attractive and exchange nature-the deuteron-tensor forces- Meson theory of nuclear force-Low energy n-p scattering and effective range theory.

Energetic of nuclear reactions - Weisskopf diagram for reaction mechanisms
Partial wave method of calculating cross section - Reciprocity theorem-Compound nucleus hypothesis - Scattering matrix - Breit-Weigner one-level formula - Resonance scattering-Energy production in stars.

Unit II
Nuclear Models and Nuclear Decay

Doublet method of mass spectroscopy- Hofstadter experiment - Bethe-Weizscater formula for nuclear binding energy - Segre chart - Bohr & Wheeler theory of nuclear fission -Shell model-Magic numbers, Spin-orbit coupling, Magnetic moments and Schmidt lines –Collective model of Bohr and Mottelson.

Fermi's theory of β-decay - Kurie plot - Selection rules the ^{60}Co experiment -Helicity of neutrino - Multipole transitions in nuclei - Angular momentum and parity selection rules - Internal conversion - Nuclear isomerism.

Unit III
Particle Physics

Sub-nuclear particles - Intrinsic properties and conservation laws - Symmetries; unitary symmetry SU(2) and SU(3) groups - Gell- Mann Okubo mass formula - Mesons and baryons in quark model - (Quantum chromo dynamics - Fundamental interactions electromagnetic weak and strong couplings - Quark jets in $e^+ - e^-$ annihilation - CP violation in K^o decay-Unification of weak and electromagnetic interactions - Neutral currents. Standard model - Grand unification theory (GUT) and cosmological implications.

References

1. Ghoshal S. N : Nuclear Physics (S Chand 2003)
2. Burchani W.F and Lobes M : Nuclear and Particle Physics (Longman 1995)
3. Sharnia R C : Nuclear Physics (K Nath & Co.,2007)
4. Ernest M Henley & Alejandro Garcia : Subatomic Physics 3 e/d (Word Scientific Publication Co., 2007)
5. Allersandro Beetni : Introduction to Elementary Particle Physics (Cambridge Uim Hess 2008)
6. Fermi E : Nuclear Physics (Univ. of chicago Press 1974)
7. Blin Stoyie R J : Nuclear & Particle Physics (Chapman & Hall1992)
8. Ho-Kim Quang Pham & Xuan Yem: Elementary particles & their interaction Concept & Phenomena (Springer 1998)
9. Halzen F & Martin A D : An Introductory Course in Modern Particle Physics (John Wile; 1984)
10. Hughes I S : ElementaryParticles3e/d(CambridgeUniv.press 1991)
11. Kachhava C M : Nuclear Physics & Application (Raj Publ. 1997)

PHY 534: Computational Methods and Programming (Elective)

Unit I

1. Non-Linear Algebraic And Trancsendentalequations

Introduction-Bisection method (Method of equal interval)- Iteration method (The method of successive approximation)-Convergence criterion- acceleration of convergence-Aitken's $(delta)^2$ process-The method of false position-Newton-Raphson method-Generalised Newton's method-Lin Bairstow method Solution of systems of Non-linear equations - The method of Iteration –Newton Raphson Method

2. Eigen Values And Eigen Vectors Of Matrices

Determinant of a Matrix - The eigen value problem- Power methods to find the largest and smallest eigen values- House Holder's method- Eigen values of a symmetric tri-diagonal mar x- The QR method- Singular values of decomposition.

Unit II

3. Interpolation

Introduction - Finite differences-Forward -Backward and Central Differences-Symbolic relations and separation of symbols- Differences of a polynomial-Newton's formula for Interpolation-Central Difference Interpolation Formulae-Gauss's Central difference fonnulae-Stirling's formula- Bessel's formula - **Everette**'s formula-Interpolation of unevenly spaced points- Lagrange s Interpolation formula- Divided differences and Newton's General interpolation formula- Interpolation with Cubic splines.

4. Curve Fitting

Least square curve fitting procedure- Fitting a straight line- Non linear curve fitting-Curve fitting by sum of exponentials- Weighted least square approximation- Linear and non-linear - Methods of least squares for continuous functions.

Unit III

5. **Numerical Differentiation and Integaration**

Numerical differentiation - Derivation of numerical differentiation formula from Newton's difference formulae - Cubic spline method

Numerical Integration Trapezoidal rule- Simpson's 1/3 rule- Simpson 378 rule- Use of cubic splines- Newton - Cotes Integration formula- Numerical calculation of Fourier Integrals - Trapezoidal rule- Filon's formula.

-Monte Carlo Method Description of method- Applications- Numerical Integration-Monte Carlo Summation

6. Numerical Solutions of Ordinary Differential Equations

Introduction - Solution by Taylor's series- Picaid's method of successive approximations- Euler's method- Modified Euler s method- Runge- Kutta method

References

1. "Introductory methods of Numerical Analysis", S S Sastry, 3 Edition, Prentice Hail India Pvt Ltd , New Delhi. 2000 (Eastern Economy Edition)

2."Numerical methods for Engineers" D V Griffiths and I M Smith, Oxford University Press, 1993

3.'Elementary Numerical analysis", Samuel D Conte and Carl de Boor. 3rd Edition,Mc Graw Hili International Edition ~

4"Numerical Algorithms", E V Krishnamoorthy and S K Sen, Affiliated East WestPress Pvt Ltd, 1986..

5.Applications of Numerical Techniques w.th C", Suresh Chandra, Narosa Publishing House, 2003 -

6. Numerical methods for scientific and Engineering computation-", M. K. Jain, S R.K lyenga:, R K New age, international.

7. Numerical Methods S Arumugam, A Thangapandi Isaac, A Somasundaram, Scitech (2006).

PHY 535 : Electronics I (Elective)

Unit I

Digital Electronics :Logic Gates- Boolean algebra- Decoder/ Demultiplexer - Multiplexer-Encoder-Seven segment Decoder-Flip flops-RS, Clocked RS, D, T, JK, MSJK FF-Shift Registers-Counters-Synchronous and Asynchronous Counters-Cascade Counters-Semiconductor Memories-RAM,ROM,PROM,EPROM- Digital to Analog Convertors-Ladder and Weighted Resistor type-Analog to digital converters-Counter type, Successive Approximation type, Dual slope convertors. Application of DAC and ADC converters.

Unit II

Introduction to Microprocessors: Microprocessor architecture and its operations- s-logic devices for interfacing- the 8085 microprocessor-Instruction and Data format - instruction classification-8085 Instruction set-8085 assembly language programming-illustrative programs-looping, counting and indexing-time delays-Stack and subroutines. Interfacing I/O ad memory devices: Memory interfacing-I/O interfacing-Data transfer schemes-programmed data transfer-asynchronous data transfer-synchronous data transfer-Interrupts.

Unit III

Interfacing devices: the programmable peripheral interface: 8255A-Programming and applications-Programmable Interrupt Controller: 8259A-features and Programming-the 8237 DMA Controller-the USART 8251

Digital Signal processing: Signals and Systems-Classification of Signals-Discrete Time signals and systems-Z transform -Fourier series and Fourier Transform-Convolution and Correlation-Discrete Fourier Transform of DT signals-Fast Fourier Transform-Digital Filtering in Time Domain-FIR Filter-HR filter.

References

1. Malvino A.P. and Leach D.P. : Digital principles and applications (Tata Me Graw - Hill publishing company limited, 2004)
2. Millman J and Halkias C.C. .Integrated Electronics (Tata Mc Graw -Hill publishing company limited, 1991)
3 Jain R.P Modern Digital Electronics (Tata Mc Graw -Hill publishing company limited, 1984)
4. Gaonkar R.S. Microprocessor architecture .Programming and applications wij 8085 (Penram International publishing (India) Pvt. Ltd-Fifth edition)

5. Ram B. :Fundamentals of Microprocessor and microcomputers (Dlianpar Rai and Sons, 1996)
6. Mathur A.P .-Introduction to Microprocessors (Tata Mc Graw-Hill , 2004)
7. Nagoor Kar.i A. Digital Signal Processing (RBA Publications,2006)
8. Ramesh.Babu P Digital Signal Processing (Scitech publications Pvt.Ltd-200S)
9 John G. Proakis and Dimitris G Manolakis : Digital Signal Processing (Pearson- Prentice Hiill.2007)
10. Bu-Cliin Wang . Digital Signal Processing techniques and applications in Radar image processing (John Wiley,2008)

Semester IV

PHY 541: Electronics – II (Elective)

Unit I Basic Communication:

Signal representation - Power and energy spectral density - Noise in communication systems - Need for modulation-Principle, generation and demodulation of SSB, VSB & FM - Frequency & time division multiplexing - Binary ASK. FSK,. PSK modulation schemes - Information & channel capacity - Sampling theory - Quantizing of analog signals -PAM - PCM - Errors and codes.

Unit II Microwave & Satellite Communications:

Principles - Line of sight systems - microwave relay systems - Antennas for microwave systems - Terminal transmitters & receivers - Repeaters - Troposcatter microwave systems - Scatter loss - Aperture loss - Troposcatter link equipment - Microwave absorption in atmospheric gases.

Satellite orbit and orbital parameters - Geo stationary *Sc.* geo-synchronous satellites- Antenna look angles- Frequency allocation - Satellite system link models: up-link, \ transponder and down-link - Multiple accessing methods: frequency division, time-division and code-division multiple access.

Unit III Radar & TV Systems:

Basic radar system - Radar range equation - Factors influencing maximum range: effects of noise, Target properties- Moving Target Indication (MTI) radar - Antenna Scanning – Antenna tracking - Display methods: A scope, Plan Position Indicator . TV systems& standards - Scanning - Blanking & synchronizing pulses - Picture definition - Video band width -- The TV signal - Black and White transmission & reception - Color transmission & reception.

References

1) Wayne Tomasi, Electronic communication Systems-FundamentalsThrough Advanced . 5/e. Pearson Education. 2004.
2) K Sam Shanmugam, Digital and Analog communication systems,Wiley.1994
3) Rajeswari Chatterjee, Microwave Engineering - Special topics. East-West press, 2001
4) Simon Haykin, Communication Systems, 3/e, Wiley. 1995.
5)Dennis Roddy & John Coolen, lectronic Communications, 3/e. PI Jl, 1992
6) George Kennedy & Bemard Davis, Electronic Communications Systems. **3/e**MGH, 1991
7) Robert M Gagliardi, Satellite Communications. CBS publication 200

PHY 542: Electronics – III (Elective)

Unit I

Measurement and Errors (4hrs)

Definitions, Accuracy and Precision, Significant figures. Types of errors, Statistical error analysis, Probability of errors, Limiting errors

Standards of Measurement (4hrs)

Classification of standards, Time and Frequency standards. Electrical standards, Standards of Temperature and Luminous intensity, IEEE standards

Oscilloscopes (16hrs)

Oscilloscope block diagram, Cathode ray tube circuits. Vertical deflection system, Resistive divider attenuator, Compensated attenuator, Delay line - Function of the Delay line. Different kinds of Delay line - Lumped parameter Delay line. Distributed parameter Delay line, Multiple trace, Horizontal deflection system, Dual time base, Oscilloscope probes and Transducers, Oscilloscope techniques - Determination of frequency phase angle and time delay measurements, Determination of modulation characteristics, Storage oscilloscope, Sampling oscilloscope

Unit II

Signal Generation (14hrs)

Sine wave generator, Inductor - Capacitor tuned oscillators, Frequency synthesized signal generators, Frequency divider generator, Pulse and Square wave generators, Pulse characteristics, Astable multivibrator, Function generator, Audio frequency signal generation

Signal Analysis (I4hrs)

Wave analyzers - Frequency selective wave analyzer, Heterodyne wave analyzer, Harmonic distortion analyzers - Harmonic distortion, Tuned circuit harmonic analyzer, Heterodyne harmonic analyzer, Fundamental suppression harmonic distortion analyzer, Spectrum analyzer- Fourier transform spectrum analyzer, Applications of Spectrum analyzer

Unit III

Transducers (16 hrs)

Classifications of Transducers, Strain Gauge configurations, Displacement transducers - capacitive transducer, Inductive transducer, Variable differential transformer transducer, Oscillation transducer, Piezoelectric transducer, Potentiomctric transducer. Velocity transducer, Temperature measurements - Resistance thermometer, Thermocouple, Thermistor, Photosensitive devices - vacuum phototube, Gas fil'ed Phototube, Multiplier phototube, Photoconductive cells, Photovoltaic cells

Analog and Digital Data Acquisition Systems (8 hrs)

Instrumentation systems, Interfacing transducers to electronic control and measuring systems, multiplexing- Digital to analog multiplexing, analog to digital multiplexing **Computer Controlled Test Systems (8 nrs)**

Requirements, Testing an audio amplifier, Testing a radio receiver, Instruments used computer controlled instrumentation, IEEE 488 Electrical interfacing

References

1. "Modern Electronic Instrumentation and Measurement Techniques", Albert D Helfrick and William D Cooper (PHI), 4th Edition
2. 'Electronic Instrumentation', Prensky, Sol D and Castellucis, Richard L (PHI)
3. 'Instrumentation Devices and Systems', C S Rangan, G R Sarma, V S V Mani, Tata McGrawHill.