BHARATHIDASAN UNIVERSITY, TIRUCHIRAPPALLI – 620 024

M.Sc., Physics – Course Structure under CBCS

(applicable to the candidates admitted from the academic year 2008-2009 onwards)

Semester	Course	Course Title	Ins. Hrs / Week	Credit	Exam Hrs	Marks		Total
						Int.	Ext.	
I	Core Course – I (CC)	Mathematical Physics	5	5	3	25	75	100
	Core Course – II (CC)	Classical Dynamics and Relativity	5	5	3	25	75	100
	Core Course – III (CC)	Electronics	5	5	3	25	75	100
	Core Course – IV (CC)	Numerical Methods & Programming	5	5	3	25	75	100
	Core Course – V (CC) (Lab)	Physics Practicals- I – (General & Electronics)	10	5	4	40	60	100
II	Core Course – VI (CC)	Electromagnetic Theory	5	5	3	25	75	100
	Core Course – VII (CC)	Quantum Mechanics	5	5	3	25	75	100
	Core Course – VIII (CC)	Statistical Mechanics	5	5		25	75	100
	Core Course – IX (CC) Lab	Physics Practicals-II (General & Electronics)	10	5	4	40	60	100
	Elective Course – I (EC)	Microprocessor and Communication Electronics	5	4	3	25	75	100
III	Core Course – X (CC)	Solid State Physics	5	5	3	25	75	100
	Core Course – XI (CC)	Nuclear & Particle Physics	5	5	3	25	75	100
	Core Course – XII (CC) (Lab)	Physics Practicals – III Advanced Electronics	10	5	4	40	60	100
	Elective Course – II (EC)	Atomic and Molecular Physics	5	4	3	25	75	100
	Elective Course – III (EC)	Crystal Growth & Thin film Physics	5	4	3	25	75	100
IV	Core Course – XIII (CC) (Lab)	Physics Practical – IV Advanced Electronics	10	5	4	40	60	100
	Core Course – XIV (CC) Project Work	Dissertation 80 Marks [2 reviews– 20+20 = 40marks Report Valuation = 40 marks] Viva 20 Marks	10	5	-	-	-	100
	Elective Course – IV (EC)	Introduction To Nanoscience and Nanotechnology	5	4	3	25	75	100
	Elective Course – V (EC)	Nonlinear Optics	5	4	3	25	75	100
Grand Total			120	90				

* Physics Practical examination at the end of every semester

Elective Courses:

1. Numerical Methods & Programming
2. Microprocessor and Communication Electronics
3. Crystal Growth & Thin film Physics
4. Introduction to Nanoscience & Technology
5. Nonlinear Optics

Note:

Core Courses include Theory, Practicals & Project

No. of Courses	14 - 17
Credit per Course	4 - 5
Total Credits	70

Elective Courses

(Major based / Non Major / Internship)

No. of Courses	4 – 5
Credit per Course	4 – 6
Total Credits	20

	Internal	External
Theory	25	75
Practicals	40	60

Project

Dissertation	80 Marks	[2 reviews – 20+20	=	40 marks
		Report Valuation	=	40 marks]
Viva	20 Marks			20 marks

Passing Minimum in a Subject

CIA	40%	Aggregate 50%
UE	40%	

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CCI: MATHEMATICAL PHYSICS

Unit 1: Vector analysis

Concept of vector and scalar fields – Gradient, divergence, curl and Laplacian – Vector identities – Line integral, surface integral and volume integral – Gauss theorem, Green's Theorem, Stoke's theorem and applications – Orthogonal curvilinear coordinates – Expression for gradient, divergence, curl and Laplacian in cylindrical and spherical co-ordinates - Definitions – Linear independence of vectors – Schmidt's orthogonalisation process – Schwartz inequality.

Unit 2: Tensors and Matrix Theory

Transformation of coordinates – Summation convention – Contravariant, covariant and mixed tensors – Rank of a tensor – Symmetric and antisymmetric tensors – contraction of tensor – Charateristic equation of a matrix – Eigenvalues and eigenvectors – Cayley – Hamilton theorem-Reduction of a matrix to diagonal form – Jacobi method – Sylvester's theorem.

Unit 3: Complex Analysis

Functions of complex variables – Differentiability -- Cauchy-Riemann conditions – Complex integration – Cauchy's integral theorem and integral formula – Taylor's and Laurent's series – Residues and singularities - Cauchy's residue theorem – Evaluation of definite integrals.

Unit 4: Special Functions

Gamma and Beta functions – Sturm-Liouville problem – Legendre, Associated Legendre, Bessel, Laugerre and Hermite differential equations : series solution – Rodriguez formula – Generating functions – Orthogonality relations – Important recurrence relations.

Unit 5: Group Theory

Basic definitions – Multiplication table – Subgroups, Cosets and Classes – Direct Product groups – Point groups -- Space groups – Representation theory – Homomorphism and isomorphism– Reducible and irreducible representations – Schur's lemma – The great Orthogonality theorem – Character table -- C3v and D3h as examples – Elementary ideas of rotation groups.

Books for Study and Reference

Relevant chapters in

1. A.W. Joshi, Matrices and Tensors in Physics, Wiley Eastern Ltd., New Delhi (1975)
2. Eugene Butkov, Mathematical Physics, Addison Wesley, London (1973)
3. L.A.Pipes and L.R. Harvill, Applied Matematics for Engineers and Physcists, McGraw Hill Company, Signgapore (1967)
4. P.K.Chattopadhyay, Mathematical Physics, Wiley Eastern Ltd., New Delhi (1990)
5. A.K. Ghattak, T.C.Goyal and S.J. Chua, Mathematical Physics, Macmillan, New Delhi (1995)
6. G.Arfken and H.J.Mathemattical Methods for Physicists, 4th ed. *Physicists* (Prism Books, Banagalore, 1995).

7. M.D.Greenberg, Advanced Engineering Mathematics, 2nd ed. International ed., Prentice – Hall International, NJ, (1998)
8. E.Kreyszig, Advanced Engineering Mathematics, 8th ed. Wiley, NY (1999)
9. W.W.Bell, *Special Functions for Scientists and Engineers* (Van Nostrand, New York, 1968) .
10. A.W. Joshi, *Elements of Group Theory for Physicists* (Wiley Eastern, New Delhi, 1971).
11. F.A. Cotton, *Chemical Applications of Group Theory* (Wiley Eastern, New Delhi, 1987).

CC II: CLASSICAL DYNAMICS AND RELATIVITY

Unit 1 : Fundamental Principles and Lagrangian Formulation

Mechanics of a particle and system of particles – Conservation laws – Constraints – Generalized coordinates – D' Alembert's principle and Lagrange's equation – Hamilton's principle – Lagrange's equation of motion – conservation theorems and symmetry properties – Motion under central force : General features – The Kepler problem Scattering in a central force field.

Unit 2: Lagrangian Formulation: Applications

a) Rigid Body Dynamics
Euler angles – Moments and products of inertia – Euler's equations – Symmetrical top.

b) Oscillatory Motion
Theory of small oscillations – Normal modes and frequencies – Linear triatomic molecule
Wave motion – wave equation – Phase velocity – Group Velocity dispersion

Unit 3: Hamilton's Formulation

Hamilton's canonical equations of motion – Hamilton's equations from variational principle – Principle of least action – Canonical transformations – Poisson brackets – Hamilton – Jacobi method – Action and angle variables – Kepler's problem in action – angle variables.

Unit 4: Nonlinear Dynamics

Linear and nonlinear oscillators- phase trajectories – Period doubling phenomenon in Duffing oscillator.
Soliton: Linear and nonlinear waves – Solitary Waves – KdV equation – Numerical experiments of Kruskal and Zabusky – Solitons.

Unit 5: Relativity
Reviews of basic ideas of special relativity – Energy momentum four vector – Minkowski's four dimensional space – Lorentz transformation as rotation in Minkowski's space – Compositions of L.T. about two orthogonal directions – Thomas precession – Invariance of Maxwell's equations under Lorentz transformation – Elements of general theory of relativity.

Books for study and Reference
Relevant Chapters in

1. H.Goldstein, Classical Mechanics, Narosa Book distributors, New Delhi (1980)
2. N.C.Rana and P.S.Joag Classical Mechanics, Tata Mc: Graw Hill, New Delhi (1991)

For unit 4

3. M.Lakshmanan and S.Rajasekar: Nonlinear Dynamics: Integrability, Chaos and Patterns, Springer – Verlag, Berlin (2003), Springer (India) 2004
4. M.Lakshmanan and K.Murali: Chaos in Nonlinear Oscillators, world Scientific Co., Singapore (1996). Chapters 2-4.

CC-III: ELECTRONICS

UNIT 1: SEMI CONDUCTOR DIODES:

The continuity equation – Application of the continuity equation for an abrupt PN junction under forward and reverse bias – Einstein equation – Varactor diode – Schottky diode – Tunnel diode – Gunn diode – Optoelectronic diodes – LASER diode, LED and photo diode.

UNIT 2: SPECIAL SEMICONDUCTOR DEVICES:

JFET- Structure and working – I -V Characteristics under different conditions – biasing circuits – CS amplifier design – ac analysis – MOSFET: Depletion and Enhancement type MOSFFT – UJT characteristics – relaxation oscillator – SCR characteristics – application in power control DIAC, TRIAC.

UNIT – 3 OPERATIONAL AMPLIFIER:

Operational amplifier characteristics – inverting and non-inverting amplifier – instrumentation amplifier – voltage follower –integrating and differential circuits –log & antilog amplifiers – op-amp as comparator – Voltage to current and current to voltage conversions-active filters : low-pass, high pass, band pass & band rejection filters-Solving simultaneous and differential equations.

UNIT – 4 : OP-AMP APPLICATIONS (OSCILLATORS AND CONVERTORS)

Wien bridge, phase shift oscillators and twin-T oscillators – triangular, saw-tooth and square wave generators-Schmitt's trigger – sample and hold circuits – Voltage control oscillator – phase locked loops. Basic D to A conversion: weighted resistor DAC – Binary R-2R ladder DAC – Basic A to D conversion: counter type ADC – successive approximation converter – dual slope ADC.

UNIT – 5 IC FABRICATION AND IC TIMER:

Basic monolithic Ics – eqitaxial growth – masking –etching impurity diffusion-fabricating monolithic resistors, diodes, transistors, inductors and capacitors – circuit layout – contacts and inter connections – charge coupled device – applications of CCDs.555 timer – description of the functional diagram – mono stable operation – applications of mono shots – astable operation-pulse generation.

REFERENCES:

1. T.F.Schubert and E.M.Kim, "Active and Nonlinear Electronics", John Wiley Sons, New York (1996)
2. L.Floyd, Electronic Devices, "Pearson Education" New York (2004)
3. Dennis Le Crissitte, Transitors, Printice Hall India Pvt. Ltd (1963)

4. J.Milman and C.C. Halkias, Integrated Electronics, McGraw Hill (1972)
5. A. Mottershed, Semiconductor Devices and Applications, New Age Int Pub,
6. M.Goodge, Semiconductor Device Technology Mc Millan (1983)
7. S.M.Sze, Physices of Semiconductor Devices, Wiley-Eastern Ltd (1981)
8. Milman and Taub, Pulse, digital and switching waveforms, McGraw Hill (1965)
9. Ben.G.Streetman, Solid state electronic devices, Printice Hall, Englewood cliffs, NJ (1999)
10. R.A.Gayakwad, Op-Amps&Linear integrated circuits, Printice Hall India Pvt Ltd.(1999)

CC IV: NUMERICAL METHODS AND PROGRAMMING

Unit 1: Errors and the measurements

General formula for errors – Errors of observation and measurement – Empirical formula – Graphical method – Method of averages – Least square fitting – curve fitting – parabola, exponential.

Unit 2: Numerical solution of algebraic and transcendental equations

The iteration method – The method of false position – Newton – Raphson method – Convergence and rate of convergence – C program for finding roots using Newton – Raphson method.

Simultaneous linear algebraic equations

Gauss elimination method – Jordon's modification – Gauss–Seidel method of iteration – C program for solution of linear equations.

Unit 3: Interpolation

Linear interpolation – Lagrange interpolation Gregory – Newton forward and backward interpolation formula – Central difference interpolation formula – Gauss forward and backward interpolation formula – Divided differences – Properties – Newton's interpolation formula for unequal intervals – C programming for Lagrange's interpolation.

Unit 4: Numerical differentiation and integration

Newton's forward and backward difference formula to compute derivatives – Numerical integration : the trapezoidal rule, Simpson's rule – Extended Simpson's rule – C program to evaluate integrals using Simpson's and trapezoidal rules.

Unit 5: Numerical Solutions of ordinary differential equations

N^{th} order ordinary differential equations – Power series approximation – Pointwise method – Solutions of Taylor series – Euler's method – Improved Euler's method – Runge-Kutta method – second and fourth order – Runge-Kutta method for solving first order differential equations – C program for solving ordinary differential equations using RK method.

Books for study and Reference :

1. Introductory Methods of Numerical analysis – S.S. Sastry, Prentice – Hall of India, New Delhi (2003) 3rd Edition.
2. Numerical Methods in Science and Engineering – The National Publishing Co. Madras (2001).
3. Numerical Recipes in C, W.H. Press, B.P.Flannery, S.A.Teukolsky, W.T. Vetterling, Cambridge University (1996).
4. Monte Carlo : Basics, K.P.N. Murthy, ISRP, Kalpakkam, 2000.
5. Numerical Methods in C and C++, Veerarajan, S.Chand, New Delhi (2006).

CC V: PHYSICS PRACTICAL - I (General & Electronics)

Any fifteen Experiments (choosing a minimum of six experiments from each part)

A General Experiments

1. Determination of q, n, b by elliptical fringes method
2. Determination of q, n, b by hyperbolic fringes method
3. Determination of bulk modulus of a liquid by ultrasonic wave propagation
4. Determination of Stefan's constant
5. Identification of prominent lines by spectrum photography – Copper spectrum
6. Identification of prominent lines by spectrum photography – Iron spectrum
7. BH loop – Energy loss of a magnetic material – Anchor ring using B.G.
8. Determination of dielectric constant at high frequency by Lecher wire
9. Determination of e/m of an electron by magnetron method
10. Determination of e/m of an electron by Thomson's method
11. Determination of L of a coil by Anderson's method
12. Photoelectric effect (Planck's constant Determination)

B. Electronics Experiments

13. Study of a feedback amplifier – Determination of bank width, input and output impedances.
14. Darlington pair amplifier
15. Design and study of monostable multivibrator
16. Design and study of bistable multivibrator
17. Design and study of Wein bridge Oscillator (Op-amp)
18. Design and study of phase shift Oscillator (Op-amp)
19. Characteristics of JET
20. Characteristics of UJT
21. Characteristics of SCR
22. Characteristics of IDR
23. Common source amplifier using FET
24. Common drain amplifier using FET
25. Relaxation oscillator using UJT (or) Op-amp
26. Active 2nd order filter circuits
27. Construction of an Instrumentation amplifier

CC VI: ELECTROMAGNETIC THEORY

Unit 1: Introduction to Electrostatics

Coulomb's law – Electric field – Gauss Law – Scalar potential – Surface distribution of charges and dipoles – Poisson and Laplace Equations – Green's theorem – Dirichlet and Neumann boundary conditions – Electrostatic boundary value problems : Solution using Green's function – Method of Images – Illustrations : Point charge in the presence of (i) a grounded conducting sphere, (ii) a charged, insulated and conducting sphere, (iii) near a conducting sphere at fixed potential and (iv) conducting sphere in a uniform electric field – Green's function for the sphere.

Unit 2: Electrostatics of Macroscopic Media

Multipole expansion – Elementary treatment of electrostatics with ponderable media – Boundary value problems with dielectrics -- Illustrations : (i) a point charge embedded at a distance away from a dielectric interface, (ii) dielectric sphere in a uniform electric field and (iii) spherical cavity in a dielectric medium with applied electric field – Molecular polarizability and electric susceptibility – Electrostatic energy in dielectric media.

Unit 3: Magnetostatics

Biot and Savart law – Force between current carrying conductors – Differential equations of magnetostatics and Ampere's law – Vector potential – Magnetic field of a localized current distribution, magnetic moment – Force and torque and energy of a localized current distribution in an external magnetic induction - Macroscopic equations – Boundary conditions on B and H -- Methods of solving boundary value problems in magnetostatics – Uniformly magnetized sphere.

Unit 4: Electromagnetics

Faraday's law of induction – Maxwell's displacement current – Maxwell equations - Maxwell equations in terms of vector and scalar potentials – Gauge transformations – Lorentz gauge, Coulomb gauge – Poynting's theorem – Conservation of energy and momentum for a system of charged particles and electromagnetic fields.

Unit 5: Plane ElectromagneticWaves and Wave Propagation

Plane waves in a nonconducting medium – Linear and circular polarization, Stokes parameters – Reflection and refraction of electromagnetic waves at a plane interface between dielectrics – Fields at the surface of and within a conductor – Propagation of electromagnetic waves in hollow metallic cylinders : Cylindrical and rectangular wave guides -- TM and TE modes – Wave propagation in optical fibers.

Books for Study and Reference :

Relevant Chapters in

1. J. D. Jackson, *Classical Electrodynamics* (Wiley Eastern Ltd., New Delhi, 1999).
2. D. Griffiths, *Introduction to Electrodynamics* (Prentice-Hall, New Delhi, 1999).
3. R. P. Feynman et al, *The Feynman Lectures on Physics, Vol.II* (Narosa, New Delhi, 1989).

CC VII: QUANTUM MECHANICS

Unit 1: Schrödinger Equation and General Formulation

Schrödinger Equation – Physical meaning and conditions on the wave function – Expectation values and Ehrenfest's theorem – Hermitian operators and their properties – Commutator relations - Uncertainty relation - Bra and ket vectors - Hilbert space – Schrödinger, Heisenberg and interaction pictures.

Unit 2: Exactly Solvable Systems

Linear harmonic oscillator -- Solving the one dimensional Schrödinger equation -- Abstract operator method – Particle in a box – Square well potential -- Rectangular barrier potential – Rigid rotator – Hydrogen atom.

Unit 3: Approximation Methods

Time independent perturbation theory: Non-degenerate and degenerate perturbation theories -- Stark effect – WKB Approximation -- Application to tunneling problem and quantization rules**.**

Time dependent perturbation theory: Harmonic Perturbation -- Transition probability.

Unit 4: Scattering Theory and Angular Momentum

Scattering theory: Scattering cross section – Green's function approach -- Born Approximation – Partial wave analysis .

Angular momentum: Matrix Representation of J -- Spin angular momentum -- Eigenvalues -- Addition of angular momenta - Clebsch-Gordan coefficients (basic ideas only).

Unit 5: Relativistic Quantum Mechanics

Klein-Gordon equation for a free particle and in an electromagnetic field – Dirac equation for a free particle -- Charge and current densities -- Dirac matrices – Plane wave solution – Negative energy states – Zitterbewegung – Spin angular momentum – Spin-orbit coupling.

Books for Study and Reference :

Relevant Chapters in

1. L. Schiff, *Quantum Mechanics* (Tata McGraw Hill, New Delhi, 1968).
2. V. Devanathan, *Quantum Mechanics*, Naroso Publishing House (2005)
3. P. M. Mathews and K. Venkatesan, *A Text Book of Quantum Mechanics* (Tata McGraw Hill, New Delhi, 1987).
4. V. K. Thankappan, *Quantum Mechanics* (Wiley-Eastern, New Delhi, 1985).

CC VIII : STATISTICAL MECHANICS

Unit 1: Thermodynamics

Laws of thermodynamics – Some consequences of the laws of thermodynamics – Entropy – Calculation of entropy changes in reversible processes – The principle of increase of entropy – Thermodynamic potentials –Enthalpy, Helmholtz and the Gibbs functions – Phase transitions – The Clausius-Clapeyron equation – van der Waals equation of state.

Unit 2: Kinetic Theory

Distribution function and its evolution -- Boltzmann transport equation and its validity – Boltzmann's H-theorem – Maxwell-Boltzmann distribution -- Transport phenomena – Mean free path – Conservation laws – Hydrodynamics (no derivation).

Unit 3: Classical Statistical Mechanics

Review of probability theory – Macro-and micro states – Statistical equilibrium – Phase space and ensembles – Density function -– Liouville's theorem – Maxwell-Boltzmann distribution law – Micro canonical ensemble – Ideal gas – Entropy – Partition function – Principle of equipartition of energy – Canonical and grand canonical ensembles.

Unit 4: Quantum Statistical Mechanics

Basic concepts – Quantum ideal gas – Bose-Einstein and Fermi-Dirac statistics – Distribution laws – Sackur-Tetrode equation – Equations of state -- Bose-Einstein condensation.

Unit 5: Applications of Q.S.M.

Ideal Bose gas : Photons – Black body and Planck radiation – Photons – Specific heat of solids – Liquid Helium.
Ideal Fermi gas : Properties – Degeneracy – Electron gas – Pauli paramagnetism.
Ferromagnetism : Ising and Heisenberg models.

Books for Study and Reference :
Relevant Chapters in

1. K. Huang, *Statistical Mechanics* (Wiley Eastern Limited, New Delhi, 1963).
2. B. K. Agarwal and M. Eisner, *Statistical Mechanics* (Wiley Eastern Limited, New Delhi, 1994).
3. F. Reif, *Fundamentals of Statistical and Thermal Physics* (McGraw Hill, Singapore, 1985).
4. N. Sears and L. Salinger, *Thermodynamics* (Narosa, New Delhi, 1989).
5. W. Greiner, L. Neise and H. Stocker, *Thermodynamics and Statistical Mechnaics* (Springer, New York, 1995).

CC–IX: PHYSICS PRACTICAL - II

GENERAL AND ELECTRONICS EXPERIMENTS

(Any Twleve)

1. Four probe method – Determination of resistivities of powdered samples.
2. Determination of carrier concentration and Hall coefficients in semiconductors.
3. Determination of magnetic susceptibility of liquid by Guoy method.
4. Determination of magnetic susceptibility of liquids by Quincke's method.
5. Determination of dielectric constant of a liquid by RF oscillator method.
6. Determination of wavelength and thickness of a film by using Michelson's interferometer.
7. Brass spectrum – Determination of composition.
8. Salt analysis by using Spectrograph.
9. ALO band spectrum.
10. Charge of an electron by spectrometer.
11. Polarizability of liquids by finding the refractive indices at different wavelengths.
12. Determination of wavelength of monochromatic source using biprism.
13. Determination of refractive index of liquids using biprism (by scale & telescope method).
14. Determination of specific rotatory power of a liquid using polarimeter.
15. Rydberg's constant using spectrometer.
16. Determination of coefficient of coupling by AC bridge method.
17. Magnetoresistance of powder samples using CE bridge.
18. Forbe's method of determining thermal conductivity.
19. Determination of dielectric loss using CRO.
20. Particle size determination using He-Ne Laser.
21. Laser diode characteristics.

CC X : SOLID STATE PHYSICS

Unit 1: Crystal Structure
Crystal classes and symmetry – 2D, 3D lattices – Bravais lattices – Symmetry point groups – Space groups – Reciprocal lattice – Ewald's sphere construction – Bragg's law – Systematic absences – Atomic scattering factor – Diffraction – Structure factor – Experimental techniques – Laue, Powder, Rotation methods – Phase problem – Electron density distribution (elementary ideas only).

Unit 2: Lattice Vibrations and Thermal Properties
Vibration of monoatomic lattices – Lattices with two atoms per primitive cell – Quantization of lattice vibrations – Phonon momentum – Inelastic scattering of neutrons by phonons -- Lattice heat capacity – Einstein model – Density of modes in one-dimension and three-dimension – Debye model of the lattice heat capacity – Thermal conductivity – Umklapp process.

Unit 3: Free Electron Theory, Energy Bands and Semiconductor Crystals
Energy levels and density of orbitals – Fermi-Dirac distribution – 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 – Nearly free electron model – Electron in a periodic potential – Semiconductors – Band gap – Effective mass – Intrinsic carrier concentration.

Unit 4: **Diamagnetism, Paramagnetism, Ferro magnetism and Antiferromagnetism**
Langevin classical theory of Diamagnetism and paramagnetism – Weiss theory - Quantum theory of paramagnetism – Demagnetization of a paramagnetic salt – Paramagnetic susceptibility of conduction electrons - Hund's rules - Ferroelectric order – Curie point and the exchange integral – Temperature dependence of saturation magnetization – Magnons – Ferromagnetic order – Antiferromagnetic order –Ferromagnetic domains – Origin of domains – Coercive force and hysteresis.

Unit 5: Dielectrics and Ferroelectrics and Superconductivity
Macroscopic electric field – Local electric field at an atom – Dielectric constant and polarizability – Clausius-Mossotti equation – Polarizaion catastrophe – Occurrence of Superconductivity – Meissner effect – Thermodynamics of superconducting transition – London equation – Coherence length – BCS theory – Flux quantization – Type I and Type II Superconductors – Josephson superconductor tunneling – DC and AC Josephson effect – SQUID – Recent developments in high Temperature Superconductivity – Application of superconductors.

Books for Study and Reference: Relevant Chapters in

1. C. Kittel, *Introduction to Solid State Physics* (Wiley Eastern, New Delhi, 1977).
2. N. W. Ashcrof and N. D. Mermin, *Solid State Physics* (Holt, Rinehart and Winston, Philadelphia).
3. J. S. Blakemore, *Solid State Physics* (Cambridge University Press, Cambridge, 1974).
4. A. J. Dekker, *Solid State Physics* (McMillan, Madras, 1971).
5. M. M. Woolfson, *An Introduction to X-ray Crystallography* (Cambridge University Press, Cambridge, 1991).
6. S. O. Pillai, *Solid State Physics* (New Age International, New Delhi, 1995).

CC XI : NUCLEAR AND PARTICLE PHYSICS

Unit 1 : Basic Nuclear Properties

Nuclear size, shape, mass – Charge distribution – Spin and parity – Binding energy – Semi empirical mass formula – Nuclear stability – Mass parabola -- Nature of nuclear forces – Ground state of deuteron – Magnetic dipole moment of deuteron – Proton-neutron scattering at low energies – Scattering length, phase shift – Properties of nuclear forces – Spin dependence – Charge symmetry – Charge independence – Repulsion at short distances – Exchange forces – Meson theory.

Unit 2 : Radioactive Decays

Alpha emission – Geiger-Nuttal law – Gamow theory – Neutrino hypothesis – Fermi theory of beta decay – Selection rules – Nonconservation of parity – Gamma emission – Selection rules - Interaction of charged particles and X-rays with matter – Basic principles of particle detectors – Ionization chamber – Proportional counter and G.M counters – Solid state detectors – Scintillation and semiconductor detectors.

Unit 3 : Nuclear Reactions and Nuclear Models

Q-values and kinematics of nuclear cross sections – Energy and angular dependence – Reciprocity theorem – Breit-Wigner formula – Compound nucleus – Resonance theory – Optical model -- Shell model – Liquid drop model – Collective model.

Unit 4 : Accelerators and Reactors

Cyclotron – Synchrocyclotron – Betaron – Synchrotron – Linear accelerators --Characteristics of fission – Mass distribution of fragments – Radioactive decay processes – Fission cross section – Energy in fission – Bohr-Wheeler's theory of nuclear fission – Fission reactors – Thermal reactors – Homogeneous reactors – Heterogeneous reactors – Basic fusion processes - Characteristics of fusion – Solar fusion – Controlled fusion reactors.

Unit 5 : Elementary Particles

Building blocks of nucleus – Nucleons, leptons, mesons, baryons, hyperons, hadrons, strange particles - Classification of fundamental forces and elementary particles – Basic Conservation laws – Additional Conservation laws : Baryonic, leptonic, strangeness and isospin charges/quantum numbers — Gell-Mann-Nishijima formula – Multiplets -- Invariance under time reversal (T) charge conjugation (C) and parity (P) – TCP theorem -- Parity nonconservation in weak interactions – CP violation – Eight-fold way and supermultiples – SU(3) symmetry and quark model - Basic ideas on the theories of weak and strong interactions.

Books for Study and Reference: Relevant Chapters in

1. K. S. Krane, *Introductory Nuclear Physics* (John-Wiley, New York, 1987).
2. V. Devanathan, Nuclear Physics, Naroso Publishing House (2006)
2. S. B. Patel, *Nuclear Physics: An Introduction* (Wiley-Eastern, New Delhi, 1991).
3. B. L. Cohen, *Concepts of Nuclear Physics* (Tata McGraw Hill, New Delhi, 1988).
4. H. S. Hans, *Nuclear Physics: Experimental and Theoretical* (New Age International Publishers, New Delhi, 2001).
5. D. C. Cheng and G. K. O'Neill, *Elementary Particle Physics: An Introduction* (Addison-Wesley, 1979).
6. D. Griffiths, *Introduction to Elementary Particles* (Wiley International, New York, 1987).

CC XII : PHYSICS PRACTICAL - III
ADVANCED ELECTRONICS

Any **Fifteen** only

1. Logic gates – Universality of NAND / NOR gates Using IC's
2. Verification of Demorgans theorems and Boolean Expressions
3. Astable and bistable and monostable multivibrator using IC 555
4. FET amplifier (CD and CS configuration)
5. Phase shift network and Oscillator using IC 741
6. Wien's bridge oscillator using IC 741
7. Construction of dual regulated power supply
8. Half and Full wave precision rectifier using IC 741
9. Characteristics of LVDT
10. Characteristics of LDR
11. Calibration of thermistor
12. Calibration of thermocouple
13. Study of the characteristics of Strain gauge
14. Study of the characteristics of Load cell
15. Study of the characteristics of torque transducer
16. Digital to analog converter - R-2R method and Weighted method
17. Study the function of multiplexer and demultiplexer
18. Study the function of decoder and encoder
19. Flip flops
20. Half adder and Full adder (using only NAND & NOR gates)
21. Half subtractor and Full Subtractor (using only NAND & NOR gates)
22. Digital comparator using XOR and NAND gates
23. BCD to seven segment display
24. Study of counter using IC 7490 (0-9 and 00-99)
25. Measurement of Resistance using AC Wheatstone bridge

CC XIII: PHYSICS PRACTICAL – IV - ADVANCED ELECTRONICS

MICROPROCESSORS AND COMPUTER LABORATORY

(Any fifteen only -- Choosing a minimum of six experiments from each part)

A. Microprocessor Practicals

1. 8 bit addition, subtraction, multiplication and division using 8085/Z80.
2. 16 bit addition, 2's complement and 1's complement subtraction (8086/8088).
3. Conversion from decimal to octal and hexa systems.
4. Conversion from octal, hexa to decimal systems.
5. Interfacing hexa key board (IC 8212).
6. Study of seven segment display add on board.
7. Study of DAC interfacing (DAC 0900).
8. Study of ADC interfacing (ADC 0809).
9. Study of timer interfacing (IC 8253).
10. Study of programmable interrupt controller (IC 8259).
11. Traffic control system using microprocessor.
12. Microprocessor as digital clock.
13. Generation of square, triangular, saw-tooth staircase and sine waves using DAC 0800.
14. Microprocessor as digital thermometer (temperature controller).
15. Control of stepper motor using microprocessor.

B. Computer Practicals (By C Language)

1. Roots of algebraic equations -- Newton-Raphson method.
2. Least-squares curve fitting – Straight-line fit.
3. Least-squares curve fitting – Exponential fit.
4. Solution of simultaneous linear algebraic equations – Gauss elimination method.
5. Solution of simultaneous linear algebraic equations – Gauss-Seidal method.
6. Interpolation – Lagrange method.
7. Numerical integration – Composite trapezoidal rule.
8. Numerical integration – Composite Simpson's rules.
9. Numerical differentiation – Euler method.
10. Solution of ordinary differential equations – Runge-Kutta 2^{nd} order method.
11. Solution of ordinary differential equations – Runge-Kutta 4^{th} order method.
12. Uniform random number generation – Park and Miller method.
13. Gaussian random number generation – Box and Muller method.
14. Evaluation of definite integrals – Monte Carlo method.
15. Calculation of mean, standard deviation and probability distribution of a set of random numbers.

CC XIV: PROJECT WORK

EC I: MICROPROCESSOR AND COMMUNICATION ELECTRONICS

Unit 1: Microprocessor Architecture and Instruction set

8085, 8086/8088 microprocessor architectures – Various registers – Central processing unit of micro computers – Timing and control unit – Instruction and data flow – System timings – Examples – Instruction set -- Data transfer group – Logical group – Branch group – Stack and I/O control instructions – Addressing modes.

Unit 2 : Software Programs (8085 only)

Addition – Subtraction – Multiplication – Division – BCD arithmetic – Searching an array of a given number – Choosing the biggest and smallest numbers from a list – Ascending and descending orders – Square root of a number – Time delay – Square wave generator.

Unit 3 : Interfacing memory and I/O devices

Interfacing memory and devices -- I/O and Memory mapped I/O -- Type of interfacing devices -- Data transfer schemes -- Programmed and DMA data transfer schemes -- Programmable Peripheral Interface (8255A) -- 8253 Timer Interface -- DMA controller -- Programmable Interrupt controller (8259) -- Programmable communication Interface (8251).

Unit 4 : Digital Transmission Systems & Modulation Techniques

Point-to-point links -- Line coding coherent optical fiber communications -- Definition and classification coherent systems – Requirements on semiconductor lasers.
Modulation – Demodulation – Principles of amplitude, frequency and phase modulations – Simple circuits for amplitude, frequency and phase modulation and demodulation – Pulse modulation.

Unit 5 : Satellite Communications

Ground Station – Antenna, angle of elevation and transmission path – Height of geostation orbits -- Problems – Satellite works – Frequency allocation and polarization – Various blocks of equipment abroad the satellite – Transmit and receiver contour – Block diagram of network control station (NCS) interconnecting telephone traffic between remote stations – SS/TDMA concepts.

References

1. R. Goankar, *Micropressor Architecture, Programming and Applications* (Wiley Eastern, New Delhi, 1985).
2. B. Ram, *Fundamentals of Microprocessors and Microcomputers* (Dhanapet Rai & Sons, New Delhi, 1995).
3. M. Schwarts, W. R. Bennet and S. Stein, *Communication Systems and Techniques* (McGraw Hill, New Delhi).
4. G. Kennedy, *Electronic Communication Systems* (Tata McGraw Hill, New Delhi, 1995).
5. J. Millman and L. C. Halkias, *Electronic Devices and Circuits* (McGraw Hill, Singapore, 1972).

EC-II: ATOMIC AND MOLECULAR PHYSICS

Unit 1 : Atomic Spectra

Quantum states of electron in atoms – Hydrogen atom spectrum – Electron spin – Stern-Gerlach experiment – Spin-orbit interaction – Two electron systems – LS-JJ coupling schemes – Fine structure – Spectroscopic terms and selection rules – Hyperfine structure - Exchange symmetry of wave functions – Pauli's exclusion principle – Periodic table – Alkali type spectra – Equivalent electrons – Hund's rule

Unit 2: Atoms in External Fields and Quantum Chemistry

Atoms in External Fields : Zeeman and Paschen-Back effect of one and two electron systems -- Selection rules – Stark effect .
Quantum Chemistry of Molecules : Covalent, ionic and van der Waals interactions – Born-Oppenheimer approximation – Heitler-London and molecular orbital theories of H_2 – Bonding and anti-bonding MOs – Huckel's molecular approximation – Application to butadiene and benzene.

Unit 3: Microwave and IR Spectroscopy

Rotational spectra of diatomic molecules – Effect of isotopic substitution – The non-rigid rotor - Rotational spectra of polyatomic molecules – Linear, symmetric top and asymmetric top molecules – Experimental techniques -- Vibrating diatomic molecule – Diatomic vibrating rotator – Linear and symmetric top molecules – Analysis by infrared techniques – Characteristic and group frequencies

Unit 4: Raman Spectroscopy and Electronic Spectroscopy of Molecules

Raman spectroscopy : Raman effect -- Quantum theory of Raman effect – Rotational and vibrational Raman shifts of diatomic molecules – Selection rules.
Electronic spectroscopy of molecules : Electronic spectra of diatomic molecules -- The Franck-Condon principle – Dissociation energy and dissociation products – Rotational fine structure of electronic vibration transitions

Unit 5: Resonance Spectroscopy

NMR: Basic principles – Classical and quantum mechanical description – Bloch equations – Spin-spin and spin-lattice relaxation times – Chemical shift and coupling constant -- Experimental methods – Single coil and double coil methods – High resolution methods.
ESR: Basic principles – ESR spectrometer – nuclear interaction and hyperfine structure – relaxation effects – g-factor – Characteristics – Free radical studies and biological applications.

Books for Study and Reference :
Relevant Chapters in

C. N. Banwell, *Fundamentals of Molecular Spectroscopy* (McGraw Hill, New York, 1981).
B. P. Straughan and S. Walker, *Spectroscopy Vol.I.* (Chapman and Hall, New York, 1976).
R. P. Feynman et al. *The Feynman Lectures on Physics Vol. III.* (Narosa, New Delhi, 1989).
H. S. Mani and G. K. Mehta, *Introduction to Modern Physics* (Affiliated East West, New Delhi, 1991).
A. K. Chandra, *Introductory Quantum Chemistry* (Tata McGraw Hill, New Delhi, 1989).
Pople, Schneiduer and Berstein, *High Resolution NMR* (McGraw Hill, New York).
Manas Chanda, *Atomic Stucture and Chemical Bond* (Tata McGraw Hill, New Delhi, 1991).
Ira N. Levine, *Quantum Chemistry* (Prentice-Hall, New Delhi, 1994).
Arthur Beiser, *Concepts of Modern Physics* (McGraw Hill, New York, 1995).
C.P. Slitcher, *Principles of Magnetic Resonance* (Harper and Row).

EC-III - CRYSTAL GROWTH AND THIN FILM PHYSICS

Unit 1 : Nucleation and Growth

Nucleation – Different kinds of nucleation - Concept of formation of critical nucleus – Classical theory of nucleation - Spherical and cylindrical nucleus - Growth Kinetics of Thin Films - Thin Film Structure – Crystal System and Symmetry.

Unit 2 : Growth Techniques
Solution Growth Technique:
Low temperature solution growth: Solution - Solubility and super solubility – Expression of super saturation – Miers T-C diagram - Constant temperature bath and crystallizer - Seed preparation and mounting - Slow cooling and solvent evaporation methods.

Gel Growth Technique :
Principle – Various types – Structure of gel – Importance of gel – Experimental procedure – Chemical reaction method – Single and double diffusion method – Chemical reduction method – Complex and decomplexion method – Advantages of gel method.

Unit 3 : Melt and Vapour Growth Techniques
Melt technique:
Bridgman technique - Basic process – Various crucibles design - Thermal consideration – Vertical Bridgman technique - Czochralski technique – Experimental arrangement – Growth process.

Vapour technique:
Physical vapour deposition – Chemical vapour deposition (CVD) – Chemical Vapour Transport.

Unit 4 : Thin Film Deposition Techniques

Thin Films – Introduction to Vacuum Technology - Deposition Techniques - Physical Methods – Resistive Heating, Electron Beam Gun, Laser Gun Evaporation and Flash Evaporations, Sputtering - Reactive Sputtering, Radio-Frequency Sputtering - Chemical Methods – Spray Pyrolysis – Preparation of Transparent Conducting Oxides.

Unit 5 : Characterization Technique

X – Ray Diffraction (XRD) – Powder and single crystal - Fourier transform Infrared analysis (FT-IR) – Elemental analysis – Elemental dispersive X-ray analysis (EDAX) - Scanning Electron Microscopy (SEM) – UV-Vis-NIR Spectrometer – Etching (Chemical) – Vickers Micro hardness.

Books for Study and Reference: Relevant Chapters in

1. J.C. Brice, Crystal Growth Processes, John Wiley and Sons, New York (1986)
2. P. SanthanaRagavan and P. Ramasamy, Crystal Growth Processes and Methods, KRU Publications, Kumbakonam (2001)
3. A. Goswami, Thin Film Fundamentals, New Age International (P) Limited, New Delhi (1996)
4. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, CBS, Publishers and Distributors, New Delhi (

EC IV: INTRODUCTION TO NANOSCIENCE AND NANOTECHNOLOGY

Unit 1: Background to nanotechnology

Scientific revolution- Atomic structures-Molecular and atomic size-Bohr radius – Emergence of Nanotechnology – Challenges in Nanotechnology - Carbon age–New form of carbon. (from Graphene sheet to CNT)

Unit 2: Nucleation

Influence of nucleation rate on the size of the crystals- macroscopic to microscopic crystals and nanocrystals - large surface to volume ratio, top-down and bottom-up approaches-self assembly process-grain boundary volume in nanocrystals-defects in nanocrystals-surface effects on the properties.

Unit 3: Types of Nanostructures

Definition of a Nano system - Types of Nanocrystals-One Dimensional (1D)-Two Dimensional (2D) -Three Dimensional (3D) nanostructured materials - Quantum dots - Quantum wire-Core/Shell structures.

Unit 4: Nanomaterials and properties

Carbon Nanotubes (CNT) - Metals (Au, Ag) - Metal oxides (TiO_2, CeO_2, ZnO) - Semiconductors (Si, Ge, CdS, ZnSe) - Ceramics and Composites - Dilute magnetic semiconductor- Biological system - DNA and RNA - Lipids - Size dependent properties - Mechanical, Physical and Chemical properties.

Unit 5: Applications of nanomaterials

Molecular electronics and nanoelectronics – Quantum electronic devices - CNT based transistor and Field Emission Display - Biological applications - Biochemical sensor - Membrane based water purification.

References:

1. M. Wilson, K. Kannangara, G Smith, M. Simmons, B. Raguse, Nanotechnology: Basic science and Emerging technologies, Overseas Press India Pvt Ltd, New Delhi, First Edition, 2005.
2. C.N.R.Rao, A.Muller, A.K.Cheetham (Eds), *The chemistry of nanomaterials: Synthesis, properties and applications*, Wiley VCH Verlag Gmbh&Co, Weinheim, 2004.
3. Kenneth J. Klabunde (Eds), *Nanoscale Materials Science*, John Wiley & Sons, InC, 2001.
4. C.S.S.R.Kumar, J.Hormes, C.Leuschner, *Nanofabrication towards biomedical applications,* Wiley –VCH Verlag GmbH & Co, Weinheim, 2004.
5. W. Rainer, *Nano Electronics and information Technology*, Wiley, 2003.
6. K.E.Drexler, *Nano systems*, Wiley, 1992.
7. G.Cao, *Naostructures and Nanomaterials: Synthesis, properties and applications*, Imperical College Press, 2004.

EC V: NONLINEAR OPTICS

Unit 1: Lasers

Gas lasers – He-Ne, $A_z{}^+$ ion lasers – Solid state lasers – Ruby – Nd: YAG, Ti Sapphire – Organic dye laser – Rhodamine – Semiconductor lasers – Diode laser, p-n-junction laser, GaAs laser

Unit 2: Introduction to Nonlinear Optics

Wave propagation in an anisotropic crystal – Polarization response of materials to light – Harmonic generation – Second harmonic generation – Sum and difference frequency generation – Phase matching – Third harmonic generation – bistability – self focusing

Unit 3: Multiphoton Processes

Two photon process – Theory and experiment – Three photon process Parametric generation of light – Oscillator – Amplifier – Stimulated Raman scattering – Intensity dependent refractive index optical Kerr effect – photorefractive, electron optic effects

Unit 4: Nonlinear Optical Materials

Basic requirements – Inorganics – Borates – Organics – Urea, Nitroaniline – Semiorganics – Thiourea complex – X-ray diffraction FTIR, FINMR- Second harmonic generation – Laser induced surface damage threshold.

Unit 5: Fiber Optics

Step – Graded index fibers – wave propagation – Fiber modes – Single and multimode fibers – Numerical aperture – Dispersion – Fiber bandwidth – Fiber loss – Attenuation coefficient – Material absorption.

Books for Reference

Relevant Chapters in

1. B.B. Laud, Lasers and Nonlinear Optics, 2^{nd} Edn. New Age International (P) Ltd., New Delhi, 1991
2. Robert W. Boyd, Nonlinear Optics, 2^{nd} Edn., Academic Press, New York, 2003
3. Govind P. Agarwal, Fiber-Optics Communication Systems, 3^{rd} Edn. John Wiley & Sons, Singapore 2003
4. William T. Silvast, Laser Fundamentals, Cambridge University Press, Cambridge 2003
5. Nonlinear Optics – Basic Concepts D.L. Mills, Springer, Berlin 1998.

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