

SEMESTER : 1

Approved in the Physics P.G. Board of studies A.N.U. meeting held on 18-02-2006. Applicable for the batch of students admitted in M.Sc Physics in the academic year 2006-2007.

**M.Sc. Physics ( I Semester)**

**Paper I : MATHEMATICAL PHYSICS**

**PHY 11**

**Unit-I**

Vector Spaces and Matrices; Linear independence; Bases; Dimensionality; Inner product; Linear transformations; Matrices; Matrices: Inverse; Orthogonal and unitary matrices; Independent elements of a matrix; Eigen-values and eigen-vectors; diagonalization; complete Ortho-normal sets of functions.

Differential Equations and Special Functions: second order linear ODEs with variable Coefficients: solution by series expansion; Legendre, Bessel, Hermite and Laguerre equations: physical applications; Generating functions; recursion relations.

**Unit-II**

Integral Transforms, Laplace transform; first and second shifting theorems; Inverse LT by partial fractions; LT of derivative and integral of a function; Fourier series; F of arbitrary period; Half-wave expansions; Partial sums; Fourier n integral and transformations; FT of delta function.

Text and reference books:

Mathematical Methods for Physics. By G. Arfken

Matrices and tensors for Physicists. by A W. Joshi

**NOTE:** Question paper contains FIVE questions of equal marks. A candidate has to answer ALL. Fifth question contains four short notes question and the candidate has to answer any TWO

*N. Veeraiah*

Prof. N. Veeraiah,  
Chairman, P.G. Board of Studies in Physics

## SEMESTER : 1

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### M.Sc. Physics ( I Semester)

#### Paper II : CLASSICAL MECHANICS

PHY 12

##### UNIT I

Preliminaries ; Newtonian mechanics of one and many particle systems; conservation laws, work-energy theorem; open systems (with variable mass); Constraints;their classification; D'Alembert's principle ;generalized Coordinates.  
Lagrange's equations; gyroscopic forces ; dissipative systems; Jacobi integral; gauge invariance; generalized coordinates and momenta ;  
Integrals of motion ; symmetries of space and time with conservation Laws ; invariance under Galilean transformations.Rotating frames; inertial forces; terrestrial and astronomical applications of Coriolis force.  
Central force; definition and characteristics; Two-Body problem;  
Closure and stability of circular orbits; general analysis of orbits;  
Kepler's laws and equation; artificial satellites; Rutherford's scattering.

##### UNIT II

Principle of least action; derivation of equation of motion; variation and end points; Hamilton's principle and characteristic functions;  
Hamilton- Jacobi equation.  
Canonical transformation; generating functions; properties; group Property; examples ; infinitesimal generators ; Poisson bracket; Poisson theorems; angular momentum PBs; small oscillations; normal modes and coordinates.

##### Text and Reference books:

Classical mechanics, by N.C.Rana and P.S.Joag (TMH (1991))

Classical mechanics, by H.Goldstein (Addison wesley,1980)

Mechanics , by A. Sommerfield (Academic Press, 1952)

Introduction to Dynamics, by Perceival and D.Richards(Cambridge Univ.Press 1982)

Classical Mechanics – Mondal PHI

NOTE : Question paper contains 5 questions. Two questions with internal choice have to be set from each unit. The 5<sup>th</sup> question is a short answers question covering units I and II



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**M.Sc. Physics ( I Semester)**

**Paper III : QUANTUM MECHANICS I**

**PHY 1.3**

**Unit-I**

Why QM? Revision; Inadequacy of classical mechanics; Schrodinger equation; continuity equation; Ehrenfest theorem; admissible wave functions; Stationary states. One-dimensional problems, wells and barriers; Harmonic oscillator by Schrodinger equation and by operator method.

Uncertainty relation of  $x$  and  $p$ , states with minimum uncertainty product; General formalism of wave mechanics; commutation relations; Representation of states and dynamical variables; completeness of eigenfunctions; Dirac delta function; bra and ket notation; Matrix representation of an operator; Unitary transformation.

Angular momentum in QM; Central force problem; Solution of Schrodinger equation for spherically symmetric potentials; Hydrogen atom.

**Unit-II**

Time-independent perturbation theory; Non-degenerate and degenerate cases; applications to a) normal helium atom b) Stark effect in Hydrogen atom . Variation method Application to ground state of Helium atom. WKB method.

Time dependent perturbation : General perturbations, variation of constants, transition rates, Einstein transition probabilities, sudden and adiabatic approximation.

***TEXT AND REFERENCE BOOKS***

Merzbecher, Quantum Mechanics

L I Schiff, Quantum Mechanics (Mc Graw-Hill)

B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)

A P Messiah, Quantum Mechanics

J J Sakural, Modern Quantum Mechanics

Mathews and Venkatesan Quantum Mechanics

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**M.Sc. Physics ( I Semester)**

**Paper IV : ELECTRONICS (General)**

**PHY 14**

### UNIT I

Operational Amplifiers

Differential Amplifier –circuit configurations - dual input, balanced output differential amplifier – DC analysis – Ac analysis, inverting and

non inverting inputs CMRR - constant current bias level translator .

Block diagram of a typical Op-Amp-analysis. Open loop configuration inverting and non-inverting amplifiers. Op-amp with negative feedback- voltage series feedback – effect of feedback on closed loop gain input resistance output resistance bandwidth and output offset voltage- voltage follower.

Practical op-amp input offset voltage- input bias current-input offset current, total output offset voltage, CMRR frequency response.

DC and AC amplifier- summing, scaling and averaging amplifiers, instrumentation amplifier, integrator and differentiator.

Oscillators principles – oscillator types – frequency stability – response – The phase shift oscillator, Wein bridge oscillator – LC tunable oscillators – Multivibrators- Monostable and astable –comparators – square wave and triangular wave generators.

Voltage regulators – fixed regulators – adjustable voltage regulators switching regulators.

### UNIT II

Communication Electronics

Amplitude modulation – Generation of AM waves – Demodulation of AM waves – DSBSC modulation. Generation of DSBSC waves., coherent detection of DSBSC waves, SSB modulation, Generation and detection of SSB waves. Vestigial side band modulation, Frequency division multiplexing (FDM).

Digital Electronics

#### 1. Combinational Logic

The transistor as a switch, OR, AND and NOT gates – NOR and NAND gates. Boolean algebra – Demorgan's theorems – Exclusive OR gate, Decoder/ De multiplexer. Data selector / multiplexer – Encoder.

#### 2. Sequential Logic

Flip-Flops: A 1 bit memory – the R-S Flip – Flop, JK Flip-Flop – JK master slave Flip-Flops – T- Flip – Flop – D Flip – Flop – Shift registers – synchronous and asynchronous counters – cascade counters.

Microprocessors

Introduction to microcomputers – memory – input/output –interfacing devices

8085 CPU -Architecture – BUS timings – Demultiplexing the address bus – generating control signals – instruction set – addressing modes – illustrative programmes – writing assembly language programmes –looping, counting and indexing – counters and timing delays – stack and subroutine.

Text and Reference Books

Electronic devices and circuit theory by Robert Boylested and Louis Nashlsky PHI 1991

Op-Amps & Linear integrated circuits by Ramakanth A.Gayakwad PHI 1991

Digital principles and applications by A.P.Malvino and Donald P.Leech TMH 1993

Microprocessor Architecture, Programming and Applications with 8085/8086 by Ramesh S.Gaonkar, Wiley-Eastern 1987.

Electronics-analog and digital – Nagarath PHI

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**M.Sc. Physics ( II Semester)**

**Paper-1 QUANTUM MECHANICS-II**

**PHY 21**

**Unit - I**

Angular momentum: commutation relations for angular momentum operator. Eigen value problem for  $L^2$  and  $L_z$ . Spin angular momentum and Pauli spin matrices, total angular momentum J. Explicit matrices for  $J^2, J_x, J_y$  &  $J_z$ . Combination of two angular momentum and tensor operator: Clebsch-Gordon coefficients. Wigner-Eckart theorem.

**Unit - II**

Equation of motion in Schrödinger's picture and Heisenberg's picture, correspondence between the two. Correspondence with classical mechanics. Application of Heisenberg's picture to Harmonic oscillator.

The spinning electron. Pauli exclusion principle, accurate treatment of the normal and excited states of Helium atom. Slater's treatment of complex atoms, exchange and spatial degeneracies factorization and solution of the secular equation. Method of self consistent fields.

**TEXT AND REFERENCE BOOKS**

Merzbecher, Quantum Mechanics

L I Schiff, Quantum Mechanics (Mc Graw-Hill)

B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)

Thankappan, Quantum Mechanics

Mathews and Venkatesan Quantum Mechanics

Pauling and Willson, Quantum Mechanics

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**M.Sc. Physics ( II Semester)**

**Paper II : Statistical Mechanics**

**PHY 22**

**UNIT I**

1. Foundations of statistical mechanics; specification of states of a system, contact between statistics and thermodynamics, equi-partition theorem, classical ideal gas, Gibb's paradox.
2. Micro-canonical ensemble, phase space, trajectories and density of states, Liouville's theorem, canonical ensemble, calculation of statistical quantities, Energy fluctuations in canonical ensemble and grand canonical ensemble, Density fluctuations in the Grand canonical ensemble, Equivalence of the canonical ensemble and Grand canonical ensemble.

**UNIT II**

3. Density matrix, statistics of ensembles, statistics of indistinguishable particles, Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein statistics, Thermodynamic properties of ideal gases on the basis of micro canonical and grand canonical ensemble. The Partition function: Darwin and Fowler method.
4. Ideal Fermi gas, Equation of state of an ideal Fermi gas, theory of White dwarf stars, Landau diamagnetism, De Hass - van Alphen effect and Pauli para magnetism. Ideal Bose gas : Photons - Phonons - Bose Einstein condensation

**Text and Reference Books:**

Statistical and Thermal Physics by S. Lokanadham and R.S.Gambhir ( PHI).

Statistical Mechanics by K Huang ( Wiley Eastern )

Statistical Mechanics theory and applications by S.K.Sinha

Statistical Physics by Landau and Lifshitzv

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**M.Sc. Physics ( II Semester)**  
**Paper III: Numerical Methods and Programming    PHY 23**

**UNIT I**

Numerical Methods

Methods for 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.

Eigen values and eigen vectors of matrices, Power and Jacobi Method

Finite differences, interpolation with equally spaced and unevenly spaced points. Curve fitting, polynomial least squares and cubic Spline fitting.

Numerical differentiation and integration, Newton-Cotes formulae, error estimates, Gauss method.

Random variate, Monte Carlo evaluation of Integrals, Methods of importance sampling, Random walk and Metropolis method.

**UNIT II**

Numerical solution of ordinary differential equations, Euler and Runge Kutta methods, Predictor and corrector methods. Elementary ideas of solutions of partial differential equations.

**C PROGRAMMING:**

Digital Computer Principles, Compilers, Interpreters, Operating Systems,.

C programming, flow Charts, Integer and Floating Point Arithmetic, Expressions, built-in functions, assignment, control and input-output elements, functions, data structures: If, For, While, Switch etc. Using pointers and structures, and unions, Operation with files.

**Text and Reference Books**

Sastry: Introductory Methods of Numerical Analysis

Balaguruswamy : Numerical methods

Vetterling, Teukolsky, Press and Flannery: Numerical Recipes

Balaguruswamy : Programming in ANSI C (TMH)

Yaswant Kanetkar: Introduction to C

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**M.Sc. Physics ( II Semester)**

**PAPER IV : Condensed matter Physics (General) PHY 24**

### **UNIT I**

Classification of solids as crystalline and non crystalline- Essential differences in their properties-

(Elements of Solid State Physics J.P. Srivastava PHI)

Periodic arrays of atoms- fundamental types of lattices- index system for crystal planes- simple crystal structures- sodium chloride, cesium chloride, diamond structures. (Solid State Physics by C.Kittel Chap 1.)

Crystal structure determination by X-ray diffraction, Bragg's law, Laue diffraction conditions, Equivalence of the two principles, Laue powder and rotating crystal methods, comparison of their relative advantages and disadvantages. Electron and Neutron diffraction methods.

### **UNIT II**

(Solid State Physics by Gupta Kumar and Saxena)

Interatomic forces and the classification of solids. Calculation of binding energies for ionic crystals. Born's theory of lattice energy of NaCl. Stability of structures and ionic radii.

Refinements of the Born's theory.

Free electron theory of solids. Energy levels and density of states in one and three dimensions.

Electrical conductivity, thermal conductivity and Wiedemann –Franz's ratio –Specific heat contribution and paramagnetic susceptibility of conduction electrons. Hall effect.

Energy band theory of solids, Bloch's theorem. Kronig-Penney model. Motion of electrons in one dimension – Distinction between metals.

#### **REFERENCE & TEXT BOOKS:**

Solid State Physics by Herold Teach Hens Luth (Narosa pub)

Elementary Solid state Physics by Omar

Crystallography for Solid state Physics Verma & Srivatsava

Solid state Physics :Aschroft & Mermin,

Introduction to solids Azoff

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**Applicable for the batch of students admitted in to M.Sc Physics First year course in the academic year 2006-2007.**

**M.Sc. Physics (III Semester)**

**Paper I : Atomic and Molecular Physics**

**PHY 31**

UNIT I

Quantum states of one electron atoms-Atomic orbitals-Hydrogen spectrum-Pauli's principle-spectra of alkali elements-Spin orbit interaction and fine structure in alkali Spectra-equivalent and non-equivalent electrons-Normal and anomalous Zeeman effect- Paschen Back effect-stark effect- Two electron systems-interaction energy in LS and JJ Coupling-Hyperfine structure (qualitative)-Line broadening mechanisms (general ideas)

UNIT II

Types of molecules-diatomic linear symmetric top, asymmetric top and spherical top molecules-Rotational spectra of diatomic molecules as a rigid rotor-Energy levels and spectra of non rigid rotor-intensity of rotational lines-Stark modulated microwave spectrometer(qualitative)

Vibrational energy of diatomic molecule-Diatomic molecule as a simple harmonic oscillator-Energy levels and spectrum-Morse potential energy curve-Molecules as vibrating rotator-Vibration spectrum of diatomic molecule-PQR branches IR spectroscopy (qualitative)

**Text and Reference Books**

Introduction to atomic spectra – H.E. White(T)

Fundamentals of molecular spectroscopy – C.B.Banwell (T)

Spectroscopy Vol I,II & III – Walker & Straughen

Introduction to Molecular Spectroscopy – G.M.Barrow

Spectra of diatomic molecules – Herzberg

Molecular Spectroscopy – Jeanne L McHale

Molecular Spectroscopy – J.M.Brown

Spectra of atoms and molecules – P.F.Bemath

Modern Spectroscopy – J.M. Holias

**Note :** Two questions have to be set from each unit with internal choice. The fifth question is a short answer question covering the two units. Candidate has to answer all the questions.

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**M.Sc. Physics (III SEMESTER):**  
**Paper II : NUCLEAR AND PARTICLE PHYSICS**

**PHY 32A**

**UNIT I**

Mass defect – Binding energy – nuclear moments – magnetic dipole  
Moment and electric Quadrupole moment, Nuclear forces- Characteristics of nuclear forces,  
Ground state of deuteron.

Nucleon-nucleon scattering- Exchange forces and tensor forces – Meson theory of nuclear forces  
(Yukawa potential) - Spin independence of nuclear forces- Charge independence and charge  
symmetry of nuclear forces-

Types of nuclear reactions and conservation laws. Nuclear kinematics, Q-equation. Threshold  
energy. Direct and compound nuclear reaction mechanisms.

Semi empirical mass formula, Liquid drop model – Bohr – Wheeler theory of fission – Shell  
model – Spin – Orbit coupling – Magic numbers – Angular momenta and parities of nuclear  
ground states.

**UNIT II**

Nuclear energy: Nuclear fission- Energy release in fission, Nuclear fusion-chain reaction,  
Nuclear reactor- Types of reactors.

Gamow's theory of  $\alpha$ -decay, Geiger-Nuttel rule, Beta decay – Fermi theory of beta decay –  
Shape of the beta spectrum – angular momentum and parity selection rules – Allowed and  
forbidden transitions – Selection rules – Gamma decay – Multipole transitions in nuclei –  
angular momentum and parity selection rules – Internal conversion – Nuclear isomerism.

Classification of elementary particles, conservation laws.

Types of interaction between elementary particles – Hadrons and leptons – Symmetry and  
conservation laws – elementary ideas of CP and CPT invariance- Lie algebra, SU(2) – SU(3 )  
multiplets – quark model .

**Text and Reference Books**

1.D.C.Tayal, Nuclear Physics . Himalaya Publishing Company.

R.D.Evans, Atomic Nucleus, Me Graw Hill, New York, 1955.

B.L.Cohen, Concepts of Nuclear Physics, TMGH, Bombay, 1971.

R.R.Roy and B.P.Nigam, Nuclear Physics, Wiley – Eastern Ltd., 1983

Swami Gnanananda Elements of Nuclear Physics (AU, Waltair)

R.C.Sharma Nuclear Physics K.Nadh & Co Meerut.

J.M.Lango Elementary particles (MH) 1971

F.Halzen & A.D.Martin Quarks & Leptons -an introductory course in modern particle physics  
(John Wiley)

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### M.Sc. Physics III Semester

#### Paper III A

#### QUANTUM MECHANICS III

#### PHY 33A

#### Unit-I

The Born-Openheimer Approximation – The hydrogen molecule ion the Hydrogen molecule – The valance bond method – The molecular orbital method- Comparison of the methods – Heitler-London method.( Ref : Atkins, Chapter-9, 279-294).

The indistinguishability of identical particles – The state vector space for a system of identical particles – Creation and annihilation operators- continuous one particle system- (Ref : Merzbacher, Chapter – 20. PP 508-526)

#### Unit-II

Dynamical variables – the Quantum dynamics of identical particle systems – Angular momentum in system of identical particles (Ref : Merzbacher, Chapter – 20. PP 508-526)

Introduction of scattering – notion of cross section – scattering of a wave packet- scattering in continuous stream model – Green's function in scattering theory – Born's approximation – first order approximation – criteria for the validity of Born's approximation . Form factor- scattering from a square well potential – partial wave analysis – Expansion of a plane wave – optimal theorem – calculation of phase shifts – low energy limit – energy dependence of  $\beta_e$  - scattering from a square well potential.

(Ref: Kakani & Chandalia ,Chap. 14)

#### TEXT AND REFERENCE BOOKS

Merzbecher, Quantum Mechanics

L I Schiff, Quantum Mechanics (Mc Graw-Hill)

B Craseman and J D Powell, Quantum Mechanics (Addison Wesley)

A P Messiah, Quantum Mechanics

Mathews and Venkatesan Quantum Mechanics

**NOTE:** Question paper contains FIVE ( Two questions form each unit and fifth question contains four short note question and in which the candidate has to answer any TWO)



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**M.Sc. Physics (III Semester) : Special Paper I b**  
**Paper III B : ELECTRONICS PHY33B & C**

UNIT I

Microprocessors & Micro Computers

Microprocessors and Architecture : Internal Microprocessor Architecture, Real mode and protected modes of memory addressing, memory paging.

Addressing modes : Data addressing modes. Program memory addressing modes, Stack-memory addressing modes.

Instruction Set: Data movement instructions, Arithmetic and Logic instructions, Program control instructions. Assembler details.

Programming the Microprocessor : Modular programming. Using the keyboard and video display, Data conversions. Disk files. Example programs.

UNIT II

Hardware Specifications : Pin-outs and the Pin functions, clock-generator (8284A), Bus buffering and Latching, Bus timing.  
Ready and wait state. Minimum mode versus maximum mode.

Memory Interface : Memory devices, Address decoding, 8088 and 80188 (8-bit) memory interface, 8086, 80186, 80286 (16-bit) memory interface, 80386DX and 80486 (32-bit) memory Interface, dynamic RAM.

Basic I/O Interface: Introduction to I/O interface, I/O port address decoding, 8255, 8279, 8254, 16550, ADC and DAC (excluding multiplexed display & keyboard display using 8255)

Interrupts: Basic interrupt processing, Hardware interrupts. Expanding the interrupt structure, 8259A PIC.

( continue...)

Direct Memory Access: Basic DMA operation, 8237 DMA controller, Shared Bus operation, Disk memory systems, video displays.

Text and Reference Books

Barry B. Brey, `The Intel Microprocessors 8086/8088, 80186/80188, 80286, 80386, 80486, Pentium and Pentium pro processor architecture, programming and interfacing “ Fourth Edition, PHI, 1999.

Douglas V. Hall, `` microprocessors and Interfacing, Programming and Hardware”, second edition, McGraw Hill International Edition, 1992.

Muhammad Ali Maxidi and Janice Gillispie Mazidi, “the 80x86 IBM PC and Compatible Computers (volumes I & II), second edition, Prentice-Hall International, 1998.

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**M.Sc. Physics (III Semester)**

**Paper IV A: Condensed Matter Physics**

**PHY34A**

**UNIT I**

Properties of metallic lattices and simple alloys: The structure of metals – classification of lattice defects. Configurational -entropy –The number of vacancies and interstitial as function of temperature –The formation of lattice defects in metals . Lattice defect in ionic crystals and estimation of concentration of defects in ionic crystals. Edge and screw dislocation The Frank read mechanism of dislocation multiplication.

**Electronic properties of alkali halides.:**

Optical and thermal electronic excitation in ionic crystals, The ultraviolet spectrum of the alkali halides; excitons, Illustration of electron-hole interaction in single ions, Qualitative discussion of the influence of lattice defects on the electronic levels, Non stoichiometric crystals containing excess metal, The transformation of F centers into  $F_1$  centers and viceversa, Photoconductivity in crystals containing excess metal, The photoelectric effect in alkali halides, Coagulation of F centers and colloids, Color centers resulting from excess halogen, Color centers produced by irradiation with X-rays.

**UNIT II**

Specific heats of solids. Einstein and Debye theories. Vibrations of mono atomic and diatomic linear lattices. Infrared absorption. Magnetic Properties of Solids Quantum theory of Para magnetism, Crystal Field Splitting, Quenching of the orbital Angular Momentum Ferromagnetism Curie point and the Exchange integral, Saturation Magnetization at Absolute Zero, Magnons, Ferromagnetic Domains. Antiferromagnetism The two-sublattice model, Superexchange interaction Ferrimagnetism The structure of ferrites, The saturation magnetization, Elements of Neel's theory.(Solid State Physics by C.Kittel Chapters 14 and 15) Luminescence General remarks, Excitation and emission , Decay mechanisms, Thallium-activated alkali halides, The sulfide phosphors, Electroluminescence.(Solid state physics by A.J. Dekker, chapters 15 &16)

**Text and Reference Books**

1. Madelng : Introduction to Solid State theory
2. Callaway: Quantum theory of solid state
3. A.J.Dekker: Solid state physics
4. C.Kittel :Solid State Physics
5. Solid State Physics S.O.Pillai New Age International

**NOTE:** Question paper contains Nine questions of equal marks.

Two questions have to be set from each unit with internal choice. The fifth question is a short answer question covering the two units. Candidate has to answer all the questions.

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**M.Sc. Physics (III Semester)**

**Paper IV B : ELECTRONIC DEVICES**

**PHY34 B**

**UNIT I**

Transistors: JEET, BJT, MOSFET AND MESFET : Structure, working, Derivations of the equations for I-V characteristics under different conditions, High Frequency limits.

Microwave Devices: Tunnel diode, transfer electron devices (Gun diode). Avalanche Transit time devices, Impatt diodes, and parametric devices.

Photonic Devices: radiative and non-radiative transitions. Optical Absorption, bulk and thin film photoconductive devices(LDR), diode photo detectors, solar cell-(open circuit voltage and short circuit current, fill factor). LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), diode lasers (conditions for population inversion, in active region, light confinement factor. Optical gain and threshold current for lasing, Fabry-Perrot Cavity Length for lasing and the Separation.

**UNIT II**

Memory Devices: Static and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile – NMOS, magnetic, optical and ferroelectric memories, charge coupled devices(CCD).

Other Electronic Devices: Electro-Optic, Magneto-Optic and Acousto-Optic Effects. Material Properties related to get these effect. Important Ferro electric, Liquid Crystal and polymeric materials for these devices. Piezoelectric, Electro strictive and magneto strictive Effects, Important materials exhibiting these properties, and their applications in sensors and actuator devices. Acoustic Delay lines, piezoelectric resonators and filters. High frequency piezoelectric devices-Surface Acoustic wave Devices.

**Text and Reference Books**

Semiconductor Devices – Physics and Technology, by SM Sze Willey

Introduction to semiconductor devices, M.S. Tyagi, John wiley

Measurement, Instrumentations and Experimental Design in Physics and Engineering by

M.Sayer and A.Mansingh, PHI Optical electronics by Ajoy Ghatak and K.Thyagarajan.

Cambridge

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**M.Sc. Physics (III Semester)**

**Paper IVC : INFORMATICS (Internetworking Technology) PHY34C**

UNIT I

Introduction to Unix/Linux and shell scripting.

Object orientation concepts: classes, objects, methods and messages, encapsulation and inheritance, interface and implementation, reuse and extension of classes, inheritance and polymorphism; analysis and design; Notations for object-oriented analysis and design; Case studies and applications using some object oriented programming languages.

UNIT II

Introduction to web enabling technologies and authoring tools/languages (webcasting, database integration, CGI, perl, Java, HTML, C#, etc.)

Text and Reference Books

Bahrami A., Object Oriented Systems Development using the Unified Modeling Language, McGraw Hill International Edition, 1999.

Booch, G., Object-Oriented Analysis and Design with applications, Addison-Wesley, 2<sup>nd</sup> Edition, 1994.

Jesse Liberty, Beginning Object Oriented Analysis & Design Using C ++, Wrox Press, 1998 .

Timothy Budd, an Introduction to Object Oriented Programming, 2<sup>nd</sup> Ed., Addison Wesley, 1997.

NOTE: Question paper contains five questions. Two questions have to be set from Unit I and two questions from Unit II. The fifth question is a short answer question covering the two units.



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SEMESTER : 4

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**M.Sc. Physics (IV Semester)**

**PHY41**

**Paper I Electromagnetic theory and Modern optics**

**Unit-I**

Lasers: Introduction – directionality- brightness- monochromaticity- coherence – relation between the coherence of the field and the size of the source – absorption and emission processes - the Einstein coefficients - amplification in a medium- laser pumping Boltzman's principle and the population of energy levels – attainment of population inversion - two level – three level and four level pumping . Optical feedback: the optical resonator laser power and threshold condition confinement of beam within the resonator – stability condition.

Laser output: Absorption and emission - shape and width of broadening lines – line broadening mechanisms – natural, collision and Doppler broadening.

Types of Lasers: Ruby laser, He-Ne Laser, CO<sub>2</sub> laser, Semiconductor GaAs laser, Liquid and Dye lasers- Industrial, medical and other applications of lasers.

**Unit-II**

Holography : Introduction – Principle of holography - Basic theory- characteristics of holograms – hologram recording materials- film resolution - source coherence and stability - types of holograms( quantitative treatment only) .Applications of Holography - 1. Interferometry 2. Optical elements and 3. Optical memories.

Fiber Optics : Introduction – total internal refraction –optical fiber modes and configurations- fiber types – rays and modes- Step index fiber structures – ray optics representation – wave representation – Mode theory for circular wave guides- wave guide equations – wave equations for step indexed fibers – modal equation – modes in step indexed fibers – power flow in step indexed fibers .

Graded indexed fiber structure : Structure – Numerical aperture and modes in graded index fibers- Signal degradation in optical fibers – attenuation – losses – absorptive scattering – and radiative – core cladding – Signal distortion in optical wave guides – Information capacity determination – Group delay – Material dispersion – wave guide dispersion – inter modal dispersion – pulse broadening .

Fabrication of optical fibers: Different types of fabrication process of optical fibers, Mechanical properties of optical fibers, cabling of optical fibers.

(Optical fiber communication by G.Keiser)

TEXT and REFERENCE BOOKS :

- 1 Introduction to lasers and their applications D.C.Oshea, W.R.Gallen and T.Rhodes
- 2 Lasers and Non-linear optics B.B.Laud
- 3 Optical fiber communication by G.Keiser

NOTE: Question paper contains FIVE questions of equal maks. A candidate has to answer ALL. Fifth question contains four short notes question and the candidate has to answer any TWO

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## M.Sc Physics IV Semester

SEMESTER : 4

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### **M.Sc. Physics (IV Semester)**

#### **IV- Semester, Paper – II ADVANCED QUANTUM MECHANICS. PHY 42**

##### **Unit - I**

1. Relativistic quantum mechanics:

Klein –Gordon equation – Continuity equation (probability and Current density) - Klein –Gordon equation in presence of electromagnetic field – Dirac equation (for a free particle) - probability and Current density – constants of motion - Dirac equation in presence of electromagnetic fields - Hydrogen atom – Covariant notation – Covariance of Dirac equation - Invariance of Dirac equation under Lorentz transformation – Pure rotation and Lorentz transformation. Charge conjugation – Hole theory and Charge conjugation – projection Operators for energy and spin - bilinear covariant – Dirac equation for Zero mass and spin  $\frac{1}{2}$  particles.

(Kakani and Chandalia, chap – 15)

##### **Unit - II**

2. Field Quantization:

Introduction for quantization of fields – Concept of field Hamiltonian formulation of classical field – real scalar field Schrodinger field – Dirac field – Maxwell's field – Quantum equation of the field – quantization of real scalar field and second quantization – Quantization of complex scalar field – Quantization of Schrodinger field - quantization of Dirac field.

The Hamiltonian in the radiation field – The interaction term in the semi classical theory of radiation – quantization of radiation field . (Kakani and Chandalia, V chap 15,16 and 17)

##### **TEXT BOOKS:**

1. Quantum Mechanics – E.M.Merzbacher, John Wiley & Sons,
2. Advanced Quantum Mechanics – J.J.Sakurai Benjamin & co.
3. Quantum Mechanics by L.I. Schiff (Mc Graw-Hill)

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**M.Sc. Physics (IV Semester)**

**Paper - II RESONANCE SPECTRO SCOPY**

**PHY4.2AA**

### UNIT I

NMR Theory, Basic Principles, Nuclear spin and Magnetic moment, Relaxation mechanism, spin lattice and spin-spin relaxation( $T_1$ ) times by pulse methods, Bloch's equations and solutions of Bloch's equations – Experimental methods, CW NMR Spectrometer.

Electron Spin Resonance – The ESR spectrometer, experimental methods, thermal equilibrium and Relaxation methods, characteristics of  $g$  and  $A$  values, Unpaired electron, fine structure and Hyperfine structure.

### UNIT II

Nuclear quadrupole resonance (NQR) spectroscopy, The fundamental requirements of NQR spectroscopy, General principles, Integral spins and Half Integral Spin., experimental detection of NQR frequencies, block diagram of NQR spectrometer, Experimental methods of SR oscillator, CW oscillator, pulse methods.

Mossbauer spectroscopy: The Mossbauer Effect, Recoil less Emission and Absorption, The Mossbauer spectrometer, Experimental Methods, Chemical shift, Magnetic Hyperfine interactions.

Photo Electron Spectroscopy, its theory, instrumentation and Applications.

### Books of References

1. Nuclear Magnetic Resonance By E R Andrew, Cambridge University Press 1955
2. Spectroscopy by B.P. Stranghon and S.Walker Volume 1 John Wiley and Sons Inc., New York, 1976
3. Pulse and Fourier transform NMR by TC farrar and ED Becker, Academic Press 1971
4. Mossbauer Spectroscopy – M.B. Bhide.

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**M.Sc. Physics (IV Semester)**

**Paper – II : PHYSICS OF ELECTRONIC DEVICES & FABRICATION OF**

**INTEGRATED CIRCUITS AND SYSTEMS  
42BA**

**PHY**

### UNIT I

Semiconductor Materials:

Energy Bands, Intrinsic carrier concentration. Donors and Acceptors, direct and Indirect band semiconductors. Degenerate and compensated semiconductors. Elemental (Si) and compound semiconductors (GaAs). Replacement of group III element and group V elements to get tertiary alloys such as  $Al_x Ga_{(1-x)} As$  or  $GaP_y As_{(1-y)}$  and quaternary  $In_x Ga_{(1-x)} P_y As_{(1-y)}$  alloys and their important properties such as band gap and refractive index changes with x and y. Doping of Si (Group III (n) and Group V (p) compounds) and GaAs (group II (p), IV (n-p) and VI (n compounds). Diffusion of Impurities- thermal Diffusion, Constant Surface concentration, constant Total Dopant Diffusion, Ion Implantation.

Carrier Transport in Semiconductors:

Carrier Drift under low and high fields in (Si and GaAs), saturation of drift velocity. High field effects in two valley semiconductors. Carrier Diffusion, Carrier Injection, Generation Recombination Processes-Direct, Indirect band gap semiconductors.

Minority Carrier Life Time, Drift and Diffusion of Minority Carriers ( Haynes - Shockley Experiment) Determination of: Conductivity (a) four probe and (b) Van der Paw techniques. Hall coefficient, Minority Carrier Life Time. Junction Devices: (I) p-n junction- energy Band diagrams for homo and hetero junctions. Current flow mechanism in p-n junction, effect of indirect and surface recombination currents on the forward biased diffusion current, p-n junction diodes-rectifiers (high frequency limit), (ii) Metal-semiconductor (Schottky Junction): Energy band diagram, current flow mechanisms in forward and reverse bias, effect of interface states. Applications of Schottky diodes, (iii) Metal-Oxide-Semiconductor (MOS) diodes. Energy band diagram, depletion and inversion layer. High and low frequency Capacitance Voltage (C-V) characteristics. Smearing of C-V curve, flat band shift. Applications of MOS diode.

### UNIT II

#### OVER VIEW AND BASIC PRINCIPLE OF THE FOLLOWING

Static Memory Devices and dynamic random access memories SRAM and DRAM, CMOS and NMOS, non-volatile-NMOS, magnetic, optical and ferro electric memories, charge coupled devices (CCD).

#### Fabrication of Integrated Devices

Thin film Deposition Techniques: Vacuum Pumps and gauges – pumping speed, throughput. Effective conductance control. Chemical Vapor Deposition (CVD), MOCVD, PEMOCVD (Plasma enhanced chemical vapour deposition). Physical Vapor Deposition: Thermal Evaporation, Molecular Beam Epitaxy(MBE), Sputtering and Laser Ablation. Lithography, Etching and Micro-machining of silicon, Fabrication of Integrated Circuits and Integrated Micro-Electro-Mechanical-Systems (MEMS)

### Text and Reference Books

The Physics of Semiconductor Devices by D.A.Eraser, Oxford Physics Series (1986)

Semiconductor Devices – Physics and Technology by S M Sze Wiley (1985)

Introduction to Semiconductor Devices, M.S.Tyagi, John

Wiley & Sons

Measurement, Instrumentation and Experimental Design in Physics and Engineering by

M.Sayer and A.Man Singh, Prentice Hall, India(2000)

Thin Film Phenomena by K.L.Chopra

The Material Science of Thin Films by Milton S.Ohring

Optical Electronics by Ajoy Ghatak and K.Thyagarajan. Cambridge Univ.Press

Material Science for engineers, by James F. Shackelford, Prentice Hall

Deposition techniques for films and coatings, R.F.Bunshah ( Noyes Publications)

Solidstate Electronics : Ben G. Streetman

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### **M.Sc Physics IV Semester**

#### **Paper II DIGITAL SIGNAL PROCESSING PHY42BB & PHY42CB**

##### UNIT I

Discrete – time signals and systems: Discrete- time signals- sequences –linear shift- invariant systems – stability and causality -

Frequency domain representation of discrete-time signals- Some symmetry properties of the Fourier Transforms.

Z-transform - Inverse Z-transform – Two dimensional Z-transform.

The Discrete Fourier transform (DFT) and its properties . Linear convolution using Discrete Fourier transform. Two dimensional discrete Fourier Transform.

##### UNIT II

Signal flow graph representation of digital networks - Matrix representation of digital networks - Basic network structures of IIR systems – Basic network structures for FIR systems. Tellegaen's theorem for digital filters and its applications.

Digital filter design techniques : Design of IIR digital filters from Analog filters - Design examples - Properties of FIR digital filters. Design of FIR filters using Windows - A comparison of IIR and FIR filters.

Computation of the Discrete Fourier transform:

Decimation- in – time FFT algorithms. Decimation-in-frequency FFT. algorithms.

Text and Reference Books :

1. Digital Signal Processing by Alan V. Oppenheim and Ronald W.Schafer ( PHI )
2. Introduction to Digital Signal Processing by Johnny R.Johnson ( PHI)
3. Digital Signal Processing by John G,Proakis, Dimitris G.Manolakis(PHI)
4. Digital Signal Processing by P.Ramesh Babu ( Scitech )

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**M.Sc. Physics (IV Semester)**

**Paper II : Informatics ( Materials and Data communication)**

**PHY42CA**

UNIT I

Semiconductor Quantum structures, Heterostructures, Mismatch Hetero structures, coherently strained structures, Partially relaxed strained layer structures, Methods of formation of heterostructures some of the examples of heterostructures , Band gap engineering, strained layer Epitaxy, light emitting diodes, etched well surface emitting LED, continuous operation lasers hertero quantum lasers, CW hetero quantum laser , stripe geometry.

Fourier series and transforms and their applications to data communication.

Introduction to probability and random variables, Introduction to information theory and Queuing theory.

UNIT II

Introduction and evolution of telecommunication, fundamentals of electronic communication: wired, wireless ,satellite and optical Fibre, analog/digital, Serial/parallel, Simplex/half and full duplex, Synchronous/Asynchronous, Bit/baud rates, parity and error control (CRC, LRC, ARQ, etc.),signal to noise ratio, etc.

Transmission types, codes, modes, speed and throughput, modulation types, techniques and standards. Base band and carrier communication, Detection, Interference, Noise signals and their characterization, Phase Locked Loops..

Modems, transmission media (guided & unguided), common interface standards.

**Text and Reference Books:**

Data Communication by Reid and Bartskor

Data Networks by Bertsekas and Gallager (PHI)

Data Communication by William Stalling (PHI)

Communication Networks by Lffleon-Gdadrscia and Widjajka

Introduction to Communication Systems by Haykins

Analog and Digital Communication by S.Haykins

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## SEMESTER : 4

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### M.Sc. Physics (IV Semester)

#### PAPER IIIB : ELECTRONICS II

PHY43B

#### UNIT I

##### Analog and Digital Systems

Analog computation, active filters, comparators, logarithmic and anti-logarithmic amplifiers, sample and hold amplifiers, waveform generators. Square and triangular wave generators, pulse generator.

Read-only Memory (ROM) and applications. Random Access Memory (RAM) and applications.

Digital to-analog converters, ladder and weighted resistor types Analog to digital converters – counter type, successive approximation and dual slope converters, Applications of DACs and ADCs.

##### Optoelectronics

Photodetectors: Photo detectors with external photo effect, photo detectors with internal photo effect, photo conductors and photo resistors, junction photo detectors.

Circuits with Light Emitting Diodes, diode tester. Polarity and voltage tester, measuring instruments with LED indication.

LED, Numeric and alphanumeric display units. Semiconductor switches and potential isolation, the phototransistor as a switch in the optocouplers, steady state performance, dynamic performance, use of opto couplers.

##### Microwave Devices

Klystrons, Magnetrons and Travelling Wave Tubes, Velocity modulation, Basic principles of two cavity Klystrons and Reflex Klystrons, principles of operation of magnetrons. Helix Travelling wave Tubes, Wave Modes.

Effect, Principles of operation. Modes of Operation, Read diode, IMPATT diode Transferred electron devices, Gunn, TRAPATT Diode.

#### UNIT II

##### Microwave Communications

Advantage and disadvantages of microwave transmission, loss in free space, propagation of microwaves, atmospheric effects on propagation, Fresnel zone problem, ground reflection, fading sources, detectors, components, antennas used in MW communication systems.

##### Radar Systems

Radar block diagram an operation. Radar frequencies, pulse considerations. Radar range equation, derivation of radar range equation, minimum detectable signal, receiver noise, signal to noise ratio. Integration of radar pulses. Radar cross section. Pulse repetition frequency. Antenna parameters, system Losses and Propagation losses. Radar transmitters, receivers. Antennas Displays.

##### Satellite communications

Satellite communications : Orbital satellites, geo stationary satellites, orbital patterns, look angles, orbital spacing, satellite systems. Link modules.

#### Text and Reference Books

“Microelectronics” by Jacob Millman, Mc Graw-hill International Book Co., New Delhi, 1990

“Optoelectronics, Theory and Practice”, Edited by Aslien Chappal. Mc Graw Hill Book Co., New York.

“Microwaves” by K.L.Gupta, Wiley Eastern Ltd., New Delhi, 1983

“Advanced Electronics Communications systems” by Wayne Tomasi., PHI.Edn.

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**M.Sc. Physics (IV Semester)**

**Paper III C**

**INFORMATICS**

**PHY 43 C**

**UNIT I**

Multiplexing (FDM, TDM), Switching paradigms (circuit, packet and cell switching), Propagation Delay, Clock synchronization. Network access control (centralized, decentralized, distributed). Overview of satellite Communication, Broadcast Channel and Optical Fiber communication systems. Power and Energy spectra, Distortion less Transmission, Signal distortion over a Channel.

**UNIT II**

Bandwidth and Rate of Transmission, Communication in Noisy channels, Optimum signal Detection, Channel capacity, Hartley Shannon Law, error correcting Codes. Error control, Line control, Rate control, Repeaters, Concentrators, Regenerators. Link behavior, burst error, Optimum picket size, error control, Elementary coding ideas, ATM as a transport mechanism, An overview of Telecom Network, ISDN.

**Text and Reference Books**

1. Data communication by Reid and Bartskor
2. Data Networks by Gallager
3. Data Communication by William Stalling
4. Communication networks by Leon-Garcia and Widjaja
5. Introduction to communication systems by S.Haykins
6. Analog and Digital Communication by S.Haykins.

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### M.Sc. Physics (IV Semester)

PAPER IV B :

ELECTRONICS III

PHY 44B

#### UNIT I

##### Digital Communications

Pulse-Modulation systems : sampling theorem-Low-Pass and Band-pass signals, PAM, Channel BW for a PAM signal. Natural sampling. Flat-top sampling. Signal recovery through Holding. Quantization of signals, Quantization, Differential PCM, Delta Modulation, Adaptive Delta modulation, CVSD.

Digital Modulation Techniques : BPSK, DPSK, QPSK, PSK, QASK, BFSK,FSK,MSK.

Mathematical Representations of Noise : sources of noise. Frequency domain representation of noise, Effect of filtering on the probability Density of Gaussian noise, spectral component of noise, Effect of a filter on the power spectral density of noise. Superposition of noises. Mixing involving noise. Linear filtering, Noise Bandwidth, quadrature Components of noise. Power spectral density of  $n_c(t)$ ,  $n_s(t)$  and their time derivatives.

Data Transmission: base band signal receiver, probability of error. Quantum filter. White noise. Matched filter and probability of error.

#### UNIT II

Coherent reception, Correlation, PSK, FSK, Non-coherent detection of FSK, Differential PSK QPSK, calculation of error probability for BPSK, BFSK and QPSK.

Noise in pulse-code and Delta-modulation systems: PCM transmission, Calculation of quantization noise, output-signal power. Effect of thermal noise, output signal-to-noise ratio in PCM, DM, quantization noise in DM, output signal power, DM output – signal – to quantization - noise ratio. Effect of thermal noise in Delta modulation, output signal-to-noise ratio in DM.

Computer Communication Systems: Types of networks, Design features of a communication network, examples, TYMNET, ARPANET, ISDN, LAN. Mobile Radio and Satellites : Time Division multiple Access (TDMA), Frequency division Multiple Access (FDMA), ALOHA, Slotted ALOHA, Carrier Sense Multiple access (CSMA). Poisson distribution, protocols.

##### Text and Reference Books:

Taub and Schilling, Principles of Communication Systems, Second Edition, TMH, 1994.

Simon Haykin, communication Systems, Third Edition, John Wiley & Sons, Inc. 1994

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### M.Sc. Physics (IV Semester)

## Paper IV C : INFORMATICS III ( Networking Technology) PHY 44C

### UNIT I

Network types and architecture (broadcast, multicast, LAN, MAN, WAN topology, token ring, FDDI, Cabling). Protocols, interfaces and services, x.25, ISDN, ATM, VPN, frame relay, wireless transmission, bridges, TCP/IP and ISOOSI Models. Routing, congestion and flow control, tunnelling, internet work routing. Data link protocols, Multiple access protocols, TCP, UDP, Transport layer error recovery, application layer services and protocols. IP addressing, Network security.

Evolution of Internet, Internet architecture: goals and key issues related to Internetworking technologies; Internet connectivity (dial-up, dedicated lines, broadband, DSL, radio, VSAT, etc.); Domain Name Scheme, Technology and tools relevant for web access (FTP, email, search tools etc.). Internet security.

### UNIT II

Multimedia, techniques of data compression, voice, video, Mbone, and interactive video-on-demand over the Internet. Mobile computing.

Fundamentals of Network Management (NM), Need for NM, Elements of NM system (Manager, Agent and a protocol, SNSMP), Functional areas of NM defined by ISO Fault Management, Configuration Management, Performance Management, Security Management, Accounting Management, NM standards, TMN, Web based NM (Introduction), case studies: HP Open-View, IBM Net-view, SUN Solaris Enterprise Manager.

### Text and Reference Books :

Bohdan O Szuprowicz : Multimedia Networking, McGraw-Hill, Singapore, 1995 (ISE)

Marilee ford et al: Internetworking Technologies Handbook, Cisco Press, 1997.

Grady N, Drew: Using SET for Secure Electronic Commerce, PTR Prentice-Hall, 1988.

N.Buchanan: Advanced Data Communications and Networking, Chapman & Hall, London, 1997.

Dave Kojur: IP Multicasting: The complete Guide to Interactive Corporate Networks, John Wiley & Sons, New York, 1998.

Computer Networks by Andrew S. Tanenbaum (PHI)

Data and Computer Communications by William Stalling,( PHI)

Computer Networks by S Keshav, Addison Wesley

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**M.Sc. Physics (IV Semester)**  
**PAPER III A: CONDENSED MATTER PHYSICS**                      **PHY43A**

**UNIT I**

Classification of Materials: Types of materials, Metals, Ceramics (Sand glasses) polymers, composites, semiconductors.

Glasses : The glass transition - theories for the glass transition, Factors that determine the glass-transition temperature. Glass forming systems and ease of glass formation, preparation of glass materials.

Applications of Glasses: Introduction: Electronic applications, Electrochemical applications, optical applications, Magnetic applications.

**UNIT II**

**Dielectrics and Ferro electrics:**

Macroscopic description of the static dielectric constant , The static electronic and ionic polarizabilities of molecules , Orientational Polarization, The static dielectric constant of gases, The internal field according to Lorentz, The static dielectric constant of solids, The complex dielectric constant and dielectric losses, Dielectric losses and relaxation time, Cole-Cole diagrams. The classical theory of electronic polarization and optical absorption.

General properties of ferroelectric materials. Classification and properties of representative ferroelectrics, the dipole theory of ferroelectricity, objections against the dipole theory, Ionic displacements and the behaviour of  $\text{BaTiO}_3$  above the curie temperature, the theory of spontaneous polarization of  $\text{BaTiO}_3$  . Thermodynamics of ferroelectric transitions, Ferroelectric domains.

TEXT BOOKS:

1. Introduction to Materials science for Engineers by James F.Shackelford (Macmillan)
2. Physics of Amorphous Materials by S.R.Elliot (Longman Scientific)
3. Solid State Physics by A.J.Dekker (Macmillan)

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**M.Sc. Physics (IV Semester)**

**Paper IV : Condensed Matter Physics**

**PHY 44A**

#### UNIT I

Lattice Dynamics and Optical properties of Solids Inter atomic forces and lattice dynamics of simple metals, ionic and covalent crystals. Optical phonons and dielectric constants. Inelastic neutron scattering. Mossbauer effect. Debye-Waller factor. Anharmonicity, thermal expansion and thermal conductivity. Interaction of electrons and phonons with photons., Direct and indirect transitions.

Crystal growth techniques: Bridgeman-Czochralski-liquid encapsulated czochralski(LEC) growth technique-zone refining and floating zone growth-chemical vapour deposition (CVD)-Molecular beam epitaxy(MOVPE)-vapour phase epitaxy-hydrothermal growth-Growth from melt solutions-Flame fusion method.

#### UNIT II

Absorption in insulators, Polaritons, One – phonon absorption, optical properties of metals, skin effect and anomalous skin effect. Interaction of electrons with acoustic and optical phonons, polarons.

Superconductivity: The Meissner effect -- Isotope effect- specific heat-thermal conductivity and manifestation of energy gap. Quantum tunnelling-Cooper pairing due to phonons, BCS theory of superconductivity, Ginzburg-Landau theory and application to Josephson effect: d-c Josephson effect, a-c Josephson effect, macroscopic quantum interference. Vortices and type I and type II superconductors, applications of superconductivity-high temperature superconductivity (elementary).

#### *Text and Reference Books*

Madelung : Introduction to Solid State Theory.

Callaway : Quantum theory of Solid State.

Huang : Theoretical Solid State Physics

Kittel : Quantum theory of Solids

Solid state Physics by Guptha Kumar and Sarma

Solid State Physics S.O.Pillai New Age International

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