BHARATHIAR UNIVERSITY, COIMBATORE - 641 046

M . Phil . / Ph .D - PHY SICS
[From October 2011 batch onwards]

PART - 1 SYLLABUS

PAPER – I - Research Methodology

PAPER - II - Advanced Physics

PAPER - III - 1. Solid state Electronics
2. Solar Energy and its Utilization
3. Molecular Physics
4. Plasma Physics
5. Thin Film Technology
6. Molecular Quantum Mechanics
7. Solid State Ionics
8. Nuclear Physics
9. Principles and Methods of Crystal Growth
10. Physics of Nonomaterials and device
11. Nonlinear Dynamics

BHARATHIAR UNIVERSITY, COIMBATORE – 641 046

PART – I M.Phil. / Ph.D. – PHYSICS

PAPER – I RESEARCH METHODOLOGY

Unit - I

Thermodynamic potentials (A,G,H) - Microstates and macrostates – Ideal gas – Microstate and macrostate in classical systems – Microstate and macrostate in quantum systems – Entropy in terms of probability density - Density of states - Microcanonical distribution function – Two level system in microcanonical ensemble - Gibbs paradox and correct formula for entropy – Linear harmonic oscillator classical and quantum treatment

Unit – II

Carrier effective masses and band structure – Semiconductor statistics; energy distribution functions, density of states function, density of carriers in intrinsic and extrinsic semiconductors, compensation in semiconductors, bandtail states – Absorption in semiconductors; matrix elements and oscillator strength for band to band transitions, indirect intrinsic transitions, exciton absorption, donor-acceptor and impurity-band absorption, low-energy absorption - Absorption in quantum well and quantum confined Stark effect

Unit III (Problems only)

Ordinary differential equations: Runge Kutta IV order method for first order differential equation – RK4 method for simultaneous first order differential equations – RK4 method for second order differential equation – Milne's Predictor – Corrector method

Partial differential equations(PDE): Difference quotients – Graphical representation of Partial quotients – Classification of PDE of the second order – Elliptic equations – Standard five point formula – Diagonal five-point formula – Solution of Laplace's equation by Liebmann's iteration

Unit – IV (Problems only)

Numerical Integration: Trapezoidal and Simpson's $1/3^{rd}$ rule for single integrals – Error estimates – Trapezoidal and Simpson's rule for double integrals, Two and Three points Gaussian quadrature –

Interpolation - Newton's divided difference formula - Cubic spline interpolation - Least squares, straight line and parabola

Eigen value: Power method – Jacobi method (Only 2 x 2 and 3 x 3 matrices)

Unit – V

Fortran programming: Fortran character set – Data classification – Operations - Intrinsic functions - Arrays and subscripted variables – List-directed and formatted Input/ Output statements – Control statements (DO, IF, GOTO structures) - Function subprogram – subroutine subprogram - File processing - Simple programs - Ascending, descending order of numbers and characters, Solving quadratic equation, Matrix manipulation, Numerical integration through Simpson's 1/3 rule, Straight line curve fitting

Books for study:

1. An Introductory Course of Statistical Mechanics - Palash B. Pal, Narosa Publishing House (2008), New Delhi
2. Semi conductor opto-electronic devices (IInd Edition) – P. Bhattacharya, Prentice Hall, 2011
3. Numerical methods – P. Kandasamy, K. Thilagavathy and K. Gunavathi, S. Chand and Company Ltd., (2007)
4. Numerical methods – E. Balagurusamy, Tata Mcgraw Hill Publishing Company Ltd,. New Delhi, (2006)
5. Computer programming in ForTran 77, V. Rajaraman, Prentice Hall, 2009

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PAPER-II Advanced Physics

Unit-I: Physical Properties of Crystals and Phase diagram

Representation of physical quantities by scalars, vectors and tensors – Tensors of second rank- Transformations of components of a second-rank tensor – Representation quadric – Simplification of equations referred to principal axes –Geometrical properties of the representation quadric – Equilibrium properties represented by second-rank tensor: Electric Polarization: relations between D, E and P in a parallel plate condenser.

Binary phase diagram – Phase transformations: Time scale for phase changes – Nucleation kinetics – Growth and the overall transformation kinetics.

Unit-II: Optical, Non-Linear and Electro-Optical Effects of Crystals

Double refraction: Optical indicatrix – Effect of crystal symmetry on optical indicatrix – Wave surface: Uniaxial and Biaxial crystals – Non-Linear Optics: Harmonic generation – Second Harmonic Generation – Phase matching – Third Harmonic Generation – Optical Mixing: Sum and difference frequencies – Parametric generation of light – Self-focusing of intense light beams – Electro-Optic Effect: Phase retardation – Langitudinal electro-optic modulators: Amplitude modulation – Phase modulation of light – Transverse electro-optic modulators – Electro-optic beam deflection.

Unit-III:Nanomaterials and their applications

Properties of metallic and semiconducting Nanoparticles – Various physical and chemical methods of preparation (qualitative) – Arc discharge – CVD – Sol-gel – Atomic layer deposition – anodizing – electroless deposition – self assembled monolayer – VLS growth (vapour phase transport) – Synthesis of carbon nanotubes – nanostructured ferromagnetism – size and dimensionality effects in nanostructures – Applications: Biosensors, cantilevers as nanobiosensors, optical nanosensors – Nanoencapsulation for targeted drug delivery – Energy devices: Battery, Fuel cells, Hydrogen production and storage.

Unit IV: Surface analysis techniques

Atomic collision and Backscattering spectrometry: - Energy loss of light ions and Backscattering Depth profiles – Sputter Depth profile and Secondary Ion Mass Spectrometry – Channeling: Basics and its application in Thin Film analysis – X-ray Photoelectron Spectroscopy – Electron Microprobe analysis of surface – SEM, TEM, AFM and STM – Nonradiative Transitions and Auger Electron Spectroscopy.

Unit-V: Spectroscopic methods

UV-Vis-Near IR, FTIR, Laser Raman, ESR and NMR spectroscopic methods- basic concepts and theirapplications – Thermal analysis of different Materials: TG/DTA and DSC.X-ray Methods: The Bragg's Law – Powder X-ray diffraction method – Particle size determination.

Books for Study:

1. 'Physical Properties of Crystals: Their Representation by Tensors and Matrices' by J.F. Nye, 1985, Oxford University Press, New York.
2. Materials Science and Engineering by V. Raghavan, Printice Hall
3. 'Lasers and Non-Linear Optics' by B.B. Laud, Chapter-13, Wiley Esatern Ltd., 1985.
4. 'Quantum Electronics', by AmnonYariv, Chepter-14, John Wiley & Sons, Inc., 1975, New York.
5. Introduction to Nanotechnology by C.P.Pool Jr. and F.J. Owens, John Wiley & Sons.
6. Introduction to Nanoscience and Technology by G.L.Hornyak, F.G. Tibbals, J. Dutta and J.J. Moore, CRC press 2010.
7. Fundamentals of surface and thin film analysis – Leonard C. Feldman and James W. Mayer.
8. Basic Principles of Spectroscopy – Raymond Chang, McGraw Hill International book company.
9. Fundamentals of Molecular Spectroscopy by Banwell.
10. Elements of X-ray diffraction (Second Edition), B.D. Cullity.

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PAPER – III 1. Solid State Electronics

UNIT- I: High Field Phenomena and Hot electron effect

High field drift velocity of carrier – The electron transfer effect – Impact ionization and carrier multiplication Phenomena – Analysis of Junction break down – Hot electron effect in MOSFET – Analysis of velocity saturation by transport equations - electron transfer and velocity field characteristics in two valley semiconductors .

UNIT-II : Micro controllers

8051 Micro controller hardware – input / Output pins, ports and circuits – external memory – counter and timers - serial date Input and Output - Interrupts – A Generic Computer - The mechanics of Programming - The PAL practice CPU - Programming tools and techniques - Programming the 8051.

UNIT-III

Moving data - addressing modes - External data moves - code memory Read only data moves - push and pop codes - Data exchanges - The jump and call program range - Jumps - calls and sub routines Interrupts and returns - 8051 Micro controller design - Testing the design - Timing sub routines - serial data transmissions.

UNIT- IV: Combinational Circuits

Multiplexers (Data selectors) - Application of multiplexer - De multiplexers - Decoders - Liquid crystal display - Encoders - priority encoder - parity generators – code conterters - magnitude comparator - application of comparators.

UNIT-V: Opto Electronics

Optical communication system ; Modulation scheme – Analog modulation – Digital modulation – Free space communications- Fiber Optical communication systems -
Operating wave length Emitter design - Detector design - fiber choice - system design considerations - Local area networks - Integrated optics - optical fiber sensoss.

BOOKS OF STUDY AND REFERENCE

1. Fundamentals of semiconductor theory and device Physics - chapter 10 - Shyhwang Prentice – Hall International Editions - 1989 - Page 462-509 .
2. The 8051 Micro controller architecture, Programming and application - Kenneth j . Ayalar – Penram International - 1996 . Unit 1 ; Chapters – 3,4 Unit 2 chapters – 5,8,9.
3. Digital circuits and design – S. Arivazhagan - Vikas Publishing house - 1999 chapter – 6.
4. Opto Electronics and Introduction – j . Wilson J . F.E. Hawkes – Prentice Hall – 2001 , chapters 9,10 .

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PAPER-III 2. Solar Energy and its Utilization

UNIT 1 ; Radiation Geomentry:
Basis earth sun angles - Determination of Solar time - Derived Solar angles - Day length - Solar Radiation measurements - selective surfaces - Heat balance energy lost by radiation , convection and conduction - Physical characteristics of selectives surface -
Anti reflection coatings - Solar reflector materials - production methods of coatings.

UNIT II: Fundamentals of Heat Transfer:
Transfer of Heat by Conduction: Study heat flow in a slab-steady heat flow in a cylindrical shell-Heat transfer through fins – Transient heat conduction.
Thermal Radiation: Basic laws of radiation – Radiant heat transfer between two black bodies-Radiant heat transfer between grey bodies.
Convention heat loss Evaluation of convective heat transfer co-efficient –Free convection from vertical planes and cylinders – Forced convection – Heat transfer for fully established flow in tubes.

UNIT-III: Solar Thermal systems:
General description of plate collector – thermal losses and efficienty of FPC –Energy balance equation – Evaluation of overall loss coefficient – Thermal analysis of flat plate collector and useful heat gained by the fluid performance of solar air heaters – Heating and drying of agricultural products Types of drier in use.
Solar concentrators and Receiver geometries – General characteristics of focusing collector systems Evaluation of optical losses – Thermal performance of focusing collectors.

UNIT-IV: Photovoltaics:
Description of the photovoltaic effect – Electrical characteristics calibration and efficienc measurement – silicon solar energy converters – Thermal generation of recombination centers silicon.
Role of thin films in solar cells Properties of thin films for solar ells CdSe, Cete, In P, Ga As, Cd C_{u2}, Cu In SnO_2, Cd_2SnO_4 ZnO)- Transport properties of metal films – poly crystalline film silicon solar cells (Photovoltaic characteristics, junction analysis loss mechanisms) Amorpho silicon solar cells (Structural compositional optical and electrical properties)

Unit- V: Energy storage and solar applications:
Types of energy storage Thermal storage Latent heat storage – Electrical storage Principle of operation of solar ponds-Non convective solar ponds – Theortical analysis of solar pond – so distillation – solar cooking –solar pumping.

Books of Study and Reference:

1. Solar energy utilization GD. Raj. 1996
2. Treatise on solar energy volume I fundamentals of Solar Energy –H.P. Garg.1982
3. Thermal performances testing of FPC and CPC –GD Raj
4. Solar cells – Charles E. Backus IEEE Press (1976)
5. Thin film solar cells Kasturi Lal chopra and suhit Ranjan Das, (1983)
6. Solar energy Utilization G.D Raj (1996)

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Paper – III 3. Molecular Physics

UNIT I

Symmetry operation – symmetry elements – Different type of symmetry operations – symmetry point groups – Linear and non linear molecules – Representations of groups - Irreducible Representations – Character tables

UNIT II

General principles – the LACO approximation – Bonding character of orbitals - symmetry factoring of secular equations – Transformation properties of Atomic orbitals – Hybridization schemes of orbitals - Hybrid orbitals as linear combinations of Atomic orbitals – Molecular orbital theory homonuclear diatomic molecules

UNIT III

Hartree-Fock equation – The method of self consistent filed – Hydrogen ion – Hydrogen molecule – covalent bond – Heitler–London theory – The Hartree-Fock method for molecules – SCF wave functions for diatomic molecules – MO treatment of heteronuclear diatomic molecules – The valence electron approximation

UNIT IV

Huckel MO method – Extended Huckel method – The formulation of CNDO, INDO, MNDO, AM1 and PM3 methods - Potential energy (force field) in molecular mechanics – Various energy terms in force field – Newtonian and Hamiltonian dynamics – Phase space trajectories – Classification of dynamical systems – Determination of properties

UNIT V

INFRA-RED SPECTROSCOPY: The vibrating diatomic molecule - The diatomic vibrating rotator - Breakdown of the Born Oppenheimer approximation - The vibration of polyatomic molecules - The influence of rotation on the spectra of polyatomic molecules

RAMAN SPECTROSCOPY: Introduction - Pure rotational Raman spectra - Vibrational Raman spectra - Polarization of light and the Raman effect - Structure determination from Raman and infra-red spectroscopy

Books for study and References

1. Chemical applications of group theory – F .A . Cotton, Wiley Inter science.
2. Quantum Chemistry – Ira. N. Levine, Vth Edition; Prentice-Hall of India, New Delhi, 2000
2. Ab initio molecular orbital theory – W. J. Hehre, L. Radom, P. V. R. Schleyer and J. A. Pople; John Wiley & Sons, New York, 1985.
3. Molecular dynamics simulation – Elementary methods - J.M. Halie, John Wiley & sons, Inc., 1997
4. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash. Fourth edition, Tata McGraw-Hill Publishing Company Ltd, New Delhi, 2007

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PAPER III - 4. Plasma Physics

UNIT I

Plasma state – charaterisation : Occurance of Plasma in nature – Definition of Plasma – concept of temperature – Debye Shielding – The Plasma parameters – Criteria for Plasma – Applications of Plasma physics (basis ideas) single – Particle motions ; uniforms E and B fields – Gravitational field – Non uniform B fields – Gravitational field – Non – uniform B field – Curve B - magnetic mirrors non Uniform E filed Time – varying B field – Adiabatic Invariants

UNIT II

Plasma as fluids ; the equation of motion – Fluid drifts perpendicular to B fluid drifts parallel to B – The plasma approximation , Equilibrium and stability : Hydromagnetic Equilibrium – The concept of diffusion of Magnetic filed into a plasma classification of instabilities – Two stream Instability – The gravitational instability - Resistive Drift waves – The weibel instability .

UNIT III

Waves in plasma : Representation of waves – Group velocity – plasma Oscillations – Electron Plasma waves – sound waves – Ton waves – Validity of plasma approximation – comparision of ion and Electron waves – Electromagnetic waves with Bo = O – Experimental applications – Electro magnetic waves perpendicular to Bo Experimental consequences – Hydromagnetic waves – Magnetosonic waves Summary of Elementary plasma waves – The CMA Diagram .

UNIT IV : Kinetic Theory

The meaning of f (v) Equations by Kinetic theory – Derivations of the fluid equation – plasma Oscillations and Landau damping – The meaning of landay Damping – Aphysica derivation of Landu Damping – BGK and van Kampen modes – Experimental verification – Kinetic effects in a Magnetic field .

UNIT V : Plasma Diagnostics

Electrical methods : Langmuir profits spectroscopic methods – Line spectrum of a plasma – low density plasma – high density plasma ionization state of a plasma – particle methods : Beam of charged particle to measure electric field in a plasma – measurement of the density of natural particles and charged particles .

Books for study and reference:

1 . Frencies F chen : introduction to plasma and controlled Fusion vol . plasma physics (plenum press)
2 . I M podgomyl : Topics in plasma diagnostics (plenum press)
3 . Nocholas A Krail and Alvin W Trivelpiece – Principles of plasma physics (McGraw Hill kogkusha Ltd .
4 . Richard H Huddlestone and stanely Leonard – plasma Diagnostic Techniques (Academic Press)

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PAPER III - 5. Thin Film Technology

UNIT I : Preparation of Thin Films

Spray pyrolytic process – characteristic feature of the spray pyrolytic process – ion plating – Vacuum evaporation – Evaporation theory – The construction and use of vapour sources – sputtering Methods of sputtering – Reactive sputtering – RF sputtering - DC planar m magnetron sputtering .

UNIT II : (Thickness measurement and Nucleation and Growth in Thin Film)

Thickness measurement : electrical methods – optical interference methods – multiple beam interferometry – Fizeau – FECO methods – Quartz crystal thickness monitor .

Theories of thin film nucleation – Four stages of film growth incorporation of defects during growth .

UNIT III : Electrical properties of metallic thin films

Sources of resistivity in metallic conductors – sheet resistance - Temperature coefficient of resistance (TCR) – influence of thickness on resistivity – Hall effect and magneto resistance – Annealing – Agglometation and oxidation .

UNIT IV : Transport properties of semiconducting and insulating Films

Semiconducting films ; Theoretical considerations - Experimental results – Photoconduction – Field effect thin films – transistors, Insulation films Dielectric properties – dielectric losses – Ohmic contracts – Metal – Insulator and Metal – metal contacts – DC and AC conduction mechanism

UNIT V : Optical properties of thin films and thin films solar cells

Thin films optics –Theory – Optical constants of thin films – Experimental techniques – Multilayer optical system – interference filers – Antireflection coating ,Thin films solar cells : Role, Progress , and production of thin solar cells – Photovoltaic parameter, Thin film silicon (Poly crystalline) solar cells : current status of bulk silicon solar cells – Fabrication technology – Photo voltaic performance : Emerging solar cells : GaAs and CulnSe .

Books for study and reference

1 . Hand book of Thin films Technology : L I Maissel and R Clang .
2 . Thin film Phenomena : K L Chopra .
3 . physics of thin films, vol. 12 , Ed George Hass and others .
4 . Thin films solar cells – K L Chopra and S R Das .
5 . Thin films processes – J L vilsan
6 . vacuum deposition of thin films – L Holland .
7 . The use of thin films in physical investigation – J C Anderson .
8 . Thin films technology – Berry, Koil and Harris

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PAPER – III - 6. MOLECULAR QUANTUM MECHANICS

Unit I: Many-Electron systems

The Hartree-Fock self consistent field method - Electron correlation - The atomic Hamiltonian- The Condon-Slater rules - The Born-Oppenheimer approximation - The Hydrogen molecule ion - Approximate treatments of H_2^+ ground electronic state - Molecular orbitals for H_2^+ excited states - Molecular orbital configurations of homonuclear diatomic molecules - The hydrogen molecule – The valence bond treatment of H_2 – Electron probability density

Unit II: Electron correlated methods

The Hartree-Fock method for molecules – MO treatment of heteronuclear diatomic molecules - Rayleigh-Schrödinger many body perturbation theory – Configuration interaction (CI) wave functions; multiconfiguration SCF (MCSCF), complete active space SCF (CASSCF), multireference CI (MRCI) – Coupled cluster methods - Basis functions

Unit III: Molecular properties, semi-empirical and molecular mechanics methods

Population analysis – Dipole moment – Molecular geometry and conformations – Molecular vibrational frequencies and thermodynamic properties – Huckel MO method – Extended Huckel method – The formulation of CNDO, INDO, MNDO, AM1 and PM3 methods – Potential energy (force field) in molecular mechanics – Various energy terms in force field – Newtonian and Hamiltonian dynamics – Phase space trajectories – Classification of dynamical systems – Determination of properties

Unit IV: Density Functional Theory

Electron density - The original idea: The Thomas-Fermi model – The traditional Thomas-Fermi and Thomas-Fermi-Dirac models – Three theorems in Thomas Fermi theory - Thomas-Fermi-Dirac-Weizsacker model – The Hohenberg-Kohn theorems – Kohn-Sham equations – Derivation of Kohn-Sham equations – Kinetic energy functional – Local density approximation (LDA) – Density gradient and kinetic energy density corrections – Adiabatic connection methods

Unit V: TDDFT, Reactivity parameters, Plane waves and Pseudopotentials

Time-dependent Kohn-Sham equations – Reactivity parameters; chemical potential, electronegativity, chemical hardness, softness and Fukui function – Plane waves and the Brillouin zone – Bloch's theorem – Integrals in K space – Choosing K points in the Brillouin zone – Energy cutoffs – Pseudopotentials – Norm-conserving pseudopotentials – Ultrasoftpseudopotentials – Projection augmented waves

Books for study:

1. Quantum Chemistry – Ira. N. Levine, Vth Edition; Prentice-Hall of India, New Delhi, 2000

2. Ab initio molecular orbital theory – W. J. Hehre, L. Radom, P. V. R. Schleyer and J. A. Pople; John Wiley & Sons, New York, 1985.

3. Essential of Computational Chemistry - Theories and Models , IInd Edition, Christopher J. Cramer; John Wiley & Sons, England, 2004.

4. Modern quantum chemistry – Introduction to advanced electronic structure theory – Attila Szabo and Neil S. Ostlund, Dover publications INC, New York, 1996.

5. Molecular dynamics simulation – Elementary methods - J.M. Halie, John Wiley & sons, Inc., 1997

6. Density functional theory of atoms and molecules – R. G. Parr and W. Yang; Oxford University press, New York, 1989.

7. Electronic structure – Basic theory and Practical methods – Richard M. Martin, Cambridge University Press, UK, 2005

8. Density functional theory – A practical introduction – David S. Sholl, and Janice A. Steckel – John Wiley & sons, Inc., 2009

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PARER – III- 7. Solid State Ionics

UNIT – I

Crystalline solids – space lattice – the basis and crystal structure; crystal translational vectors, symmetry operation primitive lattice cell and unit cell symmetry elements, Fundamental type of lattice, atomic packing, atomic radius, lattice constants and density, crystal structure other cubic structure- type of bonding – Ionic bonding – Energy of formation of NaCl Molecules, medelung constants – potential energy of diagram of ionic molecules – calculation of repulsive exponent – Born Haber cycle characteristics of ionic bond.

UNIT - II: Transport Properties of Ionic Conductors

Ionic conductivity – Normal and super ionic conductors – Mass transport in crystals – Diffusion – Atomic diffusion theory – Experimental determination of the diffusion constant – Ionic conduction – Experimental results – for ionic conduction – The Einstein relation – Dielectric loss in ionic crystals – Electronic conduction in ionic crystals – Excess conductors – Deficit conductors. Amphoteric semiconductors.

UNIT – III

Phenomenological Models – Huberman's Theory – Ries Strassler Toom's Theory – Weleh and Diene Theory – Lattice Gas theory – Free ion model – Domain Model – Rica and Roth Theory – The Path Probability Method – The static variables – the Path variables – The path Probability – Stationary state condition – Classification of Superionic solids – Crystalline and – Amorphous – Glasses – Dispersed solid Electrolytes - polymers – Ion exchange resins – biological basis resins - Classification over conducting ion species – mode and mechanism of conduction in each case and their corresponding criteria to be superionic conductors .

UNIT - IV: Experimental Techniques and Methods

Structural characterization – XRD surface Analysis, EXAFS, IPS, and Quasi neutron scattering – Thermodynamical characterization – Differential scanning calorimetry, Differential Thermal Analysis, Thermo Gravimetric Analysis and Thermo electric power – Ion transport properties – Electrical conductivity – Two probe method – four probe method - Immittance spectroscopy – Dynamical conductivity – state conductivity – polarisation characteristic – determination of small electronic transport numbers.

UNIT – V: Electrochemical Techniques and Applications:

Fundamentals of electrochemistry, Linear Sweep Voltammetry, Cyclic Voltammetry, Chronoamperometry, Linear polarization, Electrochemical Impedance spectroscopy. Batteries: Primary and secondary batteries, Li-ion batteries, Supercapacitors: Electric double layer capacitor, Pseudocapacitor, Fuel Cells: Solid oxide Fuel cells, Direct Methanol Fuel Cells, Proton Exchange Membrane Fuel cells, Sensors: Oxygen sensors and electrochemical sensors, Electrochromic displays.

Books of Reference:

1. Superionic solid – Principles and applications (Ed . S. Chandra) North Holland 1981 .

2. Solid state ionics . (Eds. T Kudo and Fueki) VCH Publishers, Kodansha 1990 .

3. Lectures on solid state physics (Eds. G Bush and H Schade), international series on Natural Phiolosphy Vol. 79 Pergamon, press 1976 .

4. Solid Electrolytes" (Eds. S Geller) Springer Verlag New york 1977 .

5. Impedance Spectroscopy Theory, Experiment, and Applications, (Eds) Evgenij Barsoukov and J. Ross Macdonald, Wiley interscience (2005)

6. Physics of Electrolytes – Transport Processes solid Electrolytes and in Electrodes (Eds. J Hladik) Academic press, New york 1972 .

7. Fundamentals of Electrochemistry, 2nd Edition, V.S.Bagotsky, Wiley Interscience. (2006)

8. Electrochemical Methods: Fundamental and Application, Allen J.Bard Wiley and Sons Publications (2001)

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PAPER – III – Nuclear Physics

Unit – I

Mass and abundance of nuclei: Mass spectrograph – Isotope separation – Nuclear binding energy – Nuclear angular momentum and parity – Nuclear electromagnetic moments – Properties of nuclear forces – Deuteron problem (Binding energy – Spin and parity – Magnetic dipole moment – Electric quadrupole moment) - Neutron - proton scattering - Differential cross section – Scattering length – Phase shift.

Unit – II

Nuclear structure: Shell model - Evidences for shell structure – Square well, Harmonic oscillator and Woods-Saxon potential levels – Spin orbit interaction – Magnetic dipole moments – Valence nucleons – Nuclear vibrations – Nuclear rotations – Single particle states in deformed nuclei.

Unit – III

Interaction of radiation with matter: Heavy charged particles- Electrons – Electromagnetic radiation.

Detectors: Gas filled counters – Scintillation detectors – Semiconductor detectors – Energy measurements – Coincidence measurements and time resolutions in the measurements of nuclear life time.

Unit – IV

Nuclear decay: Alpha decay process - Theory of alpha emission – Angular momentum and parity in alpha decay – Alpha decay spectroscopy – Internal conversion – Lifetimes for gamma emission – Gamma-ray spectroscopy.

Nuclear fission: Characteristics of fission – Energy in fission – Fission and nuclear structure – Fission reactors.

Unit – V

Nuclear reactions: Types of nuclear reactions – Conservation laws – Energetics of nuclear reactions – Reaction cross section – Experimental techniques – Coulomb scattering – nuclear scattering – Scattering and reaction scattering cross section – Optical model – Resonance reactions – Heavy ion reactions.

Neutron Physics: Neutron sources – Absorption and moderation of neutrons – Neutron detectors – Neutron reactions and cross sections - Neutron capture - E-ΔE counter telescope – Time of flight – Magnetic analysis.

Books for study and references:

1. Introductory Nuclear Physics, Kenneth S. Krane, Wiley India Pvt. Ltd. (2008)
2. Concepts of Nuclear physics, Bernard L. Cohen, Tata McGraw Hill Edition, (2007)
3. Nuclear Physics - An Introduction, S.B. Patel, New Age International Publishers (2009)
4. Techniques for Nuclear and Particle Physics experiments, A How to Approach, W.R. Leo, Narosa Publishing house, Second revised edition (1995).

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PAPER – III - 9. Principles and Methods of Crystal Growth

Unit – I: Fundamentals of Crystal Growth

Importance of crystal growth – Classification of crystal growth methods – Basic steps: Generation, transport and adsorption of growth reactants – Nucleation: Kinds of nucleation – Classical theory of nucleation: Gibbs Thomson equations for vapour and solution – Kinetic theory of nucleation – Becker and Doring concept on nucleation rate – Energy of formation of a spherical nucleus – Statistical theory on nucleation: Equilibrium concentration of critical nuclei, Free energy of formation.

Unit – II: Theories of Crystal Growth

An introductory note to Surface energy theory, Diffusion theory and Adsorption layer theory – Concepts of Volmer theory, Bravais theory, Kossel theory and Stranski's treatment – Two-dimensional nucleation theory: Free energy of formation, Possible shapes and Rate of nucleation – Mononuclear, Polynuclear and Birth and Spread models – Modified Birth and Spread model – Crystal growth by mass transfer processes: Burton, Cabrera and Frank (BCF) bulk diffusion model, Surface diffusion growth theory.

Unit – III: Experimental Crystal Growth-Part-I: Melt Growth Techniques.

Basics of melt growth – Heat and mass transfer – Conservative growth processes: Bridgman-Stockbarger method – Czochralski pulling method – Kyropolous method – Non-conservative processes: Zone-refining – Vertical and horizontal float zone methods – Skull melting method – Vernueil flame fusion method.

Unit – IV: Experimental Crystal Growth-Part-II: Solution Growth Techniques.

Growth from low temperature solutions: Selection of solvents and solubility – Meir's solubility diagram – Saturation and supersaturation – Metastable zone width – Growth by restricted evaporation of solvent, slow cooling of solution and temperature gradient methods– Crystal growth in Gel media: Chemical reaction and solubility reduction methods – Growth from high temperature solutions: Flux growth Principles of flux method – Choice of flux – Growth by slow evaporation and slow cooling methods – Hydrothermal growth method.

Unit –V Experimental Crystal Growth-Part-III: Vapour Growth Techniques.

Basic principles – Physical VapourDoposition (PVD): Vapour phase crystallization in a closed system – Gas flow crystallization – Chemical Vapour Deposition (CVD): Advantageous and disadvantageous – Growth by chemical vapour transport reaction: Transporting agents, Sealed capsule method, Open flow systems – Temperature variation method: Stationary temperature profile, Linearly time varying temperature profile and Oscillatory temperature profile.

Books for Study and Reference

1. 'Crystal Growth Processes' by J.C. Brice, 1986, John Wiley and Sons, New York.
2. 'Crystallization' by J.W. Mullin, 2004, Elsevier Butterworth-Heinemann, London.
3. 'Crystal Growth: Principles and Progress' by A.W. Vere, 1987, Plenum Press, New York.
4. 'Crystals: Growth, Morphology and Perfection' by Ichiro Sunagawa, 2005, Cambridge University Press, Cambridge.
5. 'Crystal Growth' by B.R. Pamplin, 1975, Pergamon Press, Oxford.

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PAPER – III- 10. Physics of Nanomaterials and device

Unit – I: Physics of quantum dots
Growth of quantum dots – SK quantum dots – basics of semiconductor quantum dots – Electron photon scattering - Exciton dynamics in quantum dots – carrier relaxation in quantum dots – optical spectroscopy of single and multiple quantum dots – basics of metal quantum dots and their applications.

Unit- II: Physics of quantum wells.
Introduction – infinite deep square wells – parabolic wells –triangular wells –subband formation in low dimensional system –occupation of subbands –quantum wells in heterostructures – basics of tunneling transport – current and conductance – current in one dimension – current in two and three dimensions – basis of coherent transport

Unit – III: Growth of heterostructures
Growth of heterostructures by MBE and MOCVD method – band gap engineering – modulation doping – 2DEG formation – Strained layers and its effect – wire and dot formation – optical confinement – effective mass approximation in heterstructures – photo and electron beam lithography methods –methods in the nanoscale device fabrication

Unit – IV: Photonic devices
Metal semiconductor contacts – space charge region – schottky effect – ohmic contact – Basic microwave technology – tunnel diode – impatt diodes – transferred electron devices – quantum effect devices – light emitting diodes – basics of Solar cells – lasers and quantum well lasers

Unit – V: Transistor related devices:
Metal insulator semiconductor contacts – space charge region – capacitance at hetero interface and high frequency effect – MOSFET fundamentals and current voltage characteristics – MOSFET scaling – CMOS and BiCOMOS – MOSFET on insulators – MOS memory structures – Basics of MODFET

Books
1. The Physics of Low dimensional semiconductors by JOHN H. Davies
2. Semiconductor devices: Physics and technology by S. M. Sze
3. Optics of quantum dots an wires by S. Soloman Glenn.
4. The Physics of Semiconductors by Marius Grundmann.

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PART – I M.Phil. / Ph.D. – PHYSICS

PAPER – III- 11. Nonlinear Dynamics

UNIT – I

Linear and Nonlinear systems – Mathematical models examples – Mathematical Implications of Nonlinearity: superposition principle – Linear oscillators & Predictability – Nonlinear oscillators – Resonance and Hysteresis.

UNIT – II

Autonomous and Nonautonomous systems – Phase plane trajectories – stability, attractors & repellers, - equilibrium points and stability – limit cycle – Bifurication – Period doubling phenomenon –onset of chaos – Logistic map – Route to chaos – Lorentz systems – Sensitive dependence on initial condition – controlling of chaos.

UNIT – III

Integrability & separability – Painleve analysis – singular points – P-analysis of ordinary differential equations – symmetries – Integrals of motion – Painleve analysis of partial differential equations – Laxpair and integrable properties .

UNIT – IV

Linear wave propagation (nondispersive and dispersive) – Fourier transform and solution of intial value problem – wave packet and dispersion – Nonlinear Dispersive system – Scott Russel`s phenomenon –cnoidal waves and Korteweg-de Vries equation – Fermi Pasta Ulam phenomenon-Numerical experiments of Zabusky and Kruskal – birth of solitons.

UNIT – V

AKNS Linear eigen valve problems – standard soliton equation – Inverse scattering trnsform method – soliton solutions of KdV equation – Hirota's Direct method and 'N' soliton solutions.

Books for Study and References:

1. M. Lakshmanan and S. Rajasekar, Nonlinear Dynamics, Integrability, chaos and patterns, springer (2003)
2. M.J. Ablowitz and PA Clarkson, Solitons, Nonlinear Evolution Equations and Inverse Scattering (Cambridge University Press, Cambridge 1991)