SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

SYLLABUS EFFECTIVE FROM: 2018-19

Syllabus for M.Sc. (Physics)

Semester IV

M.Sc. Physics Semester - IV
PS04CPHY21 Nuclear & Particle Physics

Unit: I

The deuteron Problem - The ground state of deuteron - the Schrödinger wave equation and its solution, shape of ground state wave function, Normalization of deuteron wave function, radius of deuteron, Mixing of orbitals in deuteron, Magnetic moment of Deuteron, Quadrupole moment of deuteron. Nuclear Forces – charge independence, charge symmetry, Non central (Tensor) force, Exchange forces.

Single particle shell model, Explanation of nuclear data, Nordheim's rules for odd Z- odd N nuclei, islands of isomerism, Successes and failures of shell model.Collective nuclear model, Rotational motion of the nucleus, Vibration of spherical nuclei, classification of vibration of spherical nuclei.

Unit: II

Alpha Decay: Basic alpha decay processes alpha decay systematic, Geiger-Nuttall Law for Alpha Decay, Theory of alpha emission, Angular momentum and parity in alpha decay. Beta decay: Experimental information about Betaparticles, Energy released in beta decay (Q value), Continuous beta spectrum and neutrino hypothesis, Fermi theory of beta-decay, Fermi-Kurie plot, Angular momentum and parity selection rules, Experimental detection of neutrino.

Gamma decay - Electromagnetic transitions, Radiation field multipolarity, selection rules, gamma ray transition probability.

Unit: III

Interaction of heavy charged particles with matter, energy loss by electrons, Absorption curve and range, Interaction and slowing down of neutrons in matter.

Nuclear Reaction mechanism, pre-equilibrium reaction mechanism, – Compound Nucleus nuclear reaction theory, Direct interaction process in nuclear reactions, Coupled channel theory of inelastic scattering.

Nuclear Fusion, Sources of energy in stars, nucleo- synthesis processes, Controlled fusion, Lawson Criterion. Applications of Nuclear Physics: - Trace element analysis, Alpha decay application, Diagnostic and therapeutic nuclear medicine, Hadron therapy.

Unit: IV

Classification of fundamental forces, Elementary particles and their quantum numbers, Conservation laws, CPT theorem.Gellmann- Nishijima formula, Quark model, Baryons and mesons- their quark structure. Parity non-conservation in weak decays, Wu's experiment, Summary of Standard model of Particle physics

Introduction to field theory, Gauge theory,.Electro-Weak theory, Spontaneous symmetry breaking, Higgs boson, Grand Unification attempts and Early Universe.

Basic Text & Reference Books:-

- Introductory Nuclear Physics by Kenneth S Krane, John Wiley & Sons, Singapore (1988)
- Fundamentals of Nuclear Physics by J. C. Verma, R. C. Bhandari& D.R.S. Somayajulu (2005) CBS Publishers & Distributers, New Delhi.
- Fundamentals of Nuclear Physics by Jahan Singh, PragatiPrakashan, Meerut 1st ed.2012.
- Introduction to Particle Physics' by M P Khanna, Prentice Hall of India (1999) New Delhi
- An Introduction to Nuclear Physics' by W N Cottingam& Greenwood, Cambridge Univ. Press UK
- Introduction to High energy Physics' by D H Perkins, Addison Wesley
- Introduction to Elementary particles' by David Griffiths, John Wiley & Sons Singapore (1987).
- Introduction To Nuclear And Particle Physics' by R C Verma, V K Mittal S C Gupta,Prentice Hall of India (2009), New Delhi

M.Sc. Physics Semester - IV
PS04CPHY22 Advanced Experimental & Characterization Techniques

Unit: 1

Thin film deposition techniques: Radio frequency and magnetron Sputtering, CVD reaction types, PECVD, LECVD, MOCVD, HTCVD, Introduction to Epitaxy, lattice misfit, epitaxy of compound semiconductors, Applications of epitaxy : Optical communications, Light emitting semiconductor devices (e.g. GaN), Molecular beam epitaxy (MBE), Liquid Phase epitaxy (LPE), Vapour phase epitaxy (VPE), Langmuir Blodgett films, Spray method : Spray Hydrolysis, Spray pyrolysis.

Unit:2

Principles of Cryo-cooling and Thermometry: Cooling techniques, Liquifaction of gases, Closed cycle refrigerators, sample helium bath cryostats, Dilution refrigerators, Pomeranchuk cooling, adiabatic demagnetization, nuclear spin demagnetization.Primary thermometers,3He melting-curve Thermometer, Superconducting fixed-point Thermometers, Nuclear- Orientation Thermometers. Secondary Thermometers: Resistance Thermometers, Thermoelectric Elements, Magnetic Thermometers, Nuclear Spin Resonance Thermometers.

Unit: 3

Low and high resolution mass spectrometry, Chromatography-mass spectrometry, Tandem mass spectrometry, Gas chromatography, Liquid chromatography, Ion chromatography, gel permeation chromatography. Atomic absorption spectroscopy, emission spectrographic analysis, flame emission spectrometry, inductively coupled argon plasma emission spectroscopy, neutron activation analysis.

Unit: 4

SAXS and SANS (small angle X-ray and neutron scattering, spectroscopy, synchrotron X-ray sources, SEM/EPMA(scanning electron microscopy, electron probe microanalysis) Scanning Auger microscopy(AES), SIMS (Secondary ion mass spectrometry), Ultraviolet and Bremsstrahlung isochromat spectroscopy, Angular dependent X-ray photoelectron spectroscopy. Low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Electron energy loss spectroscopy (EELS), RBS (Rutherford back scattering).

Basic Text & Reference Books:-

- Handbook of thin film technology by L.I. Maissel and R. Glang (McGraw-Hill).
- The Materials Science of thin films by Milton Ohring (Academic press).
- Thin Film Phenomena by K. L. Chopra (McGraw-Hill).
- Surface Science: An Introduction By K. Oura, V.G. Lifshitz, A. A. Saranin, A. V. Zotov and M. Katayama, Springer-Verlag, 2003.
- Materials characterization and chemical analysis by John P. Sibilia.
- Preparation of thin films by Joy George

- Nanotechnology : Principles and practices : S. K. Kulkarni(Capital publishing company).
- Nanocharacterisation edited by Augus I kirkland and John L. Hutchison,
- Low Temperature Physics: Christian Enns and Siegfried Hunklinger, Springer-Berlag Berlin Heidelberg (2005).
- Matter and Methods at low Temperature (3rd edition): Frank Pobell, Springer-Verlag Berlin Heidelberg (2007).
- Experimental Techniques in Low Temperature Physics (3rd Edition): Guy K. White, Clarendon Press, Oxford (1979)

M. Sc. Physics Semester – IV

Course No. PS04EPHY21 Applied Crystallography and Bio-Physics

Unit: 1

Laue method, Rotation method, Oscillation method, Weissenberg method, Projection-Spherical, stereographic & gnomonic, Precession method, Debye Scherrer Powder method, Powder diffractometry, Measurement of integrated intensity- factors affecting the intensity of diffraction, Determination of lattice parameter: Indexing cubic and Non-cubic structure – Analytical & Graphical Method, Diffraction under non-ideal condition Accurate determination of lattice parameter for polycrystalline materials.

Unit: 2

Single crystal X-ray diffractometry, Intensity data collection from single crystal specimen, Normalized structure factor – Wilson plot, Primary & secondary extinction, systematic absences and determination of space group from intensity data. Violation of Friedel`s law, Fourier method in structure determination – estimation of relative phases. Refinement of molecular structure and interpretation of the results.

Unit: 3

Protein – Amino acids and the primary structure and secondary structure of proteins, tertiary structure, quaternary structure. Organization of nucleic acid - Primary, secondary, tertiary structure of DNA, Structure of RNA, Sequencing of nucleic acids, antigens and antibodies. Crystallization of protein – few general methods of crystallization – vapor diffusion and micro techniques.

Biological applications of delocalization in molecules, radiation damage in biological molecules, ESR studies of Myoglobin and haemoglobin molecules, electronic properties of proteins, enzyme studies, carcinogenic activity, NMR applications: biochemistry, biophysics and in medicine.

Unit: 4

Spectroscopic techniques used for studying biological molecules : Light scattering, small angle X-ray scattering, Mass Spectrometry : MALDI-TOF, Ultraviolet/visible spectroscopy, circular dichroism(CD) and optical rotatory dispersion(ORD), fluoroscence spectroscopy, Infrared spectroscopy, Raman spectroscopy.

Books:

- Elements of X-Ray diffraction – B. D. Cullity
- An introduction to X-ray Crystallography –M. M. Woolfson
- Contemporary Crystallography –M. J. Buerger
- Elementary Solid State Physics – Ali Omar
- Elements of Solid State Physics – J. P. Srivastava
- Biophysics – Vasantha Pattabhi, N. Gautham
- Bio-Physics, Principles and techniques: M. A Subramanian
- Solid State Physics by M.A.Wahab
- The Interpretation of X-ray Diffraction Photographs by N.F.M. Henry, H Liipson, W.A. Wooster.
- Basic Biophysics for biologist by M. Daniel.

Unit: 1

Nucleation, classical theory of nucleation, Gibb's – Thomson equation for vapour, melt and solution, homogeneous and heterogeneous nucleation, Crystal growth techniques – Bridgman- basic process, Crystal pulling method, Vernueil flame fusion process, float zone process, solution growth: slow cooling process at low and high temperature, growth in gels, flux growth, vapour transport.

Unit: 2

Lattice vacancies: Schottky and Frenkel, Diffusion, self diffusion in metals, color centers, Dislocations : shear strength of single crystals, slip, dislocations,Burger's vector, stress fields of dislocations, strain energy of a dislocation low angle grain boundaries,dislocation densities, dislocation multiplication and slip, Surface imperfections : grain boundary, tilt and twist boundary, stacking faults: stacking faults in fcc crystals, stacking faults in hcp crystals,strength of alloys,dislocation and crystal growth, whiskers.

Unit: 3

Dislocation observation : surface method , decoration method, electron microscopy, X-ray diffraction topography, field ion microscopy, cross-slip, velocity of dislocations, ,forces on dislocation, forces between dislocations,Intersection of dislocations,movement of dislocations containing elementary jogs, composite jogs.

Diffusion mechanisms: steady state diffusion and non-steady state diffusion, factors that influence diffusion : diffusing species and temperature, some applications of diffusion : measurement of diffusion coefficient, Carburizing and Decarburizing process in steel, random walk treatment of diffusion, Kirkendall effect, ionic conductivity.

Unit: 4

Fracture : ductile and brittle, stress concentration, fracture toughness,design using fracture mechanics,impact fracture testing, crack initiation and propagation,factors that affect fatigue life, Fatigue, cyclic stresses, the S-N curve, Creep- generalized creep behaviour, stress and temperature effects, data extrapolation method, Failure of an automobile rear axle, Hardness, Rockwell hardness tests, Brinell Hardness tests, Knoop and Vicker's microhardness tests.

Books:

- Crystal growth processes by J. C. Brice
- The Physics of engineering solids by T. S. Hutchison and D.C. Baird
- Crystal growth: Processes and Methods by P. Santana Raghavan and P. Ramasamy
- Solid State Physics by M.A. Wahab
- Materials science and Engineering an introduction by William D. Callister. Jr.
- Introduction to Solid State Physics by Charles Kittel.
- Principle of Solid State Physics by F. Levy
- Elements of Solid State physics by J.P. Srivastava
- The nature and properties of Engineering Materials by Zbigniews. D. Jasterzzebski.
- Introduction to dislocation by D. Hull
- Elementary Solid State Physics by M.A. Omar

M.Sc. Physics Semester - IV
Course No. PS04EPHY23 Signal Processing and Satellite Communication

Unit: 1 Introduction to Communication Systems and Analog Modulation

Nature of communication systems, Signals in time and frequency-domains, Need for modulation, Frequency-translation using non-linear impedance - Frequency multiplication, mixing and frequency suppression, Noise sources: external noise-atmospheric noise, extraterrestrial noise, industrial noise, internal noise-thermal agitation noise, shot noise, transit time noise, miscellaneous noise. Characterizing parameters- signal to noise ratio, noise figure.
Analog modulation: Amplitude, Frequency and Phase modulations, Spectra, Power distribution and transmission bandwidths, Single Side Band amplitude modulation.

Unit: 2 Analog Modulation, Demodulation and receivers

Principles of generating and demodulating AM – Plate and Grid modulated Class C-Amplifier, SSB – The Filter, Phase Shift & The Third Methods, and FM signals – Direct Method, Varactor diode modulator. Signal Conditioning and Recovery.
Tuned radio frequency and Superhetrodyne receiver, Choice of IF and image rejection, Automatic gain and frequency controls, Generation of composite video signals, TV transmitter and receiver.

Unit: 3 Digital, Microwave and Optical Communication Tecniques

Pulse Amplitude Modulation and sampling theorem, Pulse Code Modulation, Effects of noise and companding, Data communication systems - transmission speeds and bandwidths, Synchronisation, modems. Digital modulation and demodulation: Frequency shift keying, Phase shift keying.
Microwave repeaters, Geostationary satellites, Transponder and earth stations, Principles of multiple access systems- Frequency Division Multiplexing, Time Division Multiplexing.
Optical fibers, Single and multimode, Advantages, Optical fiber communication link.

Unit: 4 Principles of Mobile Communication

Wireless mobile communication, Transceiver, Cellular telephones-principle of operation, idea about cell structure, Principle and operation of International Mobile Equipment Identity(IMEI) number and its importance, Global System for Mobile communication(GSM)- Definition, frequency range, Advantages, limitations, Operation of Code Division Multiple Access (CDMA), advantages, limitations, comparison between GSM and CDMA ,
Books:

- Electronic Communication, D. Roody and J. Coolen Prentice Hall.
- Electronic Communication Systems, G. Kennedy, Mc-Graw Hill.
- Electronic Communication Systems, F. R. Dungan, Delmar Publishers Inc.
- Microwave Principles, H. J. Reich, J. G. Skalnik, P. F. Ordung and H. L. Krauss, East-West Press
- Modern Microwave Technology, V. F. Velley, Prentice Hall.

M. Sc. Physics Semester - IV
Course No. PS04EPHY24 Advanced Solid State Electronic Devices

Unit: 1 Heterojunction Bipolar Transistors

BJT design limitations: Need for band tailoring & its methods, Hetrojunction bipolar transistor - Si based HBTs, GaAs/AlGaAs HBTs, InGaAs/InAlAs and InGaAs/InP HBTs, JFET, MESFET : I-V characteristics in active and saturation regimes. Effects in real devices- Velocity field relations, Channel length modulation,

Unit: 2 Advanced Field Effect Devices

Heterojunction FETs-Key motivations.Charge control model for MODFET, Current control in MODFET: Active and saturation regions, High frequency, high speed issues - Small signal characteristics, Equivalent circuit, Large signal analog applications and requirements of semiconductor parameters. Charge coupled devices, Advanced MOS devices-HMOS and SIMOX.

Unit: 3 MOSFET

Metal Oxide Semiconductor capacitor, Accumulation, Depletion and Inversion regions, Capacitance-Voltage characteristics of the MOS structure, MOSFET current-Voltage characteristics, Substrate bias effects, Depletion and enhancement MOSFETs, Complementary MOSFETs, Important effects in long channel and short channel MOSFETs, High frequency issues.

Unit: 4 Optical Detectors and Emitters

Optical absorption in semiconductors, photocurrent in a P-N diode, Photoconductive detector, P-I-N photodetector, Avalanche Photodetector, APD design issues,

Materials for light emitting devices, Internal and external quantum efficiency, LED performance issues, Light-current characteristics, Spectral purity, Temporal response, Advanced LED structures, Hetrojunction LED, Edge emitting LED, Surface emitting LED.

Books:

- Semiconductor Devices - An introduction, Jasprit Singh, McGraw-Hill Inc.
- Physics of Semiconductors and their Heterostructures, Jasprit Singh, McGraw-Hill Inc.
- Semiconductor Optoelectronic Devices, Pallab Bhattacharya, Prentice Hall of India.
- Electronic Devices and Components, J. Seymore, Longman Scientific and Technical Publication.

M.Sc. IV Semester
PS04EPHY25 Theoretical Physics - II

Unit - I

Principles of quantum dynamics, the evolution of probability and the time Development operator, The pictures of Quantum dynamics, the quantization postulates for a particle, canonical quantization and constants of the motion, canonical quantization in the Heisenberg picture, the forced harmonic oscillator. The quantum dynamics of a particle, the coordinate and momentum representations, the propagator in the co-ordinate representations.

Unit -II

Feynman's path integral formulation of quantum dynamics in Direct product spaces and multiparticle systems, Bosons and Fermions – the simple harmonic oscillator, Annihilation and creation operators – coupled oscillators – three dimensional lattice and continuum limit, sources of a field and interaction between fields – Occupation number representation – second quantization. Fermion – Boson interaction.

Unit - III

Perturbation theory – the Brillouin-Wigner series, the Heisenberg and interaction representations, Time-integral expansion series, S – matrix and its expansion, momentum representation, the physical vacuum, Dyson's equation and renormalization.

Unit - IV

Green functions – The density matrix, equation of motion of density operator, The Kubo formula, the one particle green functions, energy – momentum representation, Evaluation of Green functions, Two-particle Green functions, time-independent green function, Matrix representation of Green functions.

Basic Text & Reference Books:-

- Quantum Mechanics By Eugen Merzbacher (Third Edition)
- Elements of Advanced Quantum theory By J. M. Ziman
- Modern Quantum Mechanics By J. J. Sakurai
- Quantum Mechanics By Franz Schwabl

M.Sc. IV Semester
PS04EPHY26 Computational Physics - II

Unit - I

Molecular dynamics simulations: General behaviour of a classical system. Basic methods for many – body systems Theverlet algorithm. Structure of atomic clusters The Gear predictor – corrector method Constant pressure, temperature and bond length Structure and dynamics of real materials Ab initio molecular dynamics.

Unit - II

Modeling continuous systems: Hydrodynamic equations The basic finite element method The Ritz variational method Higher-dimensional systems The finite element method for nonlinear equations The particle-in-cell method Hydrodynamics and magneto Hydrodynamics The Boltzmann lattice-gas method.

Unit - III

Monte Carlo simulations: sampling and integration The metro algorithm Applications in statistical physics. Critical slowing down and block algorithms. Variational quantum Monte Carlo simulations Green's functionMonte Carlo simulations. Path – integral Monte Carlo simulations. Quantum lattice models.

Unit - IV

Numerical renormalization: Scaling concept. Renormalization transform Critical phenomena: Ising model Renormalization with Monte Carlo simulation, Kondo problem Quantum lattice renormalization. Density matrix renormalization.

Basic Text & Reference Books:-

- An introduction to computational physics Tao Pang, Cambridge University Press, 1997
- A first course in computational physics Paul L. Devries, John-Wiley & Sons Inc., New York, 1994

M.Sc. IV Semester
PS04EPHY27 Bio – Mass & Other Systems, Energy Storage

Unit - I

Biomass conversion processes direct combustion of biomass (incineration) thermo chemical conversion of biomass – biochemical conversion, Fermentation- ethanolgaseous fuels from biomass – application of biomass energy conversion processes, introduction to the magnetohydrodynamics energy conversion – basic principle – Hall Effect and segmented electrodes – description of typical open cycle MHD plant.

Unit - II

Design aspects-alternate MHD systems-technical particulars of conceptual MHD fundamental equations of MHD generation, introduction to the fuel cells and fuel cell power plants – advantages of fuel cell power sources – theory of electro-chemistry applied to fuel cells. Classification and types of fuel cells fuels for fuel cells electrical circuit and quantities performance characteristics of fuel cells.

Unit - III

Introduction to the energy storage systems, energy storage systems for the electrical utility peak saving, pumped hydro energy storage plant, underground pumped hydro-compressed air energy storage. CASE with gas turbine peaking power plants, Huntor compressed air energy storage system with gas turbine power plant, battery energy storage systems, lead acid battery, Nickel-cadmium battery, advanced batteries superconducting magnet storage, advanced flywheel energy storage AFES.

Unit - IV

Thermal energy storage, chemical reaction material energy storage, Hydrogen energy storage, Introduction to the hydro energy, Merits and demerits of the hydroenergy, Hydroenergy resources in India, Types of hydro-electric plant and energy conversion schemes.Terms and definitions, Generation description, Typical hydro-electric power plants, Hydro-electric turbines, Specific speeds of hydro-turbines, Impulse turbine, Reaction turbine, Choice of hydro-turbine, speed control and hydrothermal coordination, Merits of hydro-turbines, Types of turbines for small hydro, classifications, Mini, micro, small hydro-electric projects, Run-of river and storage plants, Environments aspects concerned with hydro power.

Basic Text & Reference Books:-

- Energy Technology (Non conventional, Renewable and conventional) By S. Rao and Dr. P. B. Perulkar
- Solar Energy conversion, An introductory course By A. E. Dikon and J. D. Loslie
- Photoelectrochemical Solar Cells By Suresh Chandra
- Principles of Energy Conversion By Archie W. Cupl. Jr.

M.Sc. IV Semester
PS04EPHY28 Nuclear Energy & Energy Strategies

Unit - I

Introduction to the nuclear energy, Historical background status and prospectsnuclear energy application compared with coal, Fuels for nuclear fission reactor, Terms and definitions-nuclear fuel cycle-storage transportations. Nuclear fission and chain reaction, Moderators – energy from nuclear fission reactions, Uranium enrichment process – Nuclear reactor power plant, Fast breeder reactors, Boiling water reactor, pressurized heavy water reactor, and pressurized light water reactor Gas cooled reactor, Liquid metal fast breeder reactor, Nuclear waste management, Introduction to the nuclear fusion, Nuclear fusion reactions, Problems with nuclear fusion, Plasma confinement.

Unit - II

Toroidal magnetic confinement of plasma-magnetic mirror confinement, Laser inertial confinement reactors, Fusion-fission hybrid, Environmental and safety with nuclear fusion, Compact toroids, Introduction to the environmental aspects of energy and pollution control, terms and definitions. Pollution from use of energy, Combustion products of fossil fuels, Particulate matter, Electro-static precipitator (ESP), Fabric filter and bag house, Carbon dioxide, Green house effect and global warming, Emission of carbon monoxide, Pollution by sulphur dioxide and hydrogen sulphide, Emission of nitrogen oxides, Acid rains, Acid snow, Acidic fog and dry acidic deposit, FGD and SCR systems for cleaning flue gases.

Unit - III

Introduction to the hydrogen and methanol fuels, Applications of hydrogen, Productions of hydrogen, Storage and transportation of hydrogen, Methanol, Energy strategies, Energy management and energy conservation measures (Over view), Efficiency of the energy converters, Primary resources of energy, National energy strategy of India, Essential steps in energy planning, Energy planning in India.

Unit - IV

Growth of energy sector of India/world, issues on global warming and climate change, Planning in electrical power sector and the objectives in energy planning, Growth of India's energy sector, Petroleum sector in India, Planning of coal in India, Energy conservation Opportunities (ECOs) and Energy Conservation measures (ECMs), ECOs in electrical power supply sector, ECOs in transportation, ECOs in residential and commercial sectors, ECOs in industry sector, Energy management activities, Economic benefits, Nonconventional renewable sources of energy, Energy audit.

Basic Text & Reference Books:-

- Energy Technology (Non conventional, Renewable and conventional) By S. Rao and Dr. P. B. Perulkar
- Solar Energy conversion, An introductory course By A. E. Dikon and J. D. Loslie
- Photoelectrochemical Solar Cells By Suresh Chandra
- Principles of Energy Conversion By Archie W. Cupl. Jr.