SYLLABUS

For

MASTER OF SCIENCE (M.Sc.)

in

PHYSICS

[As per CBCS pattern recommended by UGC]

Effective from Academic Session: 2022-2023

VEER BAHADUR SINGH PURVANCHAL UNIVERSITY

JAUNPUR

COURSE STRUCTURE

Semester-VII

Course Code	Title of the Paper	Credit	Nature (T/P)	Marks Allotment		
				CIA	End Sem.	Total
B010701T	Mathematical and computational Physics	4	T	25	75	100
B010702T	Classical Mechanics	4	T	25	75	100
B010703T	Quantum Mechanics-I	4	T	25	75	100
B010704T	Electronics	4	T	25	75	100
B010705P	Physics Lab-I	4	P	25	75	100
B010706R	Research Project cum Dissertation	4	R	-	-	-

Semester-VIII

Course Code	Title of the Paper	Credit	Nature (T/P)	Marks Allotment		
				CIA	End Sem.	Total
B010801T	Nuclear and Particle Physics-I	4	T	25	75	100
B010802T	Atomic and Molecular Physics	4	T	25	75	100
B010803T	Condensed Matter Physics -I	4	T	25	75	100
B010804T	Thermodynamics and Statistical Physics	4	T	25	75	100
B010805P	Physics Lab-II	4	P	25	75	100
B010806R	Research Project cum Dissertation	4	R	-	-	100

Semester-IX

Course Code	Title of the Paper	Credit	Nature (T/P)			
B010901T	Classical Electrodynamics	4	T	25	75	100
B010902T	Electromagnetic Theory and Plasma Physics	4	T	25	75	100
B010903T	Quantum Mechanics - II	4	T	25	75	100
B010904T	Advanced Electronics - I	4	T	25	75	100
B010905P	Electronics Lab-I	4	P	25	75	100
B010906R	Research Project cum Dissertation	4	R	-	-	-

Semester-X

Course Code	Title of the Paper	Credit	Nature (T/P)			
B011001T	Nuclear and Particle Physics-II	4	T	25	75	100
B011002T	Condensed Matter Physics -II	4	T	25	75	100
B011003T	Laser and Modern Optics Or Atmospheric Physics Or Nanoscience and Nanotechnology Or Physics of Renewable energy	4	T	25	75	100
B011004T	Advanced Electronics - II	4	T	25	75	100
B011005P	Electronics Lab-II	4	P	25	75	100
B011006R	Research Project cum Dissertation	4	R	-	-	100

B010701T - Mathematical and Computational Physics

UNIT - I

Complex Variables

Analytic function, Cauchy-Riemann conditions and their applications. Complex integrals, Cauchy's integral and residue theorem, Cauchy's integral formula, Taylor and Laurent expansion of Complex function, Principal value of an integral.

UNIT - II

Special Functions

Bessel function, Legendre, Hermite, and Laguerre functions – Generating function, Recurrence relations and their differential equations, Orthogonality properties, Bessel's function of first kind, Spherical, Associated Legendre function, Spherical harmonics

UNIT - III

Fourier Series and Integral Transforms

Fourier series: Definition, Dirichlet's Condition, Convergence, Fourier Integral and Fourier transform, convolution theorem, Parseval's identity, Application to the solution of differential equations, Laplace transform and its properties, Fourier transform and Laplace transform of Dirac Delta function

UNIT - IV

Numerical Techniques

Interpolation, solution of algebraic equation, least-square curve fitting, linear algebra and matrix manipulations, inversion, eigenvectors and eigenvalues, numerical differentiation, numerical integration, Numerical solution of ordinary differential equations: Euler and Runge-Kutta methods, random number generation.

B010702T: Classical Mechanics

UNIT: I

Lagrangian and Hamiltonian Dynamics

Mechanics of a system of particles, constraints of motion, generalized coordinates, constraints, principle of virtual work, D'Alemberts Principle and the generalized equation of motion, Variational principle and its applications to problems like shortest distance, geodesics etc.

Lagrangian and Hamiltonian equations of motion - derivation using Hamilton's principle of least action and their applications to various problems. Hamiltonian for a charged particle.

UNIT: II

Canonical Transformations and Poisson Brackets

Canonical transformations and their applications. Canonical transformations of the free particle Hamiltonian. Poisson Brackets. Jacobi-Poisson theorem on Poisson Brackets. Invariance of Poisson brackets under canonical transformations. Dirac's formulation of generalized Hamiltonian.

UNIT: III

Central Forces and Non-inertial Frames of Reference

Lagragian formulation of motion under central forces. Kepler problem. Stability of orbits. Motion of satellites. Rotating frames of reference. Coriolis force.

UNIT: IV

Rigid Body Dynamics and Small Oscillations

Moment of inertia tensor, Euler angles, Euler equation of motion for rigid body motion, Symmetric top, Small oscillations, System of couple oscillators, Normal modes and normal coordinates.

Reference Books:

1. Classical Mechanics by H. Goldstein, C. Poole and J. Safko
2. Classical Mechanics by N. C. Rana and P.S. Joag
3. Mechanics by L. D. Landau and E.M. Lifshitz
4. Classical Mechanics by J.R. Taylor
5. Classical Mechanics by P.V. Panat
6. Classical Mechanics by Y.R. Waghmare

B010703T : Quantum Mechanics – I

UNIT: I

Linear Vector Spaces

de Broglie's hypothesis: matter waves and experimental con_rmation, wave packets; Linear vector spaces: inner product, Hilbert space, Wave Functions; Linear operators: Hermitian operators, Projection operators, Commentator algebra, Unitary operators, Eigenvalues and eigen vectors of a Hermitian operator; Basis: Re presentation in discrete bases, Matrix representation of kets, bras, and operators, Change of bases and unitary transformations, Matrix representation of the eigenvalue problem, Representation in position bases.

UNIT: II

Postulates of Quantum Mechanics

Postulates of Quantum Mechanics: State of a System, Probability Density, Superposition Principle, Observables as Operators, Position and Momentum operators, Position and Momentum representation of state vector, Connecting the position and momentum representations, Measurement in quantum mechanics, Expectation values, Commuting operators and Uncertainty relations; Time evolution of the state: Time-independent potentials and Stationary States, Time evolution operator, infinitesimal and finite Unitary Transformations; Conservation of probability; Time evolution of expectation values: Ehrenfest theorem; Poisson's brackets and commentators; Matrix and Wave mechanics.

UNIT: III

Time independent 1D problems

Discrete, continuous and mixed spectrum; symmetric potentials and parity; Infinite square well potential; Symmetric potential well; Finite square well potential: Scattering and bound state solutions; Free particle; Delta function potential; Harmonic oscillator.

UNIT: IV

Time independent 3D problems

Free particle in 3-dimensions: spherically symmetric solution; Particle in a 3D box; Schrodinger equation in presence of central Potential; Orbital angular momentum: eigen values and eigen functions of L^2 and L_z ; Hydrogen Atom; Scattering: Cross Section, Amplitude and Differential Cross Section, Scattering of Spin-less Particles, The Born Approximation, Validity of the Born Approximation.

References:

1. Nourdine Zettili, Quantum Mechanics Concepts and Applications, 2nd edition, Wiley, 2009
2. David Griths, Introduction to Quantum Mechanics, 2nd edition, Prentice Hall, 2004
3. J. J. Sakurai, Modern Quantum Mechanics, Revised edition, Addison-Wesley, 1994.
4. R. Shankar, Principle of Quantum Mechanics, 2nd edition, Kluwer Academic, 1994.
5. Mathews and Venkatesan, Textbook of Quantum Mechanics, 2nd edition, Tata McGraw Hill, 2010.
6. V.K. Thankappan, Quantum Mechanics, 4th edition, New Age International, 1985.

B010704T: Electronics

UNIT: I

Power Devices

SCR; basic structure, I-V characteristics and two transistor model, DIAC and TRIAC; basic structure, operation and equivalent and I-V characteristics, TRIAC as high power switch, DIAC as triggering device of TRIAC, UJT in over voltage protection, saw tooth wave generation using UJT.

UNIT: II

Controlled rectification

SCR controlled half and full wave rectifier circuit and their analysis, elements of SMPS, SCR control and stability in SMPS.

UNIT: III

Operational amplifier

Characteristics of Op-Amp, inverting and non-inverting inputs, input offset current and input offset voltage, slew rate and power band width, Op-Amp as an amplifier, Bode plot and frequency response of Op-Amp, voltage follower, current follower, Op-Amp as integrating and differentiating circuits, frequency to voltage and voltage to frequency converter, voltage controlled oscillator and wave shaping circuits (Triangular and square wave), Astable, Monostable and Bistable Multivibrators, clipping and clamping circuits.

UNIT: IV

Logic circuit design

Standard representation of logic function, SOP and POS terms and design of logic circuits using these terms, Karnaugh Map, simplification of Boolean expression, half adder and full adder, serial and parallel adder, half and full subtractors.

References:

1. Integrated Electronics by Milman and Halkias.
2. Hand Book of Electronics by Gupta and Kumar.
3. Operational Amplifiers and Linear Integrated Circuits by Gaykwad.
4. Digital Electronics by Malvino and Brown.
5. Digital Electronics by R. P. Jain.

B010705P: Physics Lab-I

1. Wavelength of Sodium light by Michelson Interferometer
2. Wavelength of Sodium light by Fabry Perot Interferometer
3. Young modulus of metal rod by Newton’s Ring
4. Wavelength of Laser light and thickness of wire.
5. Lande’s g factor by E.S.R

6. Study of R-C Coupled Amplifier
7. Study of Multivibrator
8. Study the characteristics and determination of h-Parameter of PNP transistor in CE.
9. Study of saw tooth wave generator by UJT.
10. Study of Clipping – Clamping circuit.

B010706R : Research Project cum Dissertation

B010801T : Nuclear and Particle Physics-I

UNIT: I

Basic Facts about Nucleus

Nuclear radius and its determination, nuclear spin and parity, quadrupole moment, magnetic moment, saturation of nuclear forces, stability of nuclei.

UNIT: II

Nuclear Models

liquid drop model, Weizsacker semi-empirical mass formula and its applications, Evidence of nuclear shell structure, Nuclear potential and sequence of energy level of nucleons, spin orbit potential and explanation of magic number, Prediction and limitation of shell model. Concept of nuclear core, Neilson unified model, optical model, elementary idea of collective and superconducting model.

UNIT: III

Nuclear Reaction

General features and concept of cross section and Q value of nuclear reaction. Example of typical nuclear reaction, compound nucleus hypothesis, Ghoshal experiment, wave mechanical picture, partial level width, resonance theory of nuclear reaction, Breit-Wigner one level formula, Direct, pickup and stripping reactions, Nuclear fission, idea of nuclear accelerators and detectors. Nuclear power reactors.

UNIT: IV

Nuclear Transitions

Gamow's quantum theory of α-decay and its predictions, Fermi theory of beta (β) decay, Allowed and forbidden transitions, Fermi-Curie plot andcomparative half life, Neutrino properties and experimental evidence, Parity conservation in weak interaction. Electromagnetic transition, multipole order, selection rules, internal conversion, and life time of Gamma emitting states and isomerism. Pair creation and annihilation.

References:

1. Introduction to nuclear physics by H. Enge.

2. Nuclei and Particles by E. Segre.

3. Atomic and Nuclear Physics Vol II by S.N. Ghoshal (S. Chand and Company Ltd, New Delhi 1994).

4. Nuclear Physics Vol I by Y M Shirikov and NP Yudin, (Mir Publisher, Moscow 1982).

5. Theory of Nuclear structure by M.K. Pal (Affiliated East West Press, New Delhi 1982).

6. Nuclear and Particle Physics by E.B. Paul (North Holland Publishing Company, Amsterdam 1969).

7. Nuclear Physics (Theory and Experiment) by R.R. Roy and B.P. Nigam (Wiley Eastern Ltd., New Delhi 1993).

B010802T : Atomic and Molecular Physics

Unit: I
Basics of Atomic Spectra

Atomic emission and absorption spectra, fine structure of hydrogen atom, relativistic correction for energy levels of hydrogen atom, mass correction, spectra of helium, deuteron and alkali atoms, hyperfine structure.

Unit: II
Many Electron Atom

Spectra of helium, deuteron and alkali atoms, hyperfine structure. Singlet and triplet fine structure in alkaline earth spectra, Lande interval rule, L-S and J-J coupling schemes, energy levels, selection rules. Zeeman Effect, Paschen back effect, Stark effect, calculation of Zeeman pattern and intensity distribution in complex spectra. Breadth of spectral lines: Natural broadening, Doppler broadening and stark broadening.

Unit: III

Rotation and Vibration Spectra

IR and Raman spectra of rigid rotator and harmonic oscillator, IR and Raman spectra of non-rigid rotator, anharmonic oscillator and vibrating rotator, Intensities in rotation–vibration spectra, Isotope effect in rotation and vibration spectra.

Unit: IV

Electronic Spectra

Electronic energy and total energy, vibration structure of electronic transitions, progressions and sequences, rotational structure of electronic bands, b and head formation and band origin, Intensity distribution in vibrational structure, Frank-Condon principle and its quantum mechanical formulation, intensity alternation in rotational lines.

References:

1. A Beiser, “Perspectives of Modern Physics”.
2. H E White; “Introduction to Atomic Physics”.
3. Molecular Spectra and Molecular Structure by G. Herzberg (Dover Publication, London).
4. Introduction to Molecular Spectroscopy by G. M. Barrow.
5. Fundamentals of Molecular Spectroscopy by C. N. Banwell.

B010803T : Condensed Matter Physics –I

Unit-I

Crystal Binding and Structure

Inert gas, lonic, covalent, metallic and hydrogen bondings, space lattice and basis, Lattice types, Miller indices, Important crystal structure (NaCl, CsCl, ZnS, graphite and diamonds), Reciprocal Lattice and Brillouin Zone,Elementary idea of crystal structure analysis and dislocations.

Unit-II

Lattice Dynamics and Thermal Properties

Lattice vibrations of mono and diatomic chains, Infrared absorption of ionic crystals, quantization of lattice vibration and phonon, Einstein and Debye theories of specific heat, Lattice thermal conductivity, Anharmonicity and Thermal expansion.

Unit-III

Free Electron and Band Theories

Sommerfield model, Density of states, Fermi and mean energy at zero and finite temperatures, specific heat and Pauli paramagnetism, origin of energy bands, Block theorem, Kroning Penny model, concept of electron dynamics in crystalline lattice, Tight binding approximation.

Unit-IV

Magnetic Properties

Magnetic ions and magnetic excited states, Paramagnetism of non-interacting magnetic ions and its application to rare-earth and transition metal ions in solids, Ferromagnetism: Magnetic domains and Landau theory of their origin, Basic features and their explanation by molecular field theory, Heisenberg explanation of internal magnetic field, spin wave theory and magnons, Basic features and Neel’s two sublattice models of antiferro and ferrimagnetic materials.

B010804T Thermodynamics and Statistical Physics

Unit-I

Thermodynamics

Thermodynamics of first and second order phase transition, Thermodynamic properties of liquid Helium II, The Lambda transition, London’s theory, Quantum liquid, Tisza two fluid model, Landau structure, superfluidity, second sound.

Unit-II

STATISTICAL MECHANICS

Ensembles, Canonical, microcanonical and grandcanonical ensembles and their partition function, Partition function for monoatomic and diatomic gases, Gibb’s paradox, Sackur-Tetrode equation, Maxwell-Boltzman, Bose-Einstein and Fermi-Dirac statistics, Degenerate bosons and Bose-Einstein condensation, Black body radiation, electron gas and its thermodynamicproperties, White dwarfs and their limiting mass, statistical (Thomas-Fermi) model of atom.

Unit-III

Fluctuations

Mean square deviation, Fluctuation in ensembles; Concentration fluctuation in quantum statistics, one- dimensional random walk and Brownian motion, Fourier analysis of random functions, Wiener-Khintchine theorem, The Nyquist theorem.

Unit-IV

Cooperative Phenomena

Phase transition of second kind, Ising model, Bragg-Williams approximations, Kirkwood Method, Order-disorder in alloys, structural phase change.

B010805P : Physics lab – II

1. Excitation energy and wavelength by Frank Hertz experiment.
2. Study of Hall effect.
3. Study of G. M. Counter.
4. Study of Zeeman Effect (e/m).
5. Study of Lattice Dynamics.
6. Study of Energy band gap of Semiconductor.
7. Study of High pass and Low pass Active Filter.
8. Study of TTL gates.
9. Study of Audio Frequency Oscillator.
10. Study of Linear and Square wave detector.

B010806R : Research Project cum Dissertation

SEMESTER : III

B010901T : Classical Electrodynamics

Unit-I

Four Dimensional Formulation

Minkowski space, Intervals, Proper time, Lorentz transformation, Transformation of velocities, addition of velocities, relativistic Doppler effect, Four vectors, Four Tensor, Principle of least action, Four-momentum of a free particle.

Unit-II

Charges in Electromagnetic Fields

Four Potential, Minimal coupling prescription, action of a charged particle, generalized momentum and Hamilton equation of motion, Motion in constant uniform magnetic field.

Unit-III

Electromagnetic Field Equations

Four dimensional formulation of equation of motion, Electromagnetic field tensor, Transformation properties of electric and magnetic fields, Invariants of electromagnetic field, Four dimensional formulation of first and second pair of Maxwell equations, The equation of continuity, Energy-momentum tensor of electromagnetic field.

Unit-IV

The Field of Moving Charges

Retarded potentials, The Lienard-Wiechart potentials, Field due to system of charges at large distances, Dipole radiation, Quadrupole and magnetic dipole radiation, Field at near distances, Radiation from accelerated charge, Synchrotron radiation (magnetic bremsstrahlung), Radiation damping.

References:

1. The Classical theory of Fields by L. D. Landau and E.M. Lifshitz (Pergmon Press, Oxford).
2. Classical Electricity and magnetism by W. K. H. Penofsky and M. Phillips.
3. Classical Electrodynamics by J. D. Jackson (Wiley Estern Ltd., Delhi).

B010902T : Electromagnetic Theory and Plasma Physics

Unit:I

Maxwell Equations, Potential and Gauges

Microscopic and Macroscopic fields, Maxwell equations, Fields **D** and **H**, Dielectric tensor, Principal Dielectric axes, Scalar and vector potentials, Gauge transformation, Lorentz gauge and Transverse gauge, Maxwell equations in terms of electromagnetic potentials.

Unit-II

Propagation of Electromagnetic Waves

Propagation of electromagnetic waves in free space, conducting and non-conducting medium, Reflection and refraction at a plane interface between dielectrics, Polarization by reflection, dispersion (Normal and anomalous), Metallic reflection, Electromagnetic waves propagation in bound media.

Unit-III

Plasma State & its Properties

Elementary ideas of plasma state of matter, Motion of charge particles in uniform E & B fields, non-uniform fields, Adiabatic invariants, Plasma confinements (Pinch effect, Mirror confinement, Van Allen Belts), Elementary idea of fusion technology.

Unit-IV

Hydrodynamical Description of Plasmas

Hydroynamical description, Equation of magneto-hydrodynamics, High frequency plasma oscillations, Short wavelength limit and Debye-screening distance.

Wave Phenomenon in Magneto-Plasma

Electromagnetic waves perpendicular to B_0, phase velocity, Polarization, Cut-off and resonances, Electromagnetic waves parallel to B_0.

References:

1. The Classical Theory of Fields by L.D. Landau and E.M. Lifshitz (Pergmon Press, Oxford).

2. Foundations of Electromagnetic Theory by Reitz, Milford & Christy (Narosa, Delhi).

3. Classical Electrodynamics by J. D. Jackson (Wiley Eastern Ltd., Delhi).

4. Introduction to Plasma Physics by F. F. Chen (Plenum Press, New York).

5. Plasma Physics by A. Bittencourt

B010903T Quantum Mechanics – II

Unit: 1

Approximation Method

Time independent perturbation theory, non-degenerate and generate case, first order and second order perturbation, first-order Stark effect in hydrogen atom, WKB approximation, Ritz-variation method. Time dependent perturbation theory, transition probability, transition to continuum of states, Fermi's Golden rule, Einstein's coefficients, spontaneous and stimulated emission.

Unit: 2

Relativistic Quantum Mechanics

Relativistic wave equations – Klein Gordon and Dirac equations, concept of negative energy and vacuum, non relativistic limit of Dirac equation, prediction of electron spin and its relation with magnetic moment, Dirac matrices, elementary idea about field quantization.

Unit: 3

Scattering Theory

Non-relativistic scattering theory, differential and total scattering cross section, Born approximation method with examples of scattering by Coulomb, Gaussian, Square well and Yukawa potentials. Partial wave analysis, optical theorem, phase shift, example of scattering by square well potential.

References:

1. Principle of Quantum Mechanics by P. A. M. Dirac.
2. Quantum Mechanics by L. I. Schiff (Mc Graw Hill, New York).
3. Quantum Mechanics by J. L. Pawel and B. Craseman (Narosa Publishing House, London).
4. Introduction to Quantum Mechanics by A. K. Ghatak (MacMillan India Ltd., New Delhi).
5. Quantum Mechanics (non-relativistic theory) by L. D. Landau and E. M. Lifshitz (Pergamon Press, Oxford).

6. Quantum Mechanics and field Theory by B. K. Agrawal (Lok Bharti Publication, Allahabad).
7. An Introduction to Relativistic Quantum Field Theory by S.S. Schweber (Harper and Row, New York).
8. The Classical theory of Fields by L. D. Landau and E.M. Lifshitz (Pergmon Press, Oxford).

B010904T : Advanced Electronics – I

Unit-I

Analog Electronics and Combinational Logic Design

(i) Analog computation, time and amplitude scaling, PLL, Analog to digital and digital to analog convertor.

(ii) Logic design with MSI, coder and decoder, multiplexer and demultiplexer circuit.

Unit-II

Sequential Logic Circuits

(i) Basic definition, finite state model, SR, JK, T, D, Edge Triggered flip-flop, Race condition, Master Slave flip-flop, Clocked flip-flop, Characteristic table and characteristic equation, Sequential logic design, state table, state diagram, state equation.

(ii) Registers and Counters: Register, Shift register, Universal shift register, Ring counter, Twisted ring or Johnson counter, synchronous and asynchronous counters, UP/Down and scale of 2n counters.

Unit-III

Memory

Basic idea of magnetic memory. Ferrite core memory, Semi-conductor memory viz, RAM, ROM, PROM, EPROM EEPROM.

Unit-IV

Microprocessor

Introduction to Intel 8085 microprocessor, microprocessor architecture, instruction and timings, assembly language programming, stack and subroutines, code conversion, interrupts, interfacing with 8255 and memory.

References:

1. Integrated Electronics by Milman & Halkias.

2. Digital Integrated Electronics by Taub & Schilling.

3. Microprocessor, Architecture, Programming and Applications by R. S. Gaonkar.

4. Fundamental of Microprocessors and Microcomputers by B. Ram.

6. Digital Computer Electronics by Malvino and Brown

7. Digital Technology by Virendra Kumar.

B010905P : Electronics Lab-I

1. Study of Amplitude modulation and demodulation.
2. Study of Frequency modulation and demodulation.
3. Study of Multivibrator using IC 555 timer.
4. Study of characteristics Op-Amp.
5. Study of characteristics of Emitter follower.
6. Study of Decoder and seven segment display unit.
7. Study of Encoder.
8. Study of Mux and Demux.

9. Study of Microprocessor.
10. Study of Combinational logic.
11. Study of Sequential logic.

B010906R : Research Project cum Dissertation

Semester X

Syllabus for Semester X will be announced later