**SCHEME OF STUDIES FOR BS INTEGRATED 4 YEARS PROGRAM WITH SPECIALIZATION IN PHYSICS**

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<td>PHY-601</td>
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<td>PHY-602</td>
<td>Nuclear Physics</td>
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# Scheme of Studies for BS Integrated 4 Years Program with Specialization in Physics

## Semester-I

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<tr>
<th>Course Code</th>
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<td>BOT-301</td>
<td>Diversity of Plants</td>
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<td>CHEM-301</td>
<td>Inorganic Chemistry-I</td>
<td>3(2-1)</td>
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<tr>
<td>IS-301</td>
<td>Islamic Studies / Ethics</td>
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<td>ENG-301</td>
<td>English Structure</td>
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<td>MATH-301</td>
<td>Algebra and Calculus-I</td>
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<td>ZOOL-301</td>
<td>Principles of animal life</td>
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<td>CHEM-311</td>
<td>Organic Chemistry</td>
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<tr>
<td>CS-311</td>
<td>Introduction to information and Communication Technologies</td>
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<tr>
<td>SOC-311</td>
<td>Introduction to Sociology</td>
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<td>PS-311</td>
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<td>PHY-311</td>
<td>Mechanics</td>
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<td>Animal Diversity</td>
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<td>Physical Chemistry</td>
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<td>Programming Fundamentals</td>
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Semester - II

Course Code  Course Title  Credit Hours
PHY-311  MECHANICS  3(2-1)

**Vector Analysis:**
Review of Vector in 3 dimensions and fundamental Operations, Direction, Cosines, Spherical polar coordinates, Cylindrical Coordinates. Vector and scalar triple products, gradient of a scalar, Divergence and curl of a vector, Physical significance of each type, Divergence of a vector, flux, curl and line integral (mutual relation). Vector identities, Divergence Theorem, Stoke’s Theorem, their derivation, physical importance and applications to specific cases

**Systems of Particles:**
Two particle systems and generalization to many particle systems, Centre of mass, Position, velocity and equation of motion, Centre of mass of solid objects, Calculation of Centre of Mass of solid objects using integral calculus, Calculating C.M. of Uniform Rod, Cylinder and Sphere, Momentum Changes in a system of variable mass, Derivation of basic equation, application to motion of a rocket (determination of its mass as a function of time)

**Collisions:**
Elastic Collisions, Conservation of momentum during collision in one and two dimensions, Inelastic collision, Collisions in centre of Mass reference frame (One and two dimensions),

**Rotational Dynamics:**
Relationships between linear & angular variables, scalar and vector form. Kinetic energy of rotation, Moment of Inertia, Parallel axis and Perpendicular axis theorems, Proof and Illustration, application to simple cases, Equations of rotational motion and effects of application of torques,

**Angular Momentum:**
Angular Velocity, Conservation of angular momentum, effects of Torque and its relation with angular momentum, Stability of spinning objects, The spinning Top, Effects of torque on the angular momentum, precessional motion

**Gravitation:**
Gravitational effect of a spherical mass distribution, Its mathematical treatment, Gravitational Potential
Energy (develop using integration techniques), calculation of escape velocity, Gravitational field & Potential, Universal Gravitational Law. Radial and transversal velocity and acceleration, Motion of Planets and Keplers’ Laws (Derivation & explanation) Motion of Satellites, Energy considerations in planetary and satellite motion, Qualitative discussion on application of gravitational law to the Galaxy.

**Recommended Books:**
Harmonic Oscillations:
Simple harmonic motion (SHM), Obtaining and solving the basic equations of motion x(t), v(t), a(t),
Longitudinal and transverse Oscillations, Energy considerations in SHM. Application of SHM,
Torsional oscillator, Physical pendulum, simple pendulum, SHM and uniform circular
motion, Combinations of harmonic motions, Lissajous patterns, Damped harmonic motion,
Equation of damped harmonic motion, Quality factor, discussion of its solution, Forced
oscillations and resonances, Equation of forced oscillation, Discussion of its solution,
Natural frequency, Resonance, Examples of resonance.

Waves in Physical Media:
Mechanical waves, Travelling waves, Phase velocity of traveling waves, Sinusoidal waves,
Group speed and dispersion, Waves speed, Mechanical analysis, Wave equation, Discussion
of solution, Power and
intensity in wave motion, Derivation & discussion, Principle of superposition (basic ideas),
Interference of waves, Standing waves. Phase changes on reflection

Coupled Oscillators and Normal modes:
Two coupled pendulums, General methods of finding normal modes, Beats in coupled
oscillations, Two coupled masses, Two coupled LC circuits, Energy relations in coupled
oscillations, Forced oscillations of two coupled oscillators, Many coupled oscillator.

Normal Modes of Continuous systems:
Transverse vibration of a string, Longitudinal vibrations of a rod, Vibrations of air columns,
Normal modes, Fourier methods of analyzing general motion of a continuous system, Atomic
vibrations.

Recommended Books:
Semester - IV

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<td>PHY-411</td>
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**Electric Field:**
Field due to point charge(s), Electric dipole, Electric field of continuous charge distribution,
Torque and energy of a dipole in uniform field, Electric flux: Gauss's law and its application.

**Electric Potential:**
Potential due to point charge(s), potential due to dipole. Poisson"s and Laplace equation without solution, Potential and field inside and outside an isolated conductor

**Capacitors and dielectrics:**
Field in a capacitor, their shapes, and calculation of their capacitance, Energy stored in an electric field, Capacitor with dielectric.

**D C Circuits:**
Electric Current, current density J, resistance, resistivity, ρ, and conductivity, σ, Ohm"s Law,

**Magnetic Field Effects and Magnetic Properties of Matter:**

**Inductance:**

**Alternating Current Circuits:**
AC current in resistive, inductive and capacitative elements. Single loop RLC circuit, Series and parallel circuits i.e. acceptor and rejector, Power in A.C circuits: phase angles, RMS values, power factor

**Electro-Magnetic Waves (Maxwell's Equations):**
Maxwell's equations, (Integral & Differential forms) Discussion and implications, generating an electromagnetic waves, travelling waves and Maxwell"s equations.

**Recommended Books:**
SEMESTER V

Course Code  Course Title                        Credit Hours
PHY-501  MATHEMATICAL METHODS OF PHYSICS-I  3(3-0)

Vector Analysis:
Review of vectors Algebra, Vector differentiation and gradient, Divergence and Gauss"s theorem, Vector integration, Green"s theorem in the plane, Curl and Stoke's theorem.

Curvilinear Coordinates and Tensors:
Curvilinear coordinate system, Gradient, Divergence and Curl in the curvilinear coordinates system, Cartesian, Spherical and Cylindrical coordinate system, Covariant and contravariant tensors, Tensor algebra, Quotient rule.

Matrices:

Complex Variables:
Functions of a complex variable, Cauchy Riemann conditions and analytic functions, Cauchy integral theorem and integral formula, Taylor and Laurent series, Calculus of residue, Complex integration.

Recommended Books:
2. E. Butkov, Mathematical Physics, Addison-Wesley 1968.
Fundamental Concepts:
Recapitulation of the fundamental concepts, Induction B, Addition of Laplace equation and methods of images, Electric dipole. Quadropole, Magnetic intensity H, Maxwell’s equations in differential and integral forms, Poynting theorem and energy conservation

Static Electromagnetic Fields:
Electrostatic fields in several dielectric media, Magnetostatic field of magnetized matter, Magnetostatic field of stationary current, Magnetization current.

Reflection and Refraction of Electromagnetic Waves:
Laws of reflection and refraction, Fresnel’s formula, Total reflection, Refraction in conducting media, Reflection from a conducting surface

Propagation of Plane Electromagnetic Waves:
Monochromatic waves and plane waves, Forced oscillation of an electronic oscillator, Scattering by a bound electron, Dispersion in dilute medium and dense media, Dispersion in metallic conductor, Group velocity. Lorenz, grange and Coulomb grange

Books Recommended:
3. Ritze Millfadad Chirsty, Foundation of Electromagnetic Theory
Elementary Principles:
Brief Survey of Newtonian mechanics of a system of particles, constraints, Alembert's principle, Lagrange's equation and its applications, Virtual work

Variational Principles:
Calculus of variation and Hamilton's principle, Derivation of Lagrange's equation from Hamilton's principle

Two Body Central Force Problem:
Low and least action, two body problem and its reduction to one body problem, Equation of motion and solution for one body problem, Kepler's Laws Laboratory and centre of mass systems, Rutherford scattering

Kinematics of Rigid Body Motion:
Orthogonal transformations, Eulerian angles, Euler's theorem, The coriolis force

Rigid Body Equation of Motion:
Angular momentum, Tensors and dyadics, Moment of inertia, Rigid body problems and Euler's equations

Hamilton Equation of Motion:
Legendre transformation and Hamilton equations of motion, Conservation theorems

Canonical Transformations:
Examples of canonical transformations, Lagrange and Poison brackets, Liouville's theorem

Books Recommended:
2. Dr. S. L. Gupta Pragati Prakshan ,Classical Mechanics, Educational Publisher 240, Western Meerut-250001
Origin of Quantum Theory:
Black body radiation, Stefan Boltzmann-, Wiens- and Planck‟s law, consequences. The quantization of energy, Photoelectric and Compton effect, Line spectra, Explanation using quantum theory.

Wave Nature of Matter:
Wave behaviour of particle (wave function etc.) its definition and relation to probability of particle, d“Broglie hypothesis and its testing, Davisson-Germer Experiment and J.P. Thomson Experiment, Wave packets and particles, localizing a wave in space and time.

Special Theory of Relativity:
Relativity, The Relativity of Orientation and Origin, Moving Reference Frames
Classical Relativity and the Speed of Light, The Michelson - Morley Experiment
The Postulates of Relativity, Measurement of Time, The Relativity of Time;

Recommended Books:
Heat and Temperature:

Thermodynamics:

Kinetic Theory:
Mean free path and microscopic calculations of mean free path. Distribution of molecular speeds, Distribution of energies, Maxwell-Boltzmann energy distribution, Internal energy of an ideal gas. Brownian motion, Qualitative description. Diffusion, Conduction and viscosity.

Recommended Books:
4. Reif, Statistical Physics, Berkley Physics series, McGraw Hill 1965
SEMESTER VI

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<td>PHY-511</td>
<td>MATHEMATICAL METHODS OF PHYSICS-II</td>
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**Differential Equations in Physics:**

**Special Functions:**
Bessel functions and Hankel functions, Spherical Bessel functions, Legendre polynomials, Associated Legendre polynomials, Spherical harmonics Laguerre polynomials, Hermite polynomials, Gamma function

**Fourier Series:**
Definition and general properties, Fourier series of various physical functions, Uses and application of Fourier series

**Integral Transforms:**
Integral transform, Fourier transform, Convolution theorem, Elementary Laplace transform and its application

**Books Recommended:**
Time Dependent Electromagnetic Fields:
Maxwell's equations for quasi stationery fields, Potentials of a rapidly varying field, Fields of uniformly moving and accelerated charges, Radiation from an accelerated charge, Field of oscillating expansion of electromagnetic field, Multiple fields. Expansion of emf

Propagation of Plane Electromagnetic Waves:
Monochromatic waves and plane waves, Forced oscillation of an electronic oscillator, Scattering by a bound electron, Dispersion in dilute medium and dense media, Dispersion in metallic conductor, Group velocity. Lorenz, grange and Coulomb grange

Skin Effect and Wave Guides:
High frequency current in a semi-infinite conductor, Internal impedance at high frequencies, Waves guided by parallel plane conductor, Transmission by a rectangular. Wave Guidance, Power transfer and attenuation, Wave guides as cavity resonators, Q of a cavity resonator, Waves guided by dielectrics.

8. Dr. Vipin Kumar & Dr. Rajeh Mishra. ‘Electromagnetic Theory’
Quantum Mechanics of One dimensional Problems:

Review of concepts of classical mechanics, Particle Aspect of Radiation, Wave Aspect of Particles, particles versus waves, the wave function and its interpretation, State of a system, Functions and expectation values.

Formalism of Quantum Mechanics:

The state of a system, Dynamical variables and operators, commuting and non-commuting operators, Hermitian adjoint, Projection operators, Eigen values and Eigenvectors of an operator, Dirac Notation, Heisenberg uncertainty relations.

Angular Momentum:

Basic properties and Cartesian components, Orbital angular momentum, The eigenvalues and eigen functions of $L_2$ and $L_z$, Matrix representation of angular momentum operators, Addition of angular momenta.

Schrodinger Equation in Three Dimensions:

Separation of Schrödinger equation in Cartesian coordinates, The free particle, Potential, Three dimensional square well potential, The hydrogen atom, Three dimensional isotropic oscillator.

Books Recommended:

1. Introduction to Quantum Mechanics, David J. Griffiths, Prentice Hall, Int., Inc.

Molecular Spectra: Ionic and covalent bonding, Diatomic molecules-rotational, vibrational, and electronic spectra, Polyatomic molecules (brief introduction), Black body radiation, Einstein coefficient and stimulated emission, pumping schemes, characteristic of laser beam, resonators, different types of lasers.

**Recommended Books:**
6. S. N. Goshal, Atomic Physics (Modern Physics)
7. Semat, Introduction to Atomic and Nuclear Physics
8. P. Raja Gopal, Modern Physics, Prentice Hall of India Pvt Ltd New Delhi
**Electronics:**
Basic crystal structure, free electron model, energy band in solid and energy gaps, p-type, n-type semiconductor materials, p-n junction diode, its structure, characteristics and application as rectifiers. Transistor, its basic structure and operation, transistor biasing for amplifiers, characteristics of common base, common emitter, common collector, load line, operating point, hybrid parameters (common emitter), Transistor as an amplifier (common emitter mode), Positive & negative feed back R.C. Oscillators, Monostable multivibrator (basic), Logic gates OR, AND, NOT, NAND, NOR and their basic applications.

**Special diodes:**
Zener diodes, Zener regulators, Varactor diodes, Schottky diodes, Light emitting diodes, Photodiodes, Tunnel diodes, Varistors and their applications

**Transistor Circuits:**
Bipolar transistors; parameters and ratings, Ebers-Moll, Hybrid-p and h, z and y-parameter models, Switching circuits, Biasing and stability, Common emitter, Common base and common collector amplifiers, Frequency response, Power class A, B, and C amplifiers, Field Effect.

**FET**
Transistors; Junction FET, MOSFET, Operation and construction, Biasing, Common source and common drain amplifiers, Frequency response, Multistage Amplifiers; RC coupled and direct coupled stages, The differential amplifiers, Negative feedback, Tuned RF Voltage amplifiers, I-F Amplifiers and automatic gain control.

**Operational Amplifiers:**
Ideal op-amps, Simple op-amp arrangements, its data and sheet parameters, Non inverting and inverting circuits, Feedback and stability, Op-amp applications; Comparators, Summing, Active filters, Integrator and Differentiator, Instrumentation amplifier.

**Oscillators**
Armstrong, Hartley, CMOSS, Colpit's Phase shift and 555 timer oscillators

**Voltage Regulators:**
Series, Shunt and switching regulators, Power Supply

**Books Recommended:**
1. Basic Electronics by B. L. Theraja
Course Code  Course Title                        Credit Hours
PHY-516L  Lab- VI (Spectroscopy and Modern Physics)  3(3-0)

SEMESTER VII

Course Code  Course Title                        Credit Hours
PHY-601  SOLID STATE PHYSICS-I                   3(3-0)

Structure of Solids
Lattices and basis, Symmetry operations, Fundamental types of lattice, Position and orientation of planes in crystals, Simple crystal structures, Atomic potential, space groups and binding forces.

Crystal diffraction and reciprocal lattice:
Diffraction of X-rays, Neutrons and electrons from crystals, Bragg’s law, Reciprocal lattice, Reciprocal lattice to sc, bcc, fcc, orthorhombic and hexagonal crystals, Laue method, rotating crystal method, Powder methods, Scattered wave amplitude, Ewald construction and Brillouin zone, Miller Indices, Fourier analysis of the basis.

Phonons and Lattice Vibrations:
Lattice heat capacity, classical model, Einstein model, Enumeration of normal models, Density of state in one, two and three dimensions, Debye model of heat capacity, Comparison with experimental results, Thermal conductivity and resistivity, Umklapp processes.

Recommended Books:
Course Code | Course Title | Credit Hours
--- | --- | ---
PHY-602 | NUCLEAR PHYSICS | 3(3-0)

**History:**

Starting from Bacqurel’s discovery of radioactivity to Chedwick’s neutron

**Basic Properties of Nucleus:** Nuclear size, mass, binding energy, nuclear spin, magnetic dipole and electric quadrupole moment, parity and statistics

**Nuclear Forces:** Yukawa’s theory of nuclear forces. Nucleon scattering, charge independence and spin dependence of nuclear force, isotopic spin

**Nuclear Models:** Liquid drop model; Fermi gas model, Shell model; Collective model

**Theories of Radioactive Decay:**

Theory of Alpha decay and explanation of observed phenomena, measurement of Beta ray energies, the magnetic lens spectrometer, Fermi theory of Beta decay, Neutrino hypothesis, theory of Gamma decay, nuclear isomerism

**Nuclear Reactions:**

Conservation laws of nuclear reactions, Q-value and threshold energy of nuclear reaction, energy level and level width, cross sections for nuclear reactions, compound nucleolus theory of nuclear reaction and its limitations, direct reaction, resonance reactions

**Neutron Physics:**

Neutron Sources, slow neutron detectors, fast neutron detectors.

**Books Recommended:**

7. S. N. Goshal Nuclear Physics
8. Semat Introduction to Atomic and Nuclear Physics
The Hydrogen Atom:
The Radial Equation, Centrifugal Term, Spherical Bessel function, Spherical Neumann function, The Radial Wave function, Bohr formula, Bohr Radius, Binding energy, Ground State, Associated Laguerre Polynomial.

Perturbation Theory:

Time Dependent-Perturbation Theory:

Scattering in Three Dimensions:

Books Recommended:
1. Introduction to Quantum Mechanics, David J. Griffiths, Prentice Hall, Int., Inc.
Equilibrium Thermodynamics:
Basic postulates, fundamental equations and equations of state, response functions Maxwell's relation, reduction of derivatives

Elements of Probability Theory:
Probabilities, distribution functions, statistical interpretation of entropy, Boltzmann H-theorem

Formulation of Statistical Methods:
Ensembles, counting of states (in classical and quantum mechanical systems, examples) partition function, Boltzmann distribution. Formation of Microcanonical, canonical and grand canonical partition function

Partition Function:
Relations of partition function with thermodynamic variables, examples (collection of simple harmonic oscillators, Pauli and Van Vleck paramagnetics, Theorem of equipartition of energy

Statistical Systems:
Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistical systems, Examples of thermodynamics of these systems; Black body radiations, Gas of electrons in solids

Statistical Mechanics of Interacting Systems:
Lattice vibrations in solids; Van der Waals Gas: mean field calculation; Ferromagnets in Mean Field Approximation

Advanced Topics:
Fluctuations, Bose-Einstein Condensation, Introduction to density matrix approach

Books Recommended:
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<tr>
<td>ENG-601</td>
<td>Technical Writing</td>
<td>3(3-0)</td>
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<tr>
<td>PHY-605L</td>
<td>Lab-VII (Nuclear Physics)</td>
<td>3(0-3)</td>
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**SEMESTER-VIII**

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<tr>
<td>PHY-611</td>
<td>Solid State Physics-II</td>
<td>3(3-0)</td>
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Transport Properties of Solids:
 Motion of electron in bands, Effective mass, Electrical conductivity of metals, electrical Conductivity of localized electrons, Boltzmann equation

Defects in Crystals:
 Crystal imperfections, Thermodynamics of Point defects, Schottky and Frenkel defects, color centres, Dislocations in Solids, edge dislocation, Screw dislocation Slip and plastic deformation, Stacking faults and grain Boundaries, Strength of Crystals

Dielectrics and Ferroelectrics:
 Maxwell Equations, Polarization, Dielectric Constant and Dielectric Polarizability, Susceptibility, Electronic Polarizablity, Clausius-Mossotti Relation, Structural Phase Transitions, Ferroelectric crystals, Classification of Ferroelectric Crystals, Theory of Ferroelectric Displacive Transitions, Thermodynamic theory of Ferroelectric transition, Ferroelectric Domains, Piezoelectricity,

Diamagnetism and Paramagnetism:
 Atomic theory of magnetism, Diamagnetism, Paramagnetism, The quantum numbers, Orbital and spin magnetic moments of electrons, Langevin theory of Dia and Paramagnetism, Ferromagnetism, Domain theory, Weiss theory of Ferromagnetism, Magnetic relaxation and resonance phenomena

Semiconductors and Superconductivity:
 Intrinsic Semiconductors, Extrinsic semiconductors, Band structure, Energy Gap, Donor and acceptor Level, Hall Effect, Superconductivity-an introduction, zero resistivity and Meissner effect, Diamagnetism, susceptibility, Critical field, temperature and current, Type-I and type-II superconductors, BCS theory, electron-phonon-electron interaction via lattice deformation, ground state of superconductors, Cooper pairs, Coherence length, the origin of energy gap, London equations (electrodynamics),London penetration depth, thermodynamics of superconductors, entropy and the Gibbs free energy, Josephson Effect.

Books Recommended:

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<tr>
<td>PHY-612</td>
<td>COMPUTATIONAL PHYSICS</td>
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**Computer Languages:**
A brief introduction of the computer languages like Basic, C. Pascal etc and known software packages of computation

**Numerical Methods:**
Numerical Solutions of equations, Regression and interpolation, Numerical integration and differentiation, Error analysis and technique for elimination of systematic and random errors

**Modeling & Simulations:**
Conceptual models, The mathematical models, Random numbers and random walk, Doing Physics with random numbers, Computer simulation, Relationship of modeling and simulation. Some systems of interest for physicists such as Motion of Falling objects, Kepler's problems, Oscillatory motion, Many particle systems, Dynamic systems, Wave phenomena, Field of static charges and current, Diffusion, Populations genetics etc

**Books Recommended:**
PHYS-613
Optional-I
PHYS-614
Optional-II
PHYS-615
Optional-III
PHYS-616
Project / General Viva Voce/ Optional- IV

DETAIL OF ELECTIVE COURSES

PLASMA PHYSICS

Books Recommended:
SURFACE PHYSICS

An Introduction to Surfaces:
What is a surface? The energetics and thermodynamics of creating a surface. An introduction to surface Physics. Surface energies and the Wulff Theorem.

Studying Surfaces:
What is UHV? Do we need UHV to study surfaces? The kinetic theory of gases, concept of vacuum and standard vacuum hardware components, Comparison of different types of pumps with measurement of vacuum pressure, Preparing a clean surface

Surface Structures and Reconstructions:
Lattice concept, 3 D crystal structures, 2D surface structures. Specific types of surface, fcc, hcp, bcc and stepped surfaces and a discussion of their relative energies. More complex reconstruction, stability, growth mechanisms, adsorption, Desorption and experimental probes of surface structure such a LEED and RHEED. The structure of semi-conductor surfaces. The surface structures of very small metal particles.

Electron-Surface Interactions:
Electron diffraction and quasi – elastic scattering, comparison of particle scattering techniques, Electron spectroscopes, Discussion of the merits of different types of electron energy analysers and electron detectors, Signal processing and spectral analysis. Theory and practice of Auger electron spectroscopy, Quantification of Auger spectra, Auger depth, Profiling

Atom/ion surface interactions:

FLUID DYNAMICS

**Basic Fluid Mechanics:**
Fundamentals of Continuum mechanics, Kinematics of the flow field, the continuity equation, governing equations of fluid motion, Incompressible flows, Compressible flows, Thin aerofoil.

**Boundary Layer Theory:**
Laminar Boundary layer, Turbulent Boundary layer Reynold”s number

**Computational Fluid dynamics-I:**

**Computational Fluid Dynamics-II:**
Governing equations in integral and differential form, Reduced forms of governing equations, The finite volume method, Incompressible and compressible flow & their methods, Discrete methods for the steady state and time dependent advection diffusion equation, The pressure correction method on staggered and unstaggered grids, Time marching schemes, Incorporation of turbulence models, Schemes for solving large algebraic systems, Use of a commercial code for the predication off complex flows.

**Experimental Methods:**
Introduction to laboratory techniques, Laboratory sessions (preceded by lectures): water waves, air flow past a cylinder aero foils, hydraulic jumps, vortex shedding and vibrations, turbulent jets and plumes.

**Books Recommended:**
METHODS OF EXPERIMENTAL PHYSICS

Vacuum Techniques:
Gas Transport: Throughout, Pumping Speed, Pump down Time Ultimate pressure. Fore-Vacuum Pumps: Rotary Oil pumps; sorption pumps. Diffusion pumps, sorption pumps (High Vacuum). Production of ultrahigh vacuum; Fundamental concepts; guttering pumps; Ion pumps; Cryogenic pumps; Turbo molecular pumps, Measurement of total pressure in Vacuums Systems; Units pressure ranges; Manometers; Perini gauges; The McLoad gauges; Mass spectrometer for partial measurement of pressure. Design of high Vacuum system; Surface to Volume ratio; Pump Choice; pumping system design Vacuum Components; Vacuum valves; vacuum Flanges; Liquid Nitrogen trap; Mechanical feed throughs & Electrical feed throughs Leak detection: Basic consideration; leak detection equipment; Special Techniques and problems; Repair Techniques.

Radiation Detection and Measurement:
GM tubes, scintillation detector, channeltron, photo multipliers, neutron detectors, alpha/beta detectors, x-rays/gamma detectors, cosmic rays detectors, Spectrographs and Interferometers.

Sensor Technology:
Sensors for temperature, pressure displacement, rotation, flow, level, speed, rotation position, phase, current voltage, power magnetic field, tilt, metal, explosive and heat.

Electronics and Electronic Instruments:
Operational amplifiers, summing amplifiers, difference amplifiers, Differentiators, Integrators, Logarithmic amplifiers, current to voltage converter, Spectroscopy amplifiers, charge sensitive pre-amplifiers, Coincidence circuits, Isolators, Ramp Generators, and single channel analyzer. Power supplies, Signal Generators, Counters, Multichannel analyzer, Lock in Amplifiers, Boxcar averages.

Computer Introduction:
Introduction to computers, GPIB Interface, RS 232. Interfacing, DA/AD conversion, Visual c/visual Basic.

Data Analysis:
Evaluation of measurement: Systematic Errors, Accuracy; Accidental Errors, Precision, Statistical Methods; Mean Value and Variance; Statistical Control of Measurements; Errors of Direct measurements, Rejection of data; Significance of results; Propagation of errors; preliminary Estimation; Errors of Computation. Least squares fit to a polynomial. Nonlinear functions. Data manipulation, smoothing, interpolation and extrapolation, linear and parabolic interpolation.

Books Recommended:
2. J. Yarwood, High Vacuum Techniques, Chapman Hall
3. P. Bevington, Data Reduction and Error Analysis for Physical Science, McGraw Hill.
ENVIRONMENTAL PHYSICS

Introduction to the Essentials of Environmental Physics:
The economic system, living in green house, enjoying the sun, Transport of matter, Energy and momentum, the social and political context

Basic Environmental Spectroscopy:

The Global Climate:
The energy Balance, (Zero-dimensional Greenhouse Model), elements of weather and climate, climate variations and modeling

Transport of Pollutants:
Diffusion, flow in reverse, ground water. Flow equations of fluid Dynamics, Turbulence, Turbulence Diffusion, Gaussian plumes in air, Turbulent jets and planes.

Noise:
Basic Acoustics, Human Perceptions and noise criteria, reducing the transmission of sound, active control of sound.

Radiation:
General laws of Radiation, Natural radiation, interaction of electromagnetic radiation and plants, utilization of photo synthetically active radiation

Atmosphere and Climate:
Structure of the atmosphere, vertical profiles in the lower layers of the atmosphere, Lateral movement in the atmosphere, Atmospheric Circulation, cloud and Precipitation, The atmospheric greenhouse effect

Topo Climates and Micro Climates:
Effects of surface elements in flat and widely undulating areas, Dynamic action of seliq. Thermal action of relief

Climatology and Measurements of Climate Factor:
Data collection and organization, statistical analysis of climatic data, climatic indices, General characteristics of measuring equipments. Measurement of temperature, air humidity, surface wind velocity, Radiation balance, precipitation, Atmospheric Pressure, automatic weather stations.

Books Recommended:
INTRODUCTION TO QUANTUM COMPUTING

Computer technology and historical background; Basic principles and postulates of quantum mechanics: Quantum states, evolution, quantum measurement, superposition, quantization from bits to qubits, operator function, density matrix, Schrodinger equation, Schmidt decomposition, EPR and Bell’s inequality; Quantum Computation: Quantum Circuits, Single qubit operation, Controlled operations, Measurement, Universal quantum gates, Single qubit and CNOT gates; Breaking unbreakable codes: Code making, Trapdoor function, One time pad, RSA cryptography, Code breaking on classical and quantum computers, Schor’s algorithm; Quantum Cryptography: Uncertainty principle, Polarization and Spin basis, BB84, BB90, and Ekert protocols, Quantum cryptography with and without eavesdropping, Experimental realization; Quantum Search Algorithm.

Books Recommended:

PARTICLE PHYSICS

Particle Classification:
Quantum numbers, leptons, hadrons, baryons, mesons, quarks.

**The Fundamental Interactions:**
The electromagnetic coupling, the strong coupling, the weak coupling.

**Symmetry Transformation and Conservation Laws:**
Translation in space, rotation in space, the group SU (2), systems of identical particles, parity, iso-spin charge conjugation, time reversal, G parity, CPT theorem.

**The Electromagnetic Field:**
Gauge invariance and Maxwell’s equations, polarization ad photon spin, angular momentum, parity and C parity of photon.

**Hadron Spectroscopy:**
Formation experiment, partial wave formalism and the optical theorem, the Breit-Wigner resonance formula, baryon resonances, phase space considerations, production experiments.

**The Quark Model:**
The group SU (3), quarks, hadrons baryons, mesons in quark model, heave meson spectroscopy, the quarkonium model.

**The Standard Model (qualitative treatment only):**
Unification of weak and electromagnetic interactions Glashow-Salam-Weinberg Model.

**Books Recommended:**

**COMPUTER SIMULATION OF PHYSICAL PROCESSES**

**Introduction:**
Importance of computers in physics, nature of computer simulation, computer graphics and programming languages, Techniques and class of computer simulation, Accuracy and stability of numerical techniques, External points and strings, principles of vector computing in Cartesian, spherical and cylindrical coordinates.
**Numerical Approaches:**
Solution of Ordinary Differential Equations, initial (boundary) and eigen value problems, numerical integrations, special functions and Guassian quadrature, matrix operation, partial differential equations (elliptic and parabolic types)

**Computational Methods for Continuous Medium:**
Fluid equations, Governing equation in integral and differential forms, Reduce forms of the governing equation, finite volume method, compressible and incompressible flow and their methods, Discrete methods for the steady state and time dependent diffusion equation. The pressure-correction method on staggered and unstaggedar grids. Time marching schemes, incorporation of turbulence model, schemes for solving large algebraic system, use of commercial code for prediction of off complex flow, Raynold averaging and its applications to Navier stokes equations. Mean and Turbulant kinetic energy equation, Magneto hydrodynamics, Modelling ideal (MHD), resistive and viseus flow of plasmas, thermal conduction and heat transport

**Books Recommended:**
EXPERIMENTAL NUCLEAR PHYSICS

**Nuclear Radiation Detection and Measurements:**
Interaction of nuclear radiation with matter; photographic emulsions; Gas-filled detectors; Scintillation counters and solid-state detectors; Cloud chambers; Bubble chambers.

**Charged Particle Accelerators:**
Linear and orbital accelerators Van de Graaff, Cyclotron; Betatron; Synchrocyclotron; Electron-Synchrotrons; Proton-synchrotron; Alternating-gradient Synchrotron.

**Neutron Physics:**
Neutron Sources, Radioactive sources, Photo neutron sources Charged particle sources, Reactor as a neutron source, slow neutron detectors, fast neutron detectors, Measurement of neutron cross-sections as a function of energy, slowing down of neutrons, Nuclear fission, Description of fission reaction, Mass distribution of fission energy, Average number of neutrons released, Theory of fission and spontaneous fission, Nuclear chain reaction and applications.

**Elementary Reactor Physics:**
Controlled fission reactions, Types of nuclear reactors (Power and Research), Detailed study of PWR and CANDU type reactors.

**Books Recommended:**
LASERS

Introductory Concepts:

Spectroscopy of Molecule and Semiconductors:

Pumping Processes:
Optical pumping: Flash lamp and Laser, Threshold Pump Power, pumping efficiency, Electrical
Pumping: Longitudinal Configuration and Transverse Configuration, Gas Dynamics Pumping, Chemical Pumping.

Lasers Systems :

Books Recommended
   Scully and Zubairy, Quantum Optics, Cambridge University Press (1997)
**COSMOLOGY**

**Special Relativity:**
Galilean relativity, concept of ether, Michelson-Morley experiment, Einstein’s postulates of special relativity, Lorentz transformations, structure of space-time, Minkowski space time tensors, the light-cone, line element, four-vectors, relativity of simultaneity, time dilation, proper time, length contraction, time paradox, velocity transformation and velocity addition.

**Relativistic Mechanics:**
Force equation in relativity, rest mass, kinetic and total energy, conservation of energy and momentum.

**Elements of Tensor Calculus:** Manifolds and coordinates, curves and surfaces, tensor fields, Lie derivative, geodesics, Riemann tensor, metric tensor.

**Introduction to general relativity:**

**Cosmology:** Newtonian cosmology, cosmological red-shift, Hubble’s law, microwave background, the Big Bang expansion rate, matter and radiation domination, history of the universe.

**Books Recommended:**