CENTRAL UNIVERSITY OF RAJASTHAN

DEPARTMENT OF PHYSICS

Three Year Integrated M.Sc. B.Ed. Physics Program

Integrated 3 years M. Sc. B Ed. (Physics) 2017 onwards: Course Curriculum

Semester I Course	Credits	L	T	P	**Semester II** Course	Credits	L	T	P
PHY 401 Mathematical Methods in Physics	**4**	3	1	0	PHY 405 Classical Electrodynamics	**4**	3	1	0
PHY 402 Classical Mechanics	**4**	3	1	0	PHY 406 Statistical Mechanics	**4**	3	1	0
PHY 403 Quantum Mechanics I	**4**	3	1	0	PHY 407 Quantum Mechanics II	**4**	**3**	**1**	**0**
PHY 404 General Physics Lab	**4**	0	0	8	PHY 408 Electronics	**4**	**3**	**1**	**0**
ED 101 Basics of Education	**3**	3	0	0	PHY 409 Electronics Lab	**4**	0	0	8
ED 102 Senior Secondary Education in India- Status, Challenges and Strategies	**3**	3	0	0	ED 201 Philosophy of Physics	**3**	3	0	0
					ED 202 Learner and Learning	**3**	3	0	0
Total	**22**				**Total**	**26**			

Semester III Course	Credits	L	T	P	**Semester IV** Course	Credits	L	T	P
PHY 501 Condensed Matter Physics	**4**	3	1	0	PHY 410 Computational Physics Lab	**4**	0	0	8
PHY 502 Atomic and Molecular Physics	**4**	3	1	0	ED 401 Learning Assessment	**3**	3	0	0
PHY 503 Nuclear and Particle Physics	**4**	3	1	0	ED 402 Pedagogy of Physics - II	**4**	4	0	0
PHY 504 Advanced Physics Lab	**4**	0	0	8	ED 403 Classroom Organization and Management	**3**	3	0	0
ED 301 Teaching Approaches and Strategies	**3**	3	0	0	PHY 60X Open elective – II	**3**	0	0	0
ED 302 Pedagogy of Physics – I	**4**	4	0	0	PHY 60X Open elective – III	**3**	0	0	0
PHY 60X Open Elective - I	**3**	3	0	0					
Total	**26**				**Total**	**20**			

Semester V Course	Credits	L	T	P	**Semester VI** Course	Credits	L	T	P
ED 501 INTERNSHIP	**8**				PHY 505 Research Project	**15**	0	0	30
ED 502 INTERNSHIP AND TEACHING PRACTICE	**12**				ED 601 Education Project/Dissertation	**4**	0	0	8
Total	**20**				**Total**	**19**			

Total Credits: 80 + 53 = 133

PHY 401: MATHEMATICAL METHODS IN PHYSICS [Credits 4, 3-1-0]

Mathematics, as the saying goes, is the queen of all sciences. For a physicist, mathematics provides his mother tongue. Of late, we have realized that thorough knowledge of mathematics is a must not only in physics discipline but also in all other disciplines like chemistry, biology, economics *etc*. The mathematical physics course is so designed that a student learns mathematics and acquires enough practice and skills to apply what he has learnt to problems in all other subjects in physical sciences. More importantly this course trains a student into a mathematical way of thinking involving rigour and precision. What a student learns in this course will stand him in good stead in whatever vocation the student takes up in future, be it research, or teaching or science jobs.

Course Objectives:

- To expose the students to the fascinating world of real and complex numbers
- To make the students learn about special functions essential in solving physics problems
- To make them understand about Fourier series and Fourier transforms.

Learning Outcomes:

- The students will be able to compute determinants, eigenvalue problems, diagonalization of matrices in several areas of physics

Syllabus:

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals.

Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Tensors. Introductory group theory: SU(2), O(3). Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions).

Reference Books:

1. Mathematical Methods for Physics and Engineering. Ken Riley, Cambridge University Press India
2. George Arfken, Mathematical methods for Physicists, Academic Press.
3. Basic Training in Mathematics: A Fitness Program for Science Students - R. Shankar
4. Elements of group theory for physicists Joshi, A. W, New age international

5. Mathematical Methods in the Physical Sciences, Boas, Mary, Wiley India.
6. The mathematics of classical and quantum physics, Robert w. Fuller, Dover publications
7. Mathematics of physics and modern engineering. Ivan Stephen Sokolnikoff, Raymond M. Redheffer. McGraw-Hill
8. Advanced engineering mathematics, R. K. Jain, S. R. K. Iyengar, New age international
9. Matrices and tensors in physics, A. W. Joshi, New age international.

PHY 402: CLASSICAL MECHANICS [Credits 4, 3-1-0]

How and why things move the way they do? For a long time, we believed that for an object to move we require an agent. For example, we thought a chariot driven by seven horses carry then sun around. However, now we know that moving with a constant velocity is natural and does not require any external agent. We call it inertia. One needs the help of a force when one wants to change the velocity. Inertia is enshrined in the first law of Newton.

Course Objectives:

- The course on classical mechanics deals with Newton's laws of motion and several of its later metamorphoses like Euler Lagrange formulations, Hamilton Jacobi equations, Poission brackets *etc*.. It imparts knowledge on different formulations of mechanics; more importantly the Hamiltonian formulation with Poisson bracket prepares the students for quantum mechanics which is taught in two courses each of four credits. Besides, knowledge of classical mechanics is a must for studying non-linear dynamics and chaos. The subject of nonlinear dynamics and chaos has enormous scope for both basic and applied research.

Learning Outcomes:

- This course prepares the students for taking up work in nonlinear dynamics and chaos.

Syllabus:

Lagrangian and Hamiltonian Formulations of Mechanics, Calculus of variations, Hamilton's principle of least action, Lagrange's equations of motion, conservation laws, systems with a single degree of freedom, rigid body dynamics, symmetrical top, Hamilton's equations of motion, phase plots, fixed points and their stabilities.

Two-Body Central Force Problem

Equation of motion and first integrals, classification of orbits, Kepler problem, scattering in central force field.

Small Oscillations

Linearization of equations of motion, free vibrations and normal coordinates, forced oscillations.

Hamiltonian Mechanics and Chaos

Canonical transformations, Poisson brackets, Hamilton-Jacobi theory, action-angle variables, perturbation theory, integrable systems, introduction to chaotic dynamics.

Reference Books:

1. H. Goldstein, Classical Mechanics.
2. L.D. Landau and E.M. Lifshitz, Mechanics.
3. I.C. Percival and D. Richards, Introduction to Dynamics.
4. J.V. Jose and E.J. Saletan, Classical Dynamics: A Contemporary Approach.
5. E.T. Whittaker, A Treatise on the Analytical Dynamics of Particles and Rigid Bodies.
6. N.C. Rana and P.S. Joag, Classical Mechanics.
7. Upadhyaya J C, Classical Mechanics, Himalaya Publishing House.

PHY 403: QUANTUM MECHANICS -1 [Credits 4, 3-1-0]

Course Objectives:

- It is an experimental fact that often a particle behaves like a wave and a wave behaves like a particle. A wave with a precise wavelength (momentum) does not possess a precise location and vice versa. Such uncertainties in conjugate measurable properties and the consequences there of, constitute the essential content of quantum mechanics. Elementary quantum mechanics is the focus of this course.

Learning Outcomes:

- It is organized in such a way that a student at the end, is skilled enough to understand the advance level Quantum Mechanics

Syllabus:

Introduction
Inadequacy of classical concepts, wave-particle duality, electron diffraction, notion of state vector and its probability interpretation.

Structure of Quantum Mechanics
Operators and observables, significance of eigenfunctions and eigenvalues, commutation relations, uncertainty principle, measurement in quantum theory.

Quantum Dynamics
Time-dependent Schrödinger equation, stationary states and their significance, time-independent Schrödinger equation.

One-dimensional Schrödinger Equation
Free-particle solution, wave packets, particle in a square well potential, transmission through a potential barrier, simple harmonic oscillator by wave equation and operator methods, charged particle in a uniform magnetic field, coherent states.

Spherically Symmetric Potentials
Separation of variables in spherical polar coordinates, orbital angular momentum, parity, spherical harmonics, free particle in spherical polar coordinates, square well potential, hydrogen atom.

Reference Books:

1. C. Cohen-Tannoudji, B. Diu and F. Laloe, Quantum Mechanics (Volume I).
2. L.I. Schiff, Quantum Mechanics
3. E. Merzbacher, Quantum Mechanics
4. R.P. Feynman, Feynman Lectures on Physics (Volume 3)
5. R. Shankar, Principles of Quantum Mechanics

6. R. Eisberg & R Resnick, Quantum physics of atoms, molecules, solids, Wiley
7. Ishwar singh tyagi, Principles of quantum mechanics, Pearson
8. Modern approach to quantum mechanics, Johns townsend,Viva books

PHY404: General Physics Lab [Credits 4, 0-0-4]

Course Objectives:

The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments

Learning Outcomes:

At the end of this laboratory course, the students will be capable of handling sophisticated instruments besides learning the Physics concepts behind these experiments

Syllabus:

1. Measurement of Magnetic Susceptibility of Paramagnetic Solution by Quincks Method.
2. Hall Effects.
3. Fraunhofer Diffraction Pattern.
4. To determine the wavelength of laser using grating.
5. To Determine the Co-efficient of Rigidity as a Function of Temperature using Torsional Oscillator (Resonance Method).
6. Four Probe Method.
7. Faraday effect.
8. Other related experiments

Reference Books:

- A Text Book of Practical Physics, I.Prakash & Ramakrishna, 11th Ed., 2011,Kitab Mahal
- Advanced Practical Physics for Students, B.L. Worsnop, H.T. Flint
- BSc Practical Physics, Geeta Sanon, R. Chand & Co

PHY 405: Classical Electrodynamics [Credits 4, 3-1-0]

The equations of Maxwell that condense elegantly the vast experimental findings of Michael Faraday, his predecessors, and contemporaries, on electricity and magnetism constitute the course on electrodynamics. This course is important and interesting for the following reason. Maxwell remains the first of the physicists to unify - he unified the electricity and magnetism and brought them under a single umbrella. Maxwell's success at unification provided the impetus to subsequent unifications with the weak force and the strong nuclear force. However, gravity has eluded attempts to unification until now. The invariance of Maxwell's equations under Lorenz transformation provided the key to the special theory of relativity of Albert Einstein.

Course Objectives:

- To make the students learn about the unification of forces
- To give students the insights of special theory of relativity and quantum electrodynamics
- To make the students understand the propagation behavior of electromagnetic radiation in different media

Learning Outcomes:

- The students will be capable of understanding the underline Physics behind telecommunication
- This course will lay the foundation for the modern optics and photonics, ionosphere

Syllabus:

Electrostatics
Differential equation for electric field, Poisson and Laplace equations, formal solution for potential with Green's functions, boundary value problems, examples of image method and Green's function method, solutions of Laplace equation in cylindrical and spherical coordinates by orthogonal functions, dielectrics, polarization of a medium, electrostatic energy.

Magnetostatics
Biot-Savart law, differential equation for static magnetic field, vector potential, magnetic field from localized current distributions, examples of magnetostatic problems, Faraday's law of induction, magnetic energy of steady current distributions.

Maxwell's Equations
Displacement current, Maxwell's equations, vector and scalar potentials, gauge symmetry, Coulomb and Lorentz gauges, electromagnetic energy and momentum, conservation laws, inhomogeneous wave equation and Green's function solution.

Electromagnetic Waves

Plane waves in a dielectric medium, reflection and refraction at dielectric interfaces, frequency dispersion in dielectrics and metals, dielectric constant and anomalous dispersion, wave propagation in one dimension, group velocity, metallic wave guides, boundary conditions at metallic surfaces, propagation modes in wave guides, resonant modes in cavities.

Radiation

Field of a localized oscillating source, fields and radiation in dipole and quadrupole approximations, antenna, radiation by moving charges, Lienard-Wiechert potentials, total power radiated by an accelerated charge, Lorentz formula.

Covariant Formulation of Electrodynamics

Four-vectors relevant to electrodynamics, electromagnetic field tensor and Maxwell's equations, transformation of fields, fields of uniformly moving particles.

Concepts of Plasma Physics

Formation of plasma, Debye theory of screening, plasma oscillations, motion of charges in electromagnetic fields, magneto-plasma, plasma confinement, hydromagnetic waves.

Reference Books:

1. J.D. Jackson, Classical Electrodynamics
2. D.J. Griffiths, Introduction to Electrodynamics
3. J.R. Reitz, F.J. Milford and R.W. Christy, Foundations of Electromagnetic Theory
4. W.K.H. Panofsky and M. Phillips, Classical Electricity and Magnetism
5. F.F. Chen, Introduction to Plasma Physics and Controlled Fusion
6. Textbook of plasma physics, Suresh Chandra, CBS publisher

PHY 406: STATISTICAL MECHANICS [Credits 4, 3-1-0]

The time asymmetry in the behaviour of macroscopic bodies is captured in thermodynamics by the property called entropy; we have the inevitable entropic arrow of time. Contrast this with the time reversal invariance of microscopic laws be it classical or quantum mechanics, or electrodynamics. In the synthesis of macroscopic objects from its microscopic ingredients when and how does time asymmetry emerge? Ludwig Eduard Boltzmann answered this question by interpreting entropy, completely in terms of probabilities. After all, irreversibility is natural to a probabilistic evolution. Thus was born the subject of statistical mechanics which developed quickly and acquired certain robustness with the work of Josiah Willard Gibbs, James Clerk Maxwell and Albert Einstein.

Course Objectives:

- The methods of statistical ensembles and partition sums are very specific to the subject of Statistical Mechanics. An aim is to introduce the methodologies to the students so that they can apply it to the problems not only in statistical mechanics but in other fields also. A case in point is method of ensemble which has been carried over to Quantum Mechanics to provide an *Ad hoc* description of Quantum measurements

Learning Outcomes:

- At the end of the course a student would be able to competently employ a whole host of formalisms of statistical mechanics to a variety of problems in physics, chemistry, biology, computer science, economics and several other disciplines.

Syllabus:

Brief review of thermal physics
Extensive and intensive variables, laws of thermodynamics, entropy and Gibbs paradox, Legendre transformation, thermodynamic potentials, chemical potential, Jacobian determinant, Maxwell's relations and their applications.

Statistical description of many-particle systems
Binomial, Gaussian, and Poisson distributions, central limit theorem. Phase space, Liouville's theorem. Microstates and macrostates, statistical ensemble, statistical postulates, probability calculations, accessible states, constraint, equilibrium, irreversibility.

Equilibrium statistical mechanics
Microcanonical ensemble. Canonical ensemble: Boltzmann factor, Boltzmann distribution, canonical partition function and thermodynamic quantities, energy fluctuations, applications of canonical ensemble. Grand canonical ensemble: Gibbs factor, Gibbs distribution, grand partition function and thermodynamic quantities, particle number fluctuations, applications of grand

canonical ensemble. Equipartition theorem: proof of the theorem, applications, specific heat of solids. Maxwell–Boltzmann statistics.

Quantum statistics

Bosons: occupation number, Bose-Einstein statistics, specific heat of solids (Einstein model and Debye theory), black-body radiation, Bose-Einstein condensation. Fermions: occupation number, Fermi-Dirac statistics, degenerate Fermi gas.

Phase equilibria and phase transitions

Equilibrium condition, phase diagrams of some simple systems, Clausius-Clapeyron equation, critical point, first order and second order phase transitions, Ising model.

Reference Books:

1. Frederick Reif, Fundamentals of Statistical and Thermal Physics.
2. Mehran Kardar, Statistical Physics of Particles.
3. Daniel V. Schroeder, An introduction to thermal physics.
4. R. K. Pathria and Paul D. Beale, Statistical Mechanics (Third Edition).
5. L. D. Landau and E. M. Lifshitz, Statistical Physics, Third Edition, Part 1: Volume 5.
6. Kerson Huang, Statistical Mechanics (Second Edition).
7. Harvey Gould and Jan Tobochnik, Statistical and Thermal Physics: With Computer Applications.
8. James P. Sethna, Statistical Mechanics: Entropy, Order Parameters and Complexity.

PHY 407: QUANTUM MECHANICS - II [Credits 4, 3-1-0]

Course Objectives:

- Elementary quantum mechanics is taught in the first semester and after building the foundation, advanced quantum mechanics is taught in the second semester.

Learning Outcomes:

- Competent to take up research in frontier areas like quantum information, quantum computation, quantum entanglement, quantum fields and quantum gravity.
- Besides quantum mechanics for learning and appreciating phenomena in several other disciplines like condensed matter, statistical mechanics, optics

Syllabus:

Symmetry in Quantum Mechanics
Symmetry operations and unitary transformations, conservation principles, space and time translations, rotation, space inversion and time reversal, symmetry and degeneracy.

Angular Momentum
Rotation operators, angular momentum algebra, eigenvalues of J2 and Jz, spinors and Pauli matrices, addition of angular momenta.

Identical Particles
Indistinguishability, symmetric and antisymmetric wave functions, incorporation of spin, Slater determinants, Pauli exclusion principle.

Time-independent Approximation Methods
Non-degenerate perturbation theory, degenerate case, Stark effect, Zeeman effect and other examples, variational methods, WKB method, tunnelling.

Time-dependent Problems
Schrödinger and Heisenberg picture, time-dependent perturbation theory, transition probability calculations, golden rule, adiabatic approximation, sudden approximation, beta decay as an example.

Scattering Theory
Differential cross-section, scattering of a wave packet, integral equation for the scattering amplitude, Born approximation, method of partial waves, low energy scattering and bound states, resonance scattering. Relativistic quantum mechanics: Klein-Gordon and Dirac equations.

Reference Books:

1. C. Cohen-Tannoudji, B. Diu and F. Laloe, Quantum Mechanics (Volume II).
2. A. Messiah, Quantum Mechanics (Volume II).
3. S. Flügge, Practical Quantum Mechanics.
4. J.J. Sakurai, Modern Quantum Mechanics.
5. K. Gottfried, Quantum Mechanics.

PHY 408: ELECTRONICS [Credits 4, 3-1-0]

Course Objectives:

- To make the students familiar about the concepts of components used in various electronic devices
- To make the students learn the basics of digital electronics which will be useful to them in understanding the concept behind Digital India

Learning Outcomes:

- At the end of this course, the students will be able to understand the fundamentals behind analog and digital devices.

Syllabus:

Introduction
Survey of network theorems and network analysis, AC and DC bridges, transistors at low and high frequencies, FET.

Electronic Devices
Diodes, light-emitting diodes, photo-diodes, negative-resistance devices, p-n-p-n characteristics, transistors (FET, MoSFET, bipolar). Basic differential amplifier circuit, operational amplifier characteristics and applications, simple analog computer, analog integrated circuits.

Digital Electronics
Gates, combinational and sequential digital systems, flip-flops, counters, multi-channel analyzer.

Electronic Instruments
Power supplies, oscillators, digital oscilloscopes, counters, phase-sensitive detectors, introduction to micro-processors.

Reference Books:

1. P. Horowitz and W. Hill, The Art of Electronics.
2. J. Millman and A. Grabel, Microelectronics.
3. J.J. Cathey, Schaum's Outline of Electronic Devices and Circuits.
4. M. Forrest, Electronic Sensor Circuits and Projects.
5. W. Kleitz, Digital Electronics: A Practical Approach.
6. J.H. Moore, C.C. Davis and M.A. Coplan, Building Scientific Apparatus.

PHY 409: ELECTRONICS LAB [Credits 4, 0-0-4]

Course Objectives:

- To provide hands-on experience to the students to make them familiar with the working and handling of the components and electronic devices
- To make the students familiar with digital electronic components

Learning Outcomes:

- At the end of this laboratory, the students will be skilled enough to handle and understand the use of analog and digital devices.

Syllabus:

1. A/D Converter.
2. D/A Converter.
3. Study of Flip-Flops.
4. Study of transistor charactricts in all three modes
5. Study of half adder and full adder using NAND gate IC on Bread Board
6. Study of various gates using Omega Kit
7. Study of Astable, Mono, And Bi-stable Multivibrator Using IC 555 On Bread Board.
8. Study of Astable, Mono, And Bi-stable Multivibrator Using Omega Kit.
9. Decimal to BCD conversions
10. Study of Operation Amplifier.
11. Multiplexer
12. Regulated Power Supply

Reference Books:

1. P. Horowitz and W. Hill, The Art of Electronics.
2. J. Millman and A. Grabel, Microelectronics.
3. J.J. Cathey, Schaum's Outline of Electronic Devices and Circuits.
4. M. Forrest, Electronic Sensor Circuits and Projects.
5. W. Kleitz, Digital Electronics: A Practical Approach.
6. J.H. Moore, C.C. Davis and M.A. Coplan, Building Scientific Apparatus.

PHY 410: COMPUTATIONAL PHYSICS LAB [Credits 4, 0-0-4]

Course Objectives:

- To make the students learn essential aspects of a programming language, numerical techniques and their applications in a variety of Physics problems

Learning Outcomes:

- At the end of this laboratory, the students will be capable to use numerical ideas in diverse areas such as biological systems, economics, nonlinear dynamics

Syllabus:

Overview of computer organization, hardware, software, scientific programming in FORTRAN and/or C, C++.

Numerical Techniques

Sorting, interpolation, extrapolation, regression, numerical integration, quadrature, random number generation, linear algebra and matrix manipulations, inversion, diagonalization, eigenvectors and eigenvalues, integration of initial-value problems, Euler, Runge-Kutta, and Verlet schemes, root searching, optimization, fast Fourier transforms.

Simulation Techniques

Monte Carlo methods, molecular dynamics, simulation methods for the Ising model and atomic fluids, simulation methods for quantum-mechanical problems, time-dependent Schrödinger equation, discussion of selected problems in percolation, cellular automata, nonlinear dynamics, traffic problems, diffusion-limited aggregation, celestial mechanics, etc.

Parallel Computation

Introduction to parallel computation.

Reference Books:

1. V. Rajaraman, Computer Programming in Fortran 77.
2. W.H. Press, B.P. Flannery, S.A. Teukolsky and W.T. Vetterling, Numerical Recipes in FORTRAN 77: The Art of Scientific Computing. (Similar volumes in C, C++.)
3. H.M. Antia, Numerical Methods for Scientists and Engineers.
4. D.W. Heermann, Computer Simulation Methods in Theoretical Physics.
5. H. Gould and J. Tobochnik, An Introduction to Computer Simulation Methods.
6. J.M. Thijssen, Computational Physics.
7. Numerical methods : for scientific and engineering computation Jain, mahinder kumar, Iyengar, New age international

PHY 501: CONDENSED MATTER PHYSICS [Credits 4, 3-1-0]

The theoretical basis for condensed matter physics comes from quantum mechanics and statistical mechanics. Having said this, we recognize that condensed matter physics stands apart as a distinct subject with its characteristic idioms and empiricism. Condensed matter physics deals with several issues about how matter behaves and why does it behave the way it does. Condensed matter is one of the most technologically useful subjects; for we need more and more materials with different properties to meet the needs of technology. Condensed matter physics is undoubtedly the most important area of research in the recent times. Almost all the universities and institutes have elaborate research programs in theoretical and experimental condensed matter physics. Nano science, graphenes, fullerines, high temperature superconductivity etc. have emerged as areas of importance in the recent times; there is virtually unlimited scope for research and development in these new and emerging areas.

Course Objectives:

- To make the students familiar with the structures having regular and irregular arrangements of atoms, their bonding etc.
- The use of quantum mechanics in explaining the peculiar behaviour of materials
- To understand various exotic properties of materials under different length scales

Learning Outcomes:

- At the end of this course, the students will be able to understand various physical phenomena and the reasons behind them

Syllabus:

Metals
Drude theory, DC conductivity, Hall effect and magneto-resistance, AC conductivity, thermal conductivity, thermo-electric effects, Fermi-Dirac distribution, thermal properties of an electron gas, Wiedemann-Franz law, critique of free-electron model.

Crystal Lattices
Bravais lattice, symmetry operations and classification of Bravais lattices, common crystal structures, reciprocal lattice, Brillouin zone, X-ray diffraction, Bragg's law, Von Laue's formulation, diffraction from non-crystalline systems.

Classification of Solids
Band classifications, covalent, molecular and ionic crystals, nature of bonding, cohesive energies, hydrogen bonding.

Electron States in Crystals
Periodic potential and Bloch's theorem, weak potential approximation, energy gaps, Fermi surface and Brillouin zones, Harrison construction, level density.

Electron Dynamics
Wave packets of Bloch electrons, semi-classical equations of motion, motion in static electric and magnetic fields, theory of holes.

Lattice Dynamics
Failure of the static lattice model, harmonic approximation, vibrations of a one-dimensional lattice, one-dimensional lattice with basis, models of three-dimensional lattices, quantization of vibrations, Einstein and Debye theories of specific heat, phonon density of states, neutron scattering.

Semiconductors
General properties and band structure, carrier statistics, impurities, intrinsic and extrinsic semiconductors, p-n junctions, equilibrium fields and densities in junctions, drift and diffusion currents.

Reference Books:

1. C. Kittel, Introduction to Solid State Physics.
2. N.W. Ashcroft and N.D. Mermin, Solid State Physics.
3. J.M. Ziman, Principles of the Theory of Solids.
4. A.J. Dekker, Solid State Physics.
5. G. Burns, Solid State Physics.
6. M.P. Marder, Condensed Matter Physics.

PHY 502: ATOMIC AND MOLECULAR PHYSICS [Credits 4, 3-1-0]

Course Objectives:

- To make the students understand Quantum mechanical phenomenon at the atomic and molecular level
- To make the students understand various couplings effects
- To make the students understand about various absorption/emission spectroscopic transitions

Learning Outcomes:

- The students will be able to understand the normal and anomalous splitting of atomic and molecular energy levels
- The students will be capable to understand ultraviolet-visible-infrared spectroscopy
- The students will be understand the spectroscopy of non-polar molecules using Raman effect

Syllabus:

Many-electron Atoms
Review of He atom, ground state and first excited state, quantum virial theorem, Thomas-Fermi method, determinantal wave function, Hartree and Hartree-Fock method, periodic table and atomic properties: ionization potential, electron affinity, Hund's rule.

Molecular Quantum Mechanics
Hydrogen molecular ion, hydrogen molecule, Heitler-London method, molecular orbital, Born-Oppenheimer approximation, bonding, directed valence.

Atomic and Molecular Spectroscopy
Fine and hyperfine structure of atoms, electronic, vibrational and rotational spectra for diatomic molecules, role of symmetry, selection rules, term schemes, applications to electronic and vibrational problems.

Second Quantization
Basis sets for identical-particle systems, number space representation, creation and annihilation operators, representation of dynamical operators and the Hamiltonian, simple applications.

Interaction of Atoms with Radiation
Atoms in an electromagnetic field, absorption and induced emission, spontaneous emission and line-width, Einstein A and B coefficients, density matrix formalism, two-level atoms in a radiation field.

Reference Books:

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles, Eisberg & Resnick, Wiley India
2. M. Karplus and R.N. Porter, Atoms and Molecules: An Introduction for Students of Physical Chemistry.
3. P.W. Atkins and R.S. Friedman, Molecular Quantum Mechanics.
4. M. Tinkham, Group Theory and Quantum Mechanics.
5. L. Fetter and J. D. Walecka, Quantum Theory of Many-Particle Systems.
6. W.A. Harrison, Applied Quantum Mechanics.

PHY 503: NUCLEAR AND PARTICLE PHYSICS [Credits 4, 3-1-0]

The nuclear and particle physics course is the fundamental course of physics. In the quest of knowing about the fundamental building blocks of the matter, scientists have gone through a sequence from atoms to nuclei, from nuclei to hadrons and from hadrons to quarks. The course, designed here for the M.Sc. physics students incorporates several properties of the nucleus and their detailed deliberations.

Course Objectives:

The objectives of the course are as under:

- To familiarize about the essential properties of the nucleus such as its shape, size, radius, density, magnetic moment, electric quadrupole moment etc.
- In order to probe these properties several models have been proposed such as liquid drop model, shell models, collective models
- The most useful part of this knowledge is the nuclear energy which has immense applications. The concept behind this energy was first given by Hans Bethe in the form of semi-empirical mass formula which is in the course content.
- Carbon dating, modern medical applications, radio-physics all require the knowledge of radio-activity. One complete unit is dedicated for this purposes
- It is a well-known fact that all kind of interactions which we perceive in our life are essentially four in number viz. gravitational, electromagnetic, weak and strong. The ultimate aim of particle physics is to unify these interactions.

Learning Outcomes:

- Students will be enriched with the fundamental knowledge of the nucleus and its properties
- The principles behind the modern medical instruments such as nuclear magnetic resonances will be clear to the students
- Students will be enshrined in detail about the radiation hazards, peaceful use of nuclear energy and carbon dating for fossil’s age determination
- The students will be able to do higher studies in this field. They may get employment opportunities in radiology and medical field

Syllabus:

Nuclear Physics

Discovery of the nucleus, Rutherford formula, form factors, nuclear size, characteristics of nuclei, angular momentum, magnetic moment, parity, quadrupole moment. Mass defect, binding-energy statistics, Weiszacker mass formula, nuclear stability, Alpha-decay, tunnelling theory, fission, liquid drop model. Nuclear forces, nucleon-nucleon scattering, deuteron problem, properties of nuclear potentials, Yukawa's hypothesis. Magic numbers, shell model, calculation of nuclear parameters, basic ideas of nuclear reactions.

Particle Physics

Relativistic quantum theory, Dirac's equation and its relativistic covariance, intrinsic spin and magnetic moment, negative energy solution and the concept of antiparticle.

Accelerators and detectors, discovery of mesons and strange particles, isospin and internal symmetries, neutrino oscillations, quarks, parity violation, K-mesons, CP violation.

Weak Interactions

Fermi's theory of beta-decay, basic ideas of gauge symmetry, spontaneous symmetry breaking, elements of electro-weak theory, discovery of W-bosons.

Strong Interactions

Deep inelastic scattering, scaling concepts, quark model interpretation, colour quantum number, asymptotic freedom, quark confinement, standard model.

Reference Books:

1. G.D. Coughlan and J.E. Dodd, The Ideas of Particle Physics.
2. D. Griffiths, Introduction to Elementary Particles.
3. D.H. Perkins, Introduction to High Energy Physics.
4. R.R. Roy and B.P. Nigam, Nuclear Physics.
5. M.A. Preston and R.K. Bhaduri, Structure of the Nucleus.
6. M.G. Bowler, Nuclear Physics.

PHY 504: ADVANCED PHYSICS LAB [Credits 4, 0-0-4]

Course Objectives:

The aim of this laboratory course is to make the students perceive some of the fundamental laws of Physics through experiments

Learning Outcomes:

At the end of this laboratory course, the students will be capable of handling sophisticated instruments besides learning the Physics concepts behind these experiments

Syllabus:

1. Measurement of Magnetic Susceptibility of Paramagnetic Solution by Quincks Method.
2. Hall Effects. Fraunhofer Diffraction Pattern.
3. To determine the wavelength of laser using grating.
4. To Determine the Co-efficient of Rigidity as a Function of Temperature using Torsional Oscillator (Resonance Method).
5. Four Probe Method.
6. Faraday effect.

PHY 505: PROJECT [15 credits]

The project helps the student to experience science in action. The student gets to know how the knowledge he/she has gained can be put to use to solve real life problems. The student gains insight into different steps involved in science research - literature survey, getting to know various methods of solving the problem on hand, deciding the right approach and eventually solving the problem assigned.

Course Objective:

- The aim of the project is to provide glimpses of latest research going on in various areas of Physical sciences.

Learning Outcome:

- The completion of the successful project will prepare the students for higher level research