SHAHEED BENAZIR BHUTTO WOMEN UNIVERSITY
PESHAWAR

CURRICULUM FOR M.Sc-PHYSICS
SESSION (2018-onwards)

PHYSICS

DEPARTMENT OF PHYSICS
CURRICULUM
M.Sc-PHYSICS
<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
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<td>1st</td>
<td>PHY-511</td>
<td>Mathematical Methods of Physics-I</td>
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<td>PHY-512</td>
<td>Electrodynamics-I</td>
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<td>PHY-513</td>
<td>Classical Mechanics</td>
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<td>Statistical Physics</td>
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<td>PHY-515</td>
<td>Modern Physics</td>
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<td>PHY-518</td>
<td>Quantum Mechanics-I</td>
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<td>PHY-621</td>
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<td>PHY-623</td>
<td>Solid state Physics-I</td>
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<td>PHY-624</td>
<td>Lab-VII</td>
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<td>Research Project/Two Elective Courses</td>
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Total Credit Hours: 70
## List of Elective courses

<table>
<thead>
<tr>
<th>S.No</th>
<th>Course Codes</th>
<th>Electives</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td>1.</td>
<td></td>
<td>Introduction to Plasma Physics</td>
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<td>2.</td>
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<td>Introduction to Material Science</td>
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<td>3.</td>
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<td>Environmental Physics</td>
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<td>4.</td>
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<td>Renewable energy Resources</td>
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<tr>
<td>5.</td>
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<td>Computer Simulations in Physics</td>
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<td>6.</td>
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<td>Computational Physics</td>
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<td>7.</td>
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<td>Methods of Experimental Physics</td>
<td>3</td>
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<td>8.</td>
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<td>Introduction to Lasers Physics</td>
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<td>10.</td>
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<td>Functional Material</td>
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<td>11.</td>
<td></td>
<td>Introduction to Nanoscience &amp; Nanotechnology</td>
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M.Sc-PHYSICS
SEMESTER-I
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<tr>
<th>Course Code</th>
<th>PHY-511</th>
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<tr>
<td>Course Title</td>
<td>Mathematical Methods of Physics-I</td>
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<tr>
<td>Credit Hours</td>
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</tr>
<tr>
<td>Prerequisite / Co requisite</td>
<td>Mechanics, Differential Equations, Linear Algebra / None</td>
</tr>
<tr>
<td>Remarks</td>
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**Course Description**

Partial Differential Equations: Introduction to important PDEs in Physics (wave equation, diffusion equation, Poisson’s equation, Schrodinger’s equation), general form of solution, general and particular solutions (first order, inhomogeneous, second order), characteristics and existence of solutions, uniqueness of solutions, separation of variables in Cartesian coordinates, superposition of separated solutions, separation of variables in curvilinear coordinates, integral transform methods, Green’s functions  

Complex Analysis: Review of polar form of complex numbers and de Moivre’s theorem, complex logarithms and powers, functions of a complex variable, Cauchy-Riemann conditions, power series in a complex variable and analytic continuation with examples, multi-valued functions and branch cuts, singularities and zeroes of complex functions, complex integration, Cauchy’s theorem, Cauchy’s integral formula, Laurent series and residues, residue integration theorem, definite integrals using contour integration.

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<tr>
<th>Course Code</th>
<th>PHY-512</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Electrodynamics-I</td>
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<td>Credit Hours</td>
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</tr>
<tr>
<td>Prerequisite / Co requisite</td>
<td>Electricity &amp; Magnetism, Calculus-II / None</td>
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<td>Remarks</td>
<td>Maj-8</td>
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**Course Description**

**The Dirac Delta Function:** Review of vector calculus using example of Dirac Delta function, the divergence of r/r², the one-dimensional and the three dimensional Dirac delta functions. The theory of vector fields: the Helmholtz theorem, potentials.

**Electrostatics:** The electric field: introduction, Coulomb’s law, the electric field, continuous charge distributions. Divergence and curl of electrostatic fields: field lines, flux and Gauss’s law, the divergence of E, applications of Gauss’s law, the curl of E. Electric potential: introduction to potential, comments on potential, Poisson’s equation and Laplace’s equation, the potential of a localized charge distribution, summary, electrostatics boundary conditions, Work and energy in electrostatics: the work done to move a charge, the energy of a point charge distribution, the energy of a continuous charge distribution, comments on electrostatic energy. Conductors: basic properties, induced charges, surface charge and the force on a conductor, capacitors.

**Special Techniques:** Laplace’s equation: introduction, Laplace’s equation in one, two and three dimensions, boundary conditions and uniqueness theorems, conductors and second uniqueness theorems.

**The Method of Images:** The classic image problem, induced surface charge, force and energy, other image problems.
**Multi-pole Expansion:** Approximate potential at large, the monopole and dipole terms, origin of coordinates in multi-pole, expansions, the electric field of a dipole.

**Electric Fields in Matter: Polarization:** dielectrics, induced dipoles, alignment of polar molecules, polarization. The field of a polarized object: bound charges, physical interpretation of bound charges, and the field inside a dielectric. The electric displacement: Gauss’s law in the presence of dielectrics, a deceptive parallel, boundary conditions. Linear Dielectrics: susceptibility, permittivity, dielectric constant, boundary value problems with linear dielectrics, energy in dielectric systems, forces on dielectrics.

**Magnetostatics:** The Lorentz Force law: magnetic fields, magnetic forces, currents. The Biot-Savart Law: steady currents, the magnetic field of a steady current. The divergence and curl of B: straight-line currents, the divergence and curl of B, applications of Ampere’s law, comparison of magnetostatics and electrostatics.

Magnetic Vector Potential: the vector potential, summary, magnetic boundary conditions, multi-pole expansion of the vector potential.

**Magnetic Fields in Matter:** Magnetization, diamagnets, paramagnets, ferromagnets, torques and forces on magnetic dipoles, effect of a magnetic field on atomic orbits, magnetization. The Field of a Magnetized Object: bound currents, physical interpretation of bound currents, and the magnetic field inside matter. The auxiliary field H: Ampere’s law in magnetized materials, a deceptive parallel, boundary conditions. Linear and nonlinear media: magnetic susceptibility and permeability, ferromagnetism.

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<tr>
<th>Course Code</th>
<th>PHY-513</th>
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<tr>
<td>Course Title</td>
<td>Classical Mechanics</td>
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<td>Credit Hours</td>
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<td>Prerequisite / Co requisite</td>
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<td>Course Description</td>
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<td>----------------------------------------------------------------------------------</td>
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<tr>
<td><strong>Review of Newtonian Mechanics:</strong> Frame of reference, orthogonal transformations,</td>
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<tr>
<td>angular velocity and angular acceleration, Newton’s laws of motion, Galilean</td>
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<tr>
<td>transformation, conservation laws, systems of particles, motion under a constant</td>
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<tr>
<td>force, motions under variable force, time-varying mass system.</td>
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<tr>
<td><strong>The Lagrange Formulation of Mechanics and Hamilton Dynamics:</strong></td>
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<tr>
<td>Generalized co-ordinates and constraints, D’Alembert’s principle and Lagrange’s</td>
<td></td>
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<tr>
<td>Equations, Hamilton’s principle, integrals of motion, non conservative system and</td>
<td></td>
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<tr>
<td>generalized potential, Lagrange’s multiplier method, the Hamiltonian of a dynamical system, canonical equations, canonical transformations, Poisson brackets, phase space and Liouville’s theorem.</td>
<td></td>
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<tr>
<td><strong>Central Force Motion:</strong> The two-body problem, effective potential and classification of orbits, Kepler’s laws, stability of circular orbits, hyperbolic orbits and Rutherford scattering, center of mass co-ordinate system, scattering cross-sections.</td>
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<tr>
<td><strong>Motion in Non-inertial Systems:</strong> Accelerated translational co-ordinate system,</td>
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<tr>
<td>dynamics in rotating co-ordinate system, motion of a particle near the surface of the earth.</td>
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<tr>
<td><strong>The Motion of Rigid Bodies:</strong> The Euler angles, rotational kinetic energy and angular momentum, the inertia tensor, Euler equations of motion, motion of a torque-free symmetrical top, stability of rotational motion.</td>
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<td>Course Title</td>
<td>Statistical Physics</td>
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<td>Credit Hours</td>
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<td>Heat &amp; Thermodynamics, Calculus-II, Statistics /None</td>
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<td>Course Code</td>
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<tr>
<td>Prerequisite</td>
<td>Mechanics, Electric &amp; Magnetism / None</td>
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Course Description

**Motivation for Non-Classical Physics:** Quantum interference, blackbody radiation and ultraviolet catastrophe, Planck's quantization.

**Wace-Particle Duality:** Photoelectric effect, Compton effect, production and properties of X-rays, diffraction of X-rays, concept of matter waves, de Broglie relationship, electrons are waves, electron diffraction, particulate nature of matter, contributions of Faraday (atoms exist), Thomson (electron exists), Rutherford (nucleus exists) and Bohr (quantization of energies inside an atom), wave packets and wave groups, dispersion, Heisenberg uncertainty principle, direct confirmation of quantization through Franck-Hertz experiment and spectroscopy, working of electron microscopes.

**Quantum Mechanics in One Dimension:** The concept of a wavefunction, time independent Schrodinger equation and interpretation of the equation, solving the Schrodinger equation for a free particle, for a particle inside an infinite box, relationship between confinement and quantization, working of a CCD camera.

**Quantum Mechanical Tunneling:** Concept of tunneling, reflection and transmission of wave functions from barriers, applications: radioactivity, scanning tunneling microscope, decay of black holes.

**Quantum Mechanics in Three Dimensions:** The Hydrogen atom, orbitals, angular momentum and its quantization, orbital magnetism, Zeeman effect, concept of spin, Pauli’s exclusion principle, Building of the periodic table, magnetic resonance and MRI, why is iron magnetic? White dwarfs, and neutron stars.

**From Atoms to Molecules and Solids:** Ionic bonds, covalent bonds, hydrogen bonds,
molecular orbitals, how crystals are different from amorphous solids? Why and how do metals conduct electricity? Bands in solids, semiconductors, introduction to LED's and lasers, introducing graphene.

**Nuclear Structure:** Size and structure of nucleus, nuclear forces, radioactivity and nuclear reactions, radiocarbon dating.

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<tr>
<td>Course Title</td>
<td>LAB-V (Electronics)</td>
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<tr>
<td>Credit Hours</td>
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**Course Description**

**Electronics:**

**List of Experiments**

1. Determination of e/m of an electron.
2. Determination of ionization potential of mercury.
3. Characteristics of a semiconductor diode (Compare Si with Ge diode)
4. Setting up of half & full wave rectifier & study of following factors
5. Smoothing effect of a capacitor
6. Ripple factor & its variation with load.
7. Study of regulation of output voltage with load.
8. To set up a single stage amplifier & measure its voltage gain and band width.
9. To set up transistor oscillator circuit and measure its frequency by an oscilloscope.
10. To set up and study various logic gates (AND, OR, NAND etc.) using diode and to develop their truth table.
11. To set up an electronic switching circuit using transistor LDR and demonstrate its use as a NOT Gate.
13. To study the characteristic curves of a G. M. counter and use it to determine the absorption co-efficient of β-particle in Aluminum.
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<tr>
<td>14.</td>
<td>Determination of range of $\alpha$-particles.</td>
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<td>15.</td>
<td>Mass absorption coefficient of lead for $\gamma$-rays using G.M counter.</td>
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<td>16.</td>
<td>Use of computer in the learning of knowledge of GATE and other experiments.</td>
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**M.Sc-PHYSICS**

**SEMESTER-II**
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<td>Mathematical Methods of Physics-I</td>
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| Course Description | **Group Theory and Representations for finite groups:** Transformations, groups definitions and examples, subgroups and Cayley’s theorem, cosets and Lagrange’s theorem, conjugate classes, invariant subgroups, factor groups, homomorphism, direct products, mappings, linear operators, matrix representations, similarity transformation and equivalent matrix representations, group representations, equivalent representations and characters, construction of representations and addition of representations, invariance of functions and operators, unitary spaces and Hermitian matrices, operators: adjoint, self-adjoint, unitary, Hilbert space, reducibility of representations, Schur’s lemmas, orthogonality relations, group algebra, expansion of functions in basis of irreducible representations, Kronecker product, symmetrized and anti-symmetrized representations, adjoint and complex-conjugate representations, real representations, Clebsch-Gordan series and coefficients, applications of these ideas to classification of spectral terms, perturbation theory and coupled systems
**Tensor Analysis:** Vector calculus (differentiation, integration, space curves, multivariable vectors, surfaces, scalar and vector fields, gradient, divergence and curl, cylindrical and spherical coordinates, general curvilinear coordinates), change of basis, Cartesian tensor as a geometrical object, order/rank of a tensor, tensor algebra, quotient
law, pseudotensors, Kronecker delta and Levi cevita, dual tensors, physical applications, integral theorems for tensors, non-Cartesian tensors, general coordinate transformations and tensors, relative tensors, Christoffel symbols, covariant differentiation, vector operators in tensor form, absolute derivatives along curves, geodesics.

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<td>Course Title</td>
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<tr>
<td>Credit Hours</td>
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<td>Prerequisite / Co requisite</td>
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<td>Remarks</td>
<td>Maj-1</td>
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<td>Course Description</td>
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**Waves and Particles: Introduction to the fundamental ideas of quantum mechanics:** Electromagnetic waves and photon, material particles and matter waves, quantum description of a particle, wave packets, particle in a time-independent scalar potential, order of magnitude of the wavelength associated with material particles, constraints imposed by uncertainty relations, one-dimensional Gaussian wave packet: Spreading of the wave packet, stationary states of a particle in one-dimensional square potential, behavior of a wave packet at a potential step.

**The Mathematical Tools of Quantum Mechanics:** One-particle wave function space, state space, Dirac notation, representations in the state space, observable, representations, review of some useful properties of linear operators, unitary operators, study of the $\{\lvert r \rangle\}$ and $\{\lvert P \rangle\}$ representations, some general properties of two observable, $Q$ and $P$, whose commutator is equal to $i\hbar$, the two-dimensional infinite well.

**The Postulates of Quantum Mechanics:** Statement of the postulates and their physical interpretation, the physical implications of the Schrodinger equation, the superposition principle, particle in an infinite potential well, study of the probability current in some special case, root-mean-square deviations of two conjugate observables, the density and evolution operators, Schrodinger and Heisenberg pictures, Gauge invariance, bound states of a particle in a potential well of arbitrary shape, unbound states of a particle in...
the presence of a potential well or barrier of arbitrary shape, quantum properties of a particle in a one-dimensional periodic structure.

**Application of The Postulates to Simple Cases: Spin ½ And Two-Level Quantum Systems:** Spin ½ particles, quantization of the angular momentum, illustration of the postulates in the case of a spin ½, general study of two level systems, Pauli matrices, diagonalization of a 2×2 hermitian matrix, System of two spin ½ particles, Spin ½ density matrix, Spin ½ particle in a static magnetic field and a rotating field, Magnetic resonance.

**The One-Dimensional Harmonic Oscillator:** Importance of the harmonic oscillator in physics, eigenvalues and eigenstates of the Hamiltonian, mean value and root-mean-square deviations of \( \dot{X} \) and \( \dot{P} \) in state \( |q_n \rangle \), Some examples of harmonic oscillators, study of the stationary states in the \( \{|p \rangle \} \) representation, Hermite polynomials, solving the Eigenvalues of the harmonic oscillators by the polynomial method, study of the stationary states in the \( \{|P \rangle \} \) representation, isotropic three-dimensional harmonic oscillator, charged harmonic oscillator placed in a uniform electric field, coherent states, Normal vibrational modes of coupled harmonic oscillators, vibrational modes of an infinite linear chain of coupled harmonic oscillators, phonons, one dimensional harmonic oscillator in thermodynamics equilibrium at a temperature \( T \).

**General Properties of Angular Momentum in Quantum Mechanics:** concept of angular momentum in quantum mechanics, commutation relations, application to orbital angular momentum, spherical harmonics, rotation operators, rotation of diatomic molecules, angular momentum of stationary states of a two-dimensional harmonic oscillator, charged particle in a magnetic field and Landau levels.

**Particle in a Central Potential:** The Hydrogen atom, Stationary states of a particle in a central potential, motion of the center of mass and relative motion for a system of two interacting particles, Hydrogen atom, Hydrogen like systems, A solvable example of a central potential: the isotropic three dimensional harmonic oscillator, probability currents associated with the stationary states of the hydrogen atom, The hydrogen atom placed in a uniform magnetic field, para-magnetism and diamagnetism, Zeeman effect, study of some atomic orbitals, vibrational-rotational levels of diatomic molecules.

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<tbody>
<tr>
<td>Course Title</td>
<td>Electrodynamics-II</td>
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<tr>
<td>Credit Hours</td>
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<tr>
<td>Prerequisite / Co requisite</td>
<td>Electrodynamics-I / None</td>
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<tr>
<td>Remarks</td>
<td>Maj-9</td>
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</table>
Course Description

**Electrodynamics:** Electromotive force: Ohm’s law, electromotive force, motional emf, electromagnetic induction: Faraday’s law, the induced electric field, inductance, energy in magnetic fields, Maxwell’s equations: electrodynamics before Maxwell, how Maxwell fixed Ampere’s law, Maxwell’s equations, magnetic charges, Maxwell’s equations in matter, boundary conditions.

**Conservation Laws:** Charge and energy: the continuity equation, Poynting’s theorem, momentum: Newton’s third law in electrodynamics, Maxwell’s stress tensor, conservation of momentum, angular momentum.

**Electromagnetic Waves:** Waves in one dimension: the wave equation, sinusoidal waves, boundary conditions, reflection and transmission, polarization, electromagnetic waves in vacuum: the wave equation for E and B, monochromatic plane waves, energy and momentum in electromagnetic waves, electromagnetic waves in matter: propagation in linear media, reflection and transmission at normal incidence, reflection and transmission at oblique incidence, absorption and dispersion: electromagnetic waves in conductors, reflection at a conducting surface, the frequency dependence of permittivity, guided waves: wave guides, the waves in a rectangular wave guide, the coaxial transmission line.

**Potentials and Fields:** The potential formulation: scalar and vector potentials, gauge transformations, Coulomb gauge and Lorentz gauge, continuous distributions: retarded potentials, Jefimenko’s equations, point charges: Lienard-Wiechert potentials, the field of a moving point charge.

**Radiation, Dipole Radiation:** What is radiation, electric dipole radiation, magnetic dipole radiation, radiation from an arbitrary source, point charges: power radiated by a point charge, radiation reaction, the physical basis of the radiation reaction.

**Electrodynamics and Relativity:** The special theory of relativity: Einstein’s postulates, the geometry of relativity, the Lorentz transformations, the structure of space-time, relativistic mechanics: proper time and proper velocity, relativistic energy and momentum, relativistic kinematics, relativistic dynamics, relativistic electrodynamics: magnetism as a relativistic phenomenon, how the field transform, the field tensor, electrodynamics in tensor notation, relativistic potentials.

<p>| Course Code | PHY-520 |</p>
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Electronics-I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit Hours</td>
<td>3</td>
</tr>
<tr>
<td>Prerequisite /</td>
<td>Modern Physics /None</td>
</tr>
<tr>
<td>Co requisite</td>
<td></td>
</tr>
<tr>
<td>Remarks</td>
<td>Maj-4</td>
</tr>
</tbody>
</table>
| Course Description| The Semiconductor Diode: Metals, insulators and semiconductors, Conduction in Silicon and Germanium, The forbidden energy gap, n and p type semiconductors, the junction diode, diode voltage-current equation, Zener diodes, light emitting diodes, photodiodes, capacitance effects in the pn junction.  
The Diode as Rectifier and Switch: The ideal diode model, the half wave rectifier, the full wave rectifier, the bridge rectifier, measurement of ripple factor in the rectifier circuit, the capacitor filter, the Π filter, the Π-R filter, the voltage doubling rectifier circuit, rectifying AC voltmeters, diode wave clippers, diode clammers.  
Circuit Theory and Analysis: Superposition theorem, Thevenin’s Theorem, Norton’s Theorem, Model for circuit, one port and two-port network, Hybrid parameter equivalent circuit, Power in decibels.  
The Junction Transistor as an Amplifier: Transistor voltage and current designations, the junction transistors, the volt-ampere curve of a transistor, the current amplification |

18
factors, the load line and Q point, the basic transistor amplifiers, the common emitter amplifier, the trans-conductance gm, performance of a CE amplifier, relation between Ai and Av, the CB amplifier, the CC amplifier, comparison of amplifier performance.

**DC Bias for the Transistor:** Choice of Q point, variation of Q point, fixed transistor bias, the four resistor bias circuit, design of a voltage feedback bias circuit, Common emitter, common collector, common base biasing.

**Field Effect Transistor:** What is field effect transistor, JFET: Static characteristics of JFET, Metal oxide semiconductor Field Effect Transistor (MOSFET of IGFET): enhancement and depletion mode, FET biasing techniques, Common drain, common source and common gate, fixed bias and self-bias configurations, Universal JFET bias curve, Darlington pair.

**Operational Amplifiers:** The integrated amplifier, the differential amplifier, common mode rejection ratio, the operational amplifier, summing operation, integration operation, comparator, milli-voltmeter.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>PHY-521</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Atomic &amp; Molecular Physics</td>
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<tr>
<td>Credit Hours</td>
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<tr>
<td>Prerequisite / Co requisite</td>
<td>Quantum Mechanics-I / Quantum Mechanics-II</td>
</tr>
<tr>
<td>Remarks</td>
<td>Maj-14</td>
</tr>
</tbody>
</table>

**Course Description**

**One Electron Atoms:** Review of Bohr Model of Hydrogen Atom, Reduced Mass, Atomic Units and Wavenumbers, Energy Levels and Spectra, Schrodinger Equation for One-Electron Atoms, Quantum Angular Momentum and Spherical Harmonics, Electron


**Many-Electron Atoms:** Schrodinger Equation for Two-Electron Atoms, Para and Ortho States, Pauli’s Principle and Periodic Table, Coupling of Angular Momenta, L-S and J-J Coupling. Ground State and Excited States of Multi- Electron Atoms, Configurations and Terms.


<table>
<thead>
<tr>
<th>Course Code</th>
<th>PH-522</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>LAB-VI (Modern Physics)</td>
</tr>
<tr>
<td>Credit Hours</td>
<td>2</td>
</tr>
<tr>
<td>Prerequisite / Co requisite</td>
<td>Modern Physics / None</td>
</tr>
<tr>
<td>Remarks</td>
<td>Maj-17</td>
</tr>
</tbody>
</table>

**Modern Physics:**

**List of Experiments:**
1. To study the characteristics of a Geiger-Muller counter and to examine the attenuations of beta particles in Al-and Pb foils.
4. To study the characteristics of a solid-state detector and use it to measure the spectra of alpha and beta particles.
5. Use of a Lithium-drifted Ge-counter for gamma spectroscopy and to compare its
performance with that of a NA l-detector.
6. AC circuits and dielectric constants of water and ice.
7. Radio frequency measurement. Skin-effect, etc.
8. Experiments with transmission lines.
M.Sc-PHYSICS
SEMESTER-III
<table>
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<tr>
<th><strong>Course Code</strong></th>
<th>PHY-621</th>
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<tbody>
<tr>
<td><strong>Course Title</strong></td>
<td>Quantum Mechanics-II</td>
</tr>
<tr>
<td><strong>Credit Hours</strong></td>
<td>3</td>
</tr>
<tr>
<td><strong>Prerequisite / Co requisite</strong></td>
<td>Quantum Mechanics-I / None</td>
</tr>
<tr>
<td><strong>Remarks</strong></td>
<td>Maj-2</td>
</tr>
</tbody>
</table>

**Course Description**

**Addition of Angular Momenta:** Total angular momentum in classical mechanics, total angular momentum in quantum mechanics, addition of two spin ½ angular momenta, addition of two arbitrary angular momenta, Clebsch-Gordon coefficients, addition of spherical harmonics, vector operators, Wigner-Eckart theorem, electric Multi-pole moments, Evolution of two angular momenta $J_1$ and $J_2$ coupled by an interaction $aJ_1 \cdot J_2$.

**Stationary Perturbation Theory:** Description of the method, perturbation of a non-degenerate level, perturbation of a degenerate level, one-dimensional harmonic oscillator subjected to a perturbing potential, interaction between the magnetic dipoles of two spin ½ particles, Van der Waals forces, volume effect and The influence of the spatial extension of the nucleus on the atomic levels, variational method, energy bands of electrons in solids, a simple example of the chemical bond: The $\text{H}_2^+$ ion.

**Applications of Perturbation Theory to Atomic Systems:** fine and hyperfine structure of atomic levels in hydrogen, Calculation of the mean values of the spin-orbit coupling in the 1s, 2s and 2p levels, hyperfine structure And the Zeeman effect for muonium and positronium, Stark effect.

**Approximation Methods for Time-Dependent Problems:** Statement of the problem, approximate solution of the Schrödinger equation, An important special case: Sinusoidal or constant perturbation, Interaction of an atom with electromagnetic waves, linear and non-linear response of a two-level system subjected to a sinusoidal perturbation, Oscillations of a system between two discrete states under the effect of a resonant perturbation, Rabi flopping, decay of discrete state resonantly coupled to a continuum of final states, Fermi's golden rule.

**Systems of Identical Particles:** Identical particles, Permutation operators, The
symmetrization postulate, difference between bosons and fermions, Pauli’s exclusion principle, many-electrons atom and their electronic configurations, energy levels of the helium atom, configurations, terms, multiplets, spin isomers of hydrogen (ortho and parahydrogen).

**Scattering by a Potential:** Importance of collision phenomena, Stationary scattering states, scattering cross section, scattering by a central potential, method of partial waves, phenomenological description of collisions with absorption.

<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Electronics-II</td>
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<tr>
<td>Credit Hours</td>
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</tr>
<tr>
<td>Prerequisite / Co requisite</td>
<td>Electronic-I/None</td>
</tr>
<tr>
<td>Remarks</td>
<td>Maj-5</td>
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</tbody>
</table>

**Course Description**

**Amplifiers and their Frequency Response:** Cascade amplifier, The Amplifier pass band, The frequency plot, Low frequency plot, Low frequency limit, The un-bypassed emitter resistor, high frequency equivalent circuit, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier.

**Feedback:** Positive and Negative feedback, Principle of feedback amplifier, stabilization
of gain by negative feedback, Bandwidth improvement with negative feedback, Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit.

**Oscillators:** Introduction, Classification of oscillators, Damped and undamped oscillators, the oscillatory circuit, frequency stability of an oscillator, essentials of a feedback LC oscillator, tuned base oscillator, Hartley oscillator, Colpitis oscillator, crystal oscillator.

**Power Amplifiers:** Introduction, Power relation in class-A amplifiers, effect of thermal environment, determination of the output distortion, class-B amplifier, efficiency of class-A and class-B amplifiers.

**Modulation and Demodulation:** Introduction, carrier wave modulation, Need for modulation, radio Broadcasting, Methods of modulation, amplitude modulation, Forms of amplitude modulation, single side band system of modulation, Diode for linear detector for amplitude modulation, High power level amplitude modulation, automatic volume control, Frequency modulation.

**Multivibrators:** Multivibrators, Basic types of Multivibrators, uses of Multivibrators, Astable Multivibrators, Mono-stable Multivibrators, Bi-stable Multivibrators, Schmitt Trigger Circuit.

**Integrated Circuits:** Introduction, Integrated circuit advantages and drawbacks, scale of integration, classification of integrated circuit by structure, Classification of integrated circuit by function, comparison between different integrated circuit. Integrated circuit terminology, Integrated circuit fabrication, Basic processing steps. Silicon device processes Silicon wafer preparation, diffusion, Oxidation photolithography, Chemical vapour deposition, Metallization, Circuit probing, Scribing and separating into chips, Mounting and packing applications of integrated circuit.

**Digital Circuits:** Decimal, Binary, Octal, hexadecimal number systems, conversion of decimal numbers to any other number system and vice-versa, Binary codes, OR, AND, NOT, NAND, NOR logic gates, Boolean Algebra. Boolean expressions, simplification of Boolean expression using Boolean Algebra.

<table>
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<tr>
<th>Course Code</th>
<th>PHY-623</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Solid State Physics-I</td>
</tr>
<tr>
<td>Credit Hours</td>
<td>3</td>
</tr>
<tr>
<td>Prerequisite / Co requisite</td>
<td>Quantum Mechanics-I, Statistical Physics / None</td>
</tr>
<tr>
<td>Remarks</td>
<td>Maj-12</td>
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</tbody>
</table>


Course Description

**Crystal Structure:** Lattices and basis, Symmetry operations, Fundamental Types of Lattice, Position and Orientation of Planes in Crystals, Simple crystal structures.

**Crystal Diffraction and Reciprocal Lattice:** Diffraction of X-rays, Neutrons and electrons from crystals; Bragg’s law; Reciprocal lattice, Ewald construction and Brillouin zone, Fourier Analysis of the Basis.

**Phonons and Lattice:** Quantization of Lattice Vibrations, Phonon momentum, inelastic scattering by phonons, Lattice Vibrations for Monoatomic and diatomic basis, Optical Properties in the Infrared Region.

**Thermal Properties of Solids:** Lattice heat Capacity, Classical model, Einstein Model, Enumeration of normal modes, Density of state in one, two or three dimensions, Debye model of heat capacity, Comparison with experimental results, thermal conductivity and resistivity, Umklapp processes.

**Electrical Properties of Metals:** Classical free electron theory of metals, energy levels and density of orbital’s in one dimension, effect of temperature on the Fermi–Dirac distribution function, properties of the free electron gas, electrical conductivity and Ohm’s Law, thermal and electrical conductivities of metals and their ratio, motion of free electrons in magnetic fields, cyclotron frequency, static magneto conductivity and Hall Effect along with applications.

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<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>LAB-VII</td>
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</tbody>
</table>
Credit Hours | 2
---|---
Prerequisite / Co requisite | Modern Physics / Nuclear Physics
Remarks | Maj-18

Course Description

**Advanced Experiments:**

**List of Experiments:**
1. Measurement of the total neutron cross-section
2. To prove the Rutherford law of scattering of charged particles.
3. Measurement of the spectrum of gamma rays from a radioisotope (e.g. Cs) and study of their photoelectric and Compton absorption.
4. Source strength of C060 by gamma coincidence methods.
5. Determination of the constituents of substance by activation analysis.
6. To examine the characteristics of a Solid-State detector and to use it for alpha and beta Spectroscopy and compare the results with those obtained by a scintillation counter.
8. To examine the stopping-power of various substances for thermal neutrons.
9. Determination of Planck's constant (h) by using the photoelectric effect.
10. Determination of the charge on an electron (e) by Millikan's method.
11. The Frank-hertz experiment (Measurement of excitation potential of Hg).
12. Determination of the Rydberg constant from the spectrum of hydrogen.
13. Fabry-Perot interferometer used as a gas refractometer.
14. To study the Zeeman effect for a line in the spectrum of helium.
15. Experiments with microwaves. Study of their optical properties.
17. Nuclear magnetic resonance (N.M.R.) of protons in water.
18. The study of the Mossbauer effect.
19. The measurement of Hall effect in germanium and silicon.
20. To build a medium or short-wave transmitter.
22. To determine the energy gap in silicon and Germanium.


24. Simple diode manufacture and point-contact transistor.

*Note: At least 12 experiments to be performed.*
M.Sc-PHYSICS
SEMESTER-IV
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<tr>
<th>Course Code</th>
<th>PHY-625</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Nuclear Physics</td>
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<tr>
<td>Credit Hours</td>
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<tr>
<td>Prerequisite / Co requisite</td>
<td>Modern Physics / None</td>
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<tr>
<td>Remarks</td>
<td>Maj-11</td>
</tr>
<tr>
<td>Recommended Books</td>
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</tbody>
</table>

**Course Description**

**History:** Starting from Bacquarel’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, multipolarity of Gamma rays, 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, Breit-Wigner one level formula including the effect of angular momentum.
<table>
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<tr>
<th>Course Code</th>
<th>PHY-626</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Solid State Physics-II</td>
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<tr>
<td>Credit Hours</td>
<td>3</td>
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<tr>
<td>Prerequisite</td>
<td>Solid State Physics-I</td>
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<tr>
<td>Remarks</td>
<td>Maj-13</td>
</tr>
</tbody>
</table>

Course Description

**Dielectric Properties of Solids:** Polarization, Depolarization, Local and Maxwell field, Lorentz field, Clausius-Mossotti relation, Dielectric Constant and Polarizability, Measurement of dielectric constant, ferro electricity and ferroelectric crystals, Phase Transitions, First and 2nd order phase transitions, Applications

**Semiconductors:** General properties of semiconductors, intrinsic and extrinsic semiconductors, their band structure, carrier statistics in thermal equilibrium, band level treatment of conduction in semiconductors and junction diodes, diffusion and drift currents, collisions and recombination times


**Magnetic Properties of Materials:** Magnetic dipole moment and susceptibility, different kinds of magnetic materials, Langevin diamagnetic equation, Paramagnetic equation and Curie law, Classical and quantum approaches to paramagnetic materials. Ferro-magnetic and anti-ferromagnetic order, Curie point and exchange integral, Effect of temperature on different kinds of magnetic materials and applications.

**Superconductivity:** Introduction to superconductivity, Zero-Resistance and Meissner Effect, Type I and Type II superconductors, Thermodynamic fields, Tow fluid model,
ELECTIVE COURSES
M.Sc PHYSICS
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Introduction to Plasma Physics</th>
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<tbody>
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<td>Credit Hours</td>
<td>03</td>
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<tr>
<td>Remarks</td>
<td>Elective</td>
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</table>

**Course Description**

**Introduction**: Occurrence of plasma, Concept of temperature, Debye shielding, the plasma parameter, Criteria for plasma.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Introduction to Material Science</th>
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</thead>
<tbody>
<tr>
<td>Credit Hours</td>
<td>03</td>
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<tr>
<td>Remarks</td>
<td>Elective</td>
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</tbody>
</table>
4. http://www.msm.cam.ac.uk/teaching/index.php,  
5. http://www.doitpoms.ac.uk/ |
### Course Description

**Atomic Structure of Materials, Imperfections in Solids, Microstructure, Mechanical Behavior of Materials, Polymers.**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credit Hours</th>
<th>Remarks</th>
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<tr>
<td></td>
<td>Environmental Physics</td>
<td>03</td>
<td>Elective</td>
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<tr>
<td></td>
<td>Renewable Energy Resources</td>
<td>03</td>
<td>Elective</td>
</tr>
</tbody>
</table>

### Recommended Books

### Course Description

Introduction to the Essentials of Environmental Physics, Basic Environmental Spectroscopy, The Global Climate, Transport of Pollutants Noise, Radiation, Atmosphere and Climate, Topo Climates and Micro Climates, Climatology and Measurements of Climate Factor.


Course Description

**Energy Scenarios**: Importance of energy, world primary energy sources, energy demand, supplies, reserves, growth in demand, life estimates, and consumption pattern of conventional energy sources: oil, gas, coal, hydro, nuclear etc.

**Energy & Environment**: Emission of pollutants from fossil fuels and their damaging effects, and economics impact; Renewable energy and its sustainability. Renewable Scenarios: Defining renewable, promising renewable energy sources, their potential, availability, present status, existing technologies and availability.

**Solar Energy**: Sun-Earth relationship, geometry, sun path and solar irradiance, solar spectrum, solar constant, atmospheric effects, global distribution, daily and seasonal variations, effects of till angle, resource estimation, extraterrestrial, global, direct, diffuse radiation, sun shine hours, air mass, hourly, monthly and annual mean, radiation on tilted surface, measuring instruments.

**Solar Thermal**: Flat plate collectors, their designs, heat transfer, transmission through glass, absorption transmission of sun energy, selective surfaces, performance, and efficiency; low temperature applications: water heating, cooking, drying, desalination, their designs and performance; concentrators, their designs, power generation, performance and problems.

**Photovoltaics**: PV effect, materials, solar cell working, efficiencies, different types of solar cells, characteristics, (dark, under illumination), efficiency limiting factors, power, spectral response, fill-factor, temperature effect; PV systems, components, packing fraction, modules, arrays, controllers, inverters, storage, PV system sizing, designing, performance.
and applications.

**Wind**: Global distribution, resource assessment, wind speed, height and topographic effects, power extraction for wind energy conversion, wind mills, their types, capacity, properties, wind mills for water lifting and power generation, environmental effect.

**Hydropower**: Global resources, and their assessment, classification, micro, mini, small and large resources, principles of energy conversion; turbines, types, their working and efficiency for micro to small power systems; environmental impact.

**Biogas**: Biomass sources; residue, farms, forest. Solid wastes: agricultural, industrial and municipal wastes etc; applications, traditional and non-traditional uses: utilization processes, gasification, digester, types, energy forming, Environment issues. Resources availability; digester, their types, sizes, and working, gas production, efficiency; environmental effects;

**Geothermal**: Temperature variation in the earth, sites, potentials, availability, extraction techniques, applications; water and space heating, power generations, problems, environmental effects.

**Waves and Tides**: Wave motion, energy, potentials, sites, power extraction, and transmission, generation of tides, their power, global sites, power generation, resource assessment, problems, current status and future prospects.

**Hydrogen Fuel**: Importance of H₂ as energy carrier, Properties of H₂, production, hydrolysis, fuel cells, types, applications, current status and future prospects.

**Nuclear**: Global generations of reserves through reprocessing and breeder reactors, growth rate, prospects of nuclear fusion, safety and hazards issue.

**Energy Storage**: Importance of energy storage, storage systems, mechanical, chemical, biological, electrical, fuel cells etc.
### Course Description

**Programming for Scientific Computation:** unix/linux basics, the editing-coding-compiling-debugging-optimizing-visualizing-documenting production chain, Fortran95.


**Modeling and Simulation:** Molecular dynamics simulations, modeling continuous media Monte Carlo simulations.

**Project:** A project will be chosen by the student in consultation with the instructor. Selection of the project should be done soon after the module on modelling and simulation starts and continue over the course of the rest of the semester. The final part of the course is reserved for presentation of preliminary and final results.

### Course Code

<table>
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<tr>
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<th>Course Title</th>
<th>Credit Hours</th>
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<tbody>
<tr>
<td></td>
<td>Computational Physics</td>
<td>3</td>
<td>Elective</td>
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</table>

### Recommended Books

Course Description

**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.

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<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td></td>
<td>Methods of Experimental Physics</td>
<td>3</td>
<td>Elective</td>
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</table>

**Recommended Books**

### Course Code: Introduction to Laser Physics

**Course Title:** Introduction to Laser Physics  
**Credit Hours:** 3  
**Remarks:** Elective  

**Recommended Books**

**Course Description**
Introductory concepts, energy levels of molecules and semiconductors, Radiation & thermal equilibrium, population inversion & gain, laser systems, laser applications.

### Course Code: Electronic Materials & Devices

**Course Title:** Electronic Materials & Devices  
**Credit Hours:** 3  
**Remarks:** Elective  

**Recommended Books**

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<th>Course Code</th>
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<tbody>
<tr>
<td></td>
<td>Functional Materials</td>
<td>3</td>
<td>Elective</td>
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</table>

Recommended Books
- 4. Hidayat Ullah Khan, thesis on “Phase Transitions in Li-doped Ag(NbxTa1-x)O3 perovskite ceramics”. Department of Materials Science and Engineering, The University of Sheffield, UK. Available at the Department of Physics, University of Peshawar.

Course Description
Introduction to the functions of materials, Dielectrics, Pyroelectrics, Piezoelectrics, Ferroelectrics, Electro-Optic Materials.
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<tbody>
<tr>
<td>Course Title</td>
<td>Introduction to Nanoscience &amp; Nanotechnology</td>
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<tr>
<td>Credit Hours</td>
<td>3</td>
</tr>
<tr>
<td>Remarks</td>
<td>Elective</td>
</tr>
<tr>
<td>Course Description</td>
<td>Introduction, Quantum Effects, Surfaces and Interfaces, Material Properties, Tools and Instrumentation, Fabricating Nano Structures, Electrons in Nano Structures, Molecular Electronics, Nano Materials Nano Biotechnology, Nanotechnology the Road Ahead.</td>
</tr>
</tbody>
</table>