GC UNIVERSITY, FAISALABAD

Scheme of Studies

BS (Honors) Physics

8 Semesters / 4 years Degree Program for the year 2014 and onward

Department of Physics
<table>
<thead>
<tr>
<th>Course Codes</th>
<th>Course Title</th>
<th>Credit Hour</th>
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<tr>
<td></td>
<td><strong>Semester 1</strong></td>
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<tr>
<td>PHY-301</td>
<td>Mechanics-I</td>
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<tr>
<td>PHY-303</td>
<td>Waves &amp; Oscillations</td>
<td>3 (3 – 0)</td>
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<tr>
<td>MTH-321</td>
<td>Calculus-I</td>
<td>3 (3 – 0)</td>
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<tr>
<td>CSI-321</td>
<td>Introduction to Computers</td>
<td>3 (3 – 0)</td>
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<td>ISL-321</td>
<td>Islamic Studies</td>
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<td>ENG-321</td>
<td>EAP (English for Academic Purposes)</td>
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<tr>
<td>PHY-304</td>
<td>Heat &amp; Thermodynamics</td>
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<tr>
<td>PHY-306</td>
<td>Introduction to Programming for Physicists</td>
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<td>MTH-322</td>
<td>Calculus-II</td>
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<td>PST-322</td>
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<td>Reading, writing, speaking and listening skills</td>
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<td>Differential Equations-I</td>
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<td>Applied Mathematics</td>
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<td>Lab Course-I (Mechanics, Heat and Vibrations)</td>
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**Semester 4**

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<td>PHY-406</td>
<td>Differential Equations-II</td>
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<td>PHY-408</td>
<td>Lab Course-II (Optics &amp; Modern Physics)</td>
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<td>MTH-422</td>
<td>Linear Algebra</td>
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<td>Chemistry (Special Topics)</td>
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<td>PHY-503</td>
<td>Classical Mechanics</td>
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<td>PHY-505</td>
<td>Electrodynamics-I</td>
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<td>PHY-509</td>
<td>Relativity and Cosmology</td>
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<td>Lab Course-III (Electromagnetism)</td>
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<td>PHY-607</td>
<td>Particle Physics-I*</td>
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<td>Advanced Electronics*</td>
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<td>Solid State Physics-II</td>
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<td>PHY-608</td>
<td>Laser and Optics</td>
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<td>Statistical Mechanics</td>
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<td>PHY-631</td>
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**Note:**
* One optional subject to be chosen in 7th and 8th semester.
** Thesis will be allotted in the 7th semester. However, the credit hours for thesis will only count towards the 8th semesters.
*** Projects may be opted in lieu of option-II of the subject already taken by the student in 7th semester.
+ Internship will be offered to students during summer vacations as an optional activity.
### 1st Semester

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<tr>
<td>PHY-301</td>
<td>Mechanics-I</td>
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- Vectors in 3-dimensions & fundamental operations, Stoke’s theorem, Gauss’s Divergence theorem, Dynamics of Uniform circular motion, The Conical pendulum, The Rotor, The Banked curve, Equations of motion, Time-dependent forces, Velocity-dependent forces, Non-Inertial frames & Pseudo forces, projectile motion, Work done by constant & variable forces (one, & two dimension cases), K.E & the work-energy theorem, general proof of work-energy theorem, power, conservative forces, P.E, one-dimensional conservative system, Two & many particle system, calculation of c.m. of different objects, Linear momentum of Particle & system of particles, conservation of linear momentum, system of variable mass, Rocket equation, collision, impulse and momentum, Elastic and inelastic collisions in one dimension & two dimensions, centre of mass reference frame.

**Recommended Books:**


<table>
<thead>
<tr>
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<tbody>
<tr>
<td>PHY-303</td>
<td>Waves &amp; Oscillations</td>
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**Recommended Books:**


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<th>Credits</th>
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<tbody>
<tr>
<td>MTH-321</td>
<td>Calculus-I</td>
<td>3 (3 – 0)</td>
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</table>

- Number systems, bounded and unbounded sets, infimum and superimum, intervals, natural numbers, principle of induction, sequences, convergence, series and products, real valued functions, graphical representation of real valued functions. Limit of a function, properties of limit, continuity and discontinuity, differentiation, derivatives, higher derivatives, properties of differentiable functions exponential and logarithmic functions, trigonometric and inverse trigonometric functions, hyperbolic and inverse hyperbolic functions, maxima and minima, mean value theorems, intermediate forms, Taylor’s theorem, Macaroni’s series, power series. Plane curves, polar coordinates, tangents and normal, parabola, ellipse, hyperbola, vectors, equation of a straight line, scalar product, angle between two lines, equation of a plane, distance of appoint from a line, shortest distance between two lines.

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*GC University, Faisalabad*
Recommended Books:


CSI-321 Introduction to Computers 3 (3 – 0)

Fundamentals of computer operation, analogue and digital basis of computer, hardware and software concepts, operating systems (DOS, Windows etc), Processing and storing data, network basics, database management, algorithm development, Introduction to a scientific language (FORTRAN, C++ etc) and lab work with M.S Office, Origin and SPSS.

Recommended Books:


ISL-321 Islamic Studies 2 (2 – 0)


Recommended Books:

1. Dr. Muhammad Zia-ul-Haq, “Introduction to Al Sharia Al Islamia” Allama Iqbal Open University, Islamabad (2001)
5. Hameed ullah Muhammad, “Emergence of Islam”, IRI, Islamabad
6. Hameed ullah Muhammad, “Muslim Conduct of State”
7. Hameed ullah Muhammad, ‘Introduction to Islam
8. Mulana Muhammad Yousaf Islahi,”

ENG-321 | EAP (English for Academic Purposes) | 3 (3 – 0)
---|---|---
- Introducing ourselves
- Describing things
- Getting and giving information
- Recounting past events
- Talking about facts and opinions
- Agreeing and disagreeing
- Compare and Contrast
- Cause and effect
- Using your imagination
- Reporting
- Writing Essays
- Presentation skills
- Assessment

2nd Semester

PHY-302 | Mechanics-II | 3 (3 – 0)
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Recommended Books:

PHY-304 | Heat & Thermodynamics | 3 (3 – 0)
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**Recommended Books:**


PHY-306 | Introduction to Programming for Physicists | 3 (3 – 0)
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Introduction to programming, Significance of computers in the present physical sciences scenario, Software and hardware domains, Scientific computing, high and low level languages, flow charts, scientific programming languages, C/C++ and other scientific Programming language: memory management in C++, structure of C++ program, Generic form, Header files, Constants, Local variables, Input/output statements, Simple program, Variables, Data types, variables, Operators, Loops, Break, Continue, If and if-else statements, Conditional operator, Switch statement, Flags and conditional testing, One-dimensional arrays, Multi-dimensional arrays, String manipulation functions, Arrays as lists, Sorting, Searching, functions, built-in and user defined functions, file system, pointer, inheritance, polymorphism, C++ for scientific programming. Lab work.

**Recommended Books:**


MTH-322 | Calculus-II | 3 (3 – 0)
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Riemann integrals and their applications, fundamental theorems of calculus, area under the curve, integration of rational, irrational, trigonometric, exponential and logarithmic functions, improper integrals, beta and gamma integrals. Real functions of several variables, directional derivatives, partial derivatives, local maxima and minima, gradient, chain rule, stationery points, mean value theorems, total differentials, implicit functions, curve tracing, tangents, one parameter family of curves, envelops of a family of curves. Volumes of solids of revolution, area of a surface of revolution, moments and center of gravity, multiple integrals and applications, infinite series, test for its convergence, root and ratio tests, Gauss and integral tests.

**Recommended Books:**

1. J.Stewart, 1999“Calculus”, Books/Cole Publishing Co. USA,

PST-322 Pakistan Studies 2 (2 – 0)


Recommended Books
3. Mehmood, Safdar. 1994. Pakistan Political Roots & Development. Lahore,

ENG-323 Reading, writing, speaking and listening skills 3 (3 – 0)

To be provided by the concerned Department

3rd Semester

PHY-401 Electricity & Magnetism-I 3 (3 – 0)

Electric charge, coulombs law, Electric field, continuous charge distributions, image charges, electric dipole, Gauss’s Law and its applications, electric potential, electric properties of materials, capacitor, dielectric, capacitors in circuits, energy stored in capacitors, electric polarization, Gauss’s Law for dielectrics, electric current, current density and Ohm’s law, equation of continuity, DC circuits, analysis of circuits, electric fields in circuits, resistance in circuits, energy transfers in a circuit, RC circuits, magnetism, magnetic force on a charged particle, magnetic torque due to currents, magnetic dipole, Biot-Savart Law and its applications, Ampere’s law and its applications, Gauss’ law for magnetism, origin of atomic and nuclear magnetism, magnetization, magnetic materials: diamagnetic, paramagnetic, ferromagnetic. Induced magnetic fields and displacement current.
**Recommended Books:**

4. Sears, Zemansky and Young, 2000, *University Physics Ed. 11th*, Addison-Wesley, reading (MA), USA.

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**Recommended Books:**


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<tbody>
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<td>MTH-421</td>
<td>Applied Mathematics</td>
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Basic concepts of statistics, concept of probability, axioms of probability, discrete probability, & continuous probability, frequencies and probabilities, binomial, Poisson, and normal distributions, mode, mean, median, regression and correlation, sampling theory, analysis of variance. Numerical Analysis, solutions of algebraic and transcendental equations, roots of cubic and biquadratic equations, numerical methods, bisection methods, Newton-Raphson, formula, the secant method, method of false position, numerical solution of simultaneous linear algebraic equations, Gauss elimination method, Cramer’s rule, Choleski’s factorization method, Jacobi iterative method, numerical integration, rectangular rule, Trapezoidal rule, Simpson’s rule, Error analysis.

**Recommended Books:**

3. E. Butkov, Addison-Wesley1968, “Mathematical Physics” Publishing Company,

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<th>ENG-421</th>
<th>Communication Skills</th>
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<td>PHY-407</td>
<td>Lab Course-I (Mechanics, Heat and Vibrations)</td>
<td>3 (0 – 3)</td>
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1. Measurement of Oscillation period of the pendulum as a function of the angle of oscillation $\Phi$ of the oscillation plane for two different pendulum lengths.
2. Projectile motion: (a) To determine the range as a function of the angle of inclination. (b) To determine the maximum height of projectile as a function of angle of inclination. (c) To determine the range / height as a function of initial velocity of projectile.
3. To determine the value of ‘$g$’ be compound pendulum (Kater’s Pendulum).
4. To determine Horizontal/Vertical distance by Sextant.
5. To determine the frequency of A.C supply by Melde’s experiment.
6. To determine the modulus of rigidity of a flat spiral spring.
7. To determine the modulus of rigidity of a wire by solid cylindrical rod.
8. Surface tension of water by capillary flow method.

### Recommended Books:

### 4th Semester

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### Recommended Books:
Review of Bohr’s theory, Sommerfeld model, Frank Hertz Experiment, Stern Gerlach Experiment, quantum numbers, radioactive transition, selection rules, Zeeman Effect (normal and anomalous Zeeman Effect, The Stark Effect, Pauli exclusion principle, Spin orbit coupling LS coupling, JJ coupling, X-ray spectra. Molecular spectra, Ionic and covalent bonding, diatomic molecular-rotational, vibrational and electronic spectra, polyatomic molecules, black body radiation, Einstein co-efficient (A and B coefficients) and stimulated emission, pumping schemes, characteristics of laser, different types of lasers, laser applications. The fine structure of hydrogen, Helium, the ground state of helium, excited states of helium, transitions in helium.

Recommended Books:


PHY-406 Differential Equations-II 3 (3 – 0)

Modeling with higher order equations, Linear equations, initial-value problems, Spring/Mass systems (Free undamped motion, Free damped motion and driven motion), Resonance and Beats Series Circuit (RC series circuit, LC series circuit, RL series circuit and RLC series circuit), linear equations: boundary value problems, non-linear equations, Series Solutions, Series solutions about ordinary points, Review of Power series, Power series solution, solution about singular points, Method of Frobenius Series solutions, Legendre’s equation, Bessel’s equations, Bessel function of the first kind, Bessel’s function of second kinds, Parametric Bessel’s equation, Differential recurrence relations, spherical Bessel’s function, Legendre Polynomials, Recurrence relations, Laplace transform, Definition of the Laplace transform, Inverse transforms, Transforms of derivatives, Translation Theorems (translation on the s-axis and t-axis), Additional operational properties, Transforms of an integrals and a periodic functions, Dirac Delta function, Laplace transform of a Dirac Delta function, Applications to differential equations and systems of linear differential equations, Systems of linear first order differential equations, Preliminary theory, Homogeneous systems with constant coefficients, Distinct Real eigenvalues, repeated eigenvalues, Complex eigenvalues, undetermined coefficients, Variation of parameters, Matrix exponential

Recommended Books:


PHY-408 Lab Course-II (Optics & Modern Physics) 3 (0 – 3)

1. Characteristic x-rays of Molybdenum
2. Specific rotation of cane – sugar solution with Laurent’s half shade polarimeter.
3. Ionization potential of mercury / Neon.
4. $e/m$ Experiment (determination of charge to mass ratio of electron)
5. X-ray investigation of crystals
6. Characteristic curves of a solar cell.
7. Plank’s constant using photocell method.
8. Wave length of sodium light using a diffraction grating.

Recommended Books,
### MTH-422 Linear Algebra

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- Vector space, linear dependence, dimensionality, inner product, Hilbert space, linear operators, Gram-Schmidt method, matrices, addition, multiplication, division, derivatives and integrals of matrices, partition of matrices, elementary row operations, systems of linear equations, transpose, unitary and hermitian matrices, eigenvalues and eigen vectors, diagonalization, singular matrix, trace of a matrix, determinants, Cramer’s rule, inverse matrix, linear transformation. Groups, subgroups, homomorphism and isomorphism, group representation, reducible and irreducible representations, Schur’s lemma.

**Recommended Books**


### CHM-402 Chemistry (Special Topics)

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<td>CHM-402</td>
<td>Chemistry (Special Topics)</td>
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**To be provided by the concerned Department**

#### 5th Semester

### PHY-501 Methods of Mathematical Physics-I

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<td>PHY-501</td>
<td>Methods of Mathematical Physics-I</td>
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- Vector operations, Physical significance of DEL operator, Gauss’s divergence theorem, Green’s theorem, Stokes’s theorem, Orthogonal curvilinear coordinates system, Gradient, Divergence, Curl and Laplacian in orthogonal curvilinear coordinates, Spherical polar and Cylindrical coordinates systems. Complex numbers, Euler’s formula, De Moivre’s theorem, elementary functions, analytic functions of complex variables, Cauchy-Riemann equation, harmonic functions, complex integration, Cauchy’s theorem, Cauchy’s integral formula, Taylor and Laurent series, Contour integrals, singularities and residues, residue theorem, branch points and integrals of multivalued functions. Tensors Analysis and applications.

**Recommended Books:**


### PHY-503 Classical Mechanics

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<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>PHY-503</td>
<td>Classical Mechanics</td>
<td>3 (3 – 0)</td>
</tr>
</tbody>
</table>

- Historical development of classical mechanics, Newtonian mechanics of single particle & system of particles, constraints, generalized coordinates, D’Alembert’s Principle, Derivation of Lagrange’s equations, simple applications of the lagrangian formulation, Hamilton’s Principle, Techniques of the calculus of variation, Derivation of Lagrange’s equation from Hamilton’s principle, Applications of Hamilton’s principle, shortest distance between two points in a plane and space, minimum surface of revolution, the Brachistochrone problem, conservation theorem, Two body central force problem & its reduction to the equivalent one body problem, Kepler’s law as an inverse square law problem, Differential equation for the orbits and the different shapes of the orbit, planetary orbits & their equations, Legendre transformations and its applications, Derivation
of Hamilton’s equation of motion, Hamiltonian, cyclic coordinates, Routh’s Procedure, The equations & examples of canonical transformations, Poisson’s brackets & their properties, Poisson’s brackets & other canonical invariants, Poisson’s theorem, invariance of Poisson’s bracket under canonical transformation.

Recommended Books:

**PHY-505** Electrodynamics-I 3 (3 – 0)

**Electric dipole.** Electric field and electric potential at a point due to dipole, mutual interaction energy of two dipoles, Force and Couple on the dipole placed in an external electric field, **Dielectrics:** Polarization and polarization density vector, surface and volume charge densities due to polarization, electric field inside the dielectric, electric susceptibility and dielectric constant, **Poisson and Laplace equations** both for dielectric and space, Solution to Laplace equation in Cartesian, spherical and cylindrical coordinates, Uncharged conducting and dielectric sphere in uniform electric field, Electrostatic Images, Point charge near an infinite grounded conducting plane, Electric potential, electric field intensity and surface charge density in case of point charge and conducting sphere. **Electric current:** nature of electric current, current density, equation of continuity, Ohm’s law, steady current in media without source of e. m. f., Approach to electrostatic equilibrium, **Magnetic properties of steady current:** Current carrying element, Force on current carrying conductor, Biot-savart law and their applications, Ampere’s circuit law and their applications, Magnetic vector and scalar potential, Magnetic field of a distant circuit. **Magnetic properties of matter:** Magnetization vectors M, Magnetic current densities due to surface and volume currents and vector potential, Magnetic field due to the magnetized material, Magnetic scalar potential and pole density, Magnetic intensity vector H, Relation between H and M, Field equation, Magnetic susceptibility and permeability, Boundary conditions on the field vectors.

Recommended Books:

**PHY-507** Electronics-I 3 (3 – 0)

Liner network analysis; superposition, Thevenin, Norton and Mill man’s theorems, Electronics: the p-n junction, Bias the p-n junction diode, diode, characteristics of diode, different models and types of diodes, half-wave and full-wave rectifier, full-wave bridge rectifier, capacitor, inductive, and πR filters, Clipping and clamping circuits, Zener voltage regulators, regulated power supply, varactor diodes, Optical diodes, Light emitting Diodes. Bipolar junction transistor (BJT), transistor characteristics, biasing circuits such as base bias, emitter bias, voltage-divider bias, feedback bias circuits, amplifier classifications, common emitter amplifier, the emitter followers, the common base amplifier. RC-coupled amplifiers, Power amplifiers, (class A, class B amplifiers, class C amplifier), introduction to Junction field-effect transistors (JFET), JFET biasing circuits, the common source follower, introduction to MOSFET.

Recommended Books:
### PHY-509  
Relativity and Cosmology  
3 (3–0)

Special Relativity, Galilean relativity, Einstein’s postulates of special relativity. Consequences of special relativity. Michelson-Morley experiment, Lorentz transformations, consequences of Lorentz transformations (the relativity of length, the relativity of time, concept of simultaneity) Relativistic Mechanics, Transformation of relativistic velocities, addition of relativistic velocities, Relativity of mass, Force equation in relativity, rest mass, KE and total energy, conservation of energy and momentum, the conversion of mass to kinetic energy in Uranium Fission, pair production and annihilation, The Cerenkov Effect and Cerenkov radiation, Einstein’s mass-energy relationship and its practical examples, particle of Zero rest mass, Relativistic Doppler Effect, Aberration of Light, Tachyons, structure of space time, Geometry of space time, Minkowski space time tensors, the light cone, and four vectors (position four vector, four velocity, four momentum, four force). General relativity, Gravity as a Geometry, The equivalence principle, clocks in a gravitation field, space time is curved, geodesics, the geodesic equation, equation of geodesic deviation, Einstein field equation Manifolds and coordinates, curves and surfaces, tensor fields, metric tensor. Cosmology cosmological redshift, Hubble’s law, microwave background, the Big Bang, Theory, Historical background of universe, stars, neutron stars, pulsars, black holes, quasars, singularity, measuring the distance to stars, concept of open, closed and flat universe, dark matter (MACHOs and WIMPs)

**Recommended Books:**


### PHY-511  
Lab Course-III (Electromagnetism)  
3 (0–3)

1. To determine the resistance of various DC conductors by recording their current/voltage characteristics.
2. To study the internal resistance and matching in various voltage sources and draw their power diagrams.
3. Establishment of relationship between electrostatic force and charge, electrostatic force and distance between charges and to determine the electric constant using Coulomb’s Law / image charge.
4. To study the ferromagnetic hysterisis of a two ring-shaped iron cores by continuous adjustable direct current and to determine the remanence and coercive field strength.
5. Investigation of induced current and voltage in secondary coil of a transformer as a function of number of turns and current flowing in the primary coil.
6. To determine the inductance and phase displacement of coil (single, parallel and series formations) in AC circuit as a function of frequency of voltage source.
7. To determine the capacitance and phase displacement of capacitor (single, parallel and series formations) in AC circuit as a function of frequency of voltage source.
8. To determine the dielectric constants of different materials.
9. To study the ripple of the output voltage of various rectifier circuits as a function of the load current strength and the charging capacitance.
10. To study the frequency response of simple RC filters by point-by-point measurements and the sweep displayed on the oscilloscope.
11. To investigate the filter characteristics as a function of frequency of a coil, a capacitor, an Ohmic resistance and combinations of these components and to determine the phase displacement of the filters as a function of frequency.
12. To study the behavior of RLC series and parallel circuit and determination of its resonance frequency.
(Optional: To determine the dielectric constant using RLC series circuit.)

Recommended Books:
2. David J. Griffiths, Introduction to Electrodynamics, 3rd Edition

6th Semester

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<tr>
<th>Course code</th>
<th>Course Name</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PHY-502</td>
<td>Methods of Mathematical Physics-II</td>
<td>3 (3 – 0)</td>
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Recommended Books:

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<tr>
<th>Course code</th>
<th>Course Name</th>
<th>Credits</th>
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<tbody>
<tr>
<td>PHY-504</td>
<td>Quantum Mechanics-I</td>
<td>3 (3 – 0)</td>
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</tbody>
</table>

Review of concepts of classical mechanics, The state of a system, Dynamical variables and operators, Linear vector space, orthogonal systems, linear transformations, matrices, change of basis, Hilbert space, Commuting and noncommuting operators. Heisenberg uncertainty relations, Functions and expectation values, Dirac notation, Hermitian operators, Symmetry principles and conservation laws, Orbital angular momentum, Spin, The eigenvalues and eigen functions of L2 and Lx, Matrix representation of angular momentum operators, Addition of angular momenta. Properties of one dimensional potential functions, Solutions of Schrödinger equation for free particles, the potential barrier problems, The linear harmonic oscillator, Particle in a box. Schrödinger Equation in Three Dimensions, Separation of Schrodinger equation in Cartesian coordinates, Central potentials, The free particle, Three dimensional square well potential, The hydrogen atom, Three dimensional isotopic oscillator.

Recommended Books:
### Nuclear Physics-I


**Recommended Books:**

7. lilley John 2001 Nuclear physics: Basic concepts and applications,

### Electrodynamics-II

Maxwell’s equations, Differential form of Faraday law of electromagnetic induction, Maxwell correction of Amper’s law and displacement current, Electromagnetic energy vector (Poynting vector), Wave equations for scalar and vector potential, Gauge transformations, Lorentz gauge and Coulombs gauge, Retarded scalar and vector potentials, Wave equations for \(E\) and \(H\), Time dependent wave equation, Plane electromagnetic waves in a conducting and non-conducting media, Linear and circular polarization. Electromagnetic wave in matter: Propagation in linear media, Reflection and Transmission at the boundary of non-conducting media (Normal and Oblique incidence), Reflection at conducting surface, Frequency dependence of permittivity, Radiation: Electric and Magnetic dipole, Power radiated by a point charge, Radiation reaction. Electrodynamics and Relativity: Einstein’s Postulates, Geometry of Relativity, Lorentz Transformations, Proper time and velocity, Relativistic energy, momentum, kinematics, and electrodynamics, Magnetism as a relativistic phenomenon.

**Recommended Books:**


### Electronics-II

An overview of operational amplifiers (op-amp), the differential amplifier, the inverting and non-inverting amplifiers, op-amp frequency response, negative feedback, comparators, integrators and differentiators, Instrumentation amplifier, Log and Antilog amplifiers, Constant current source, Current to Voltage and Voltage to Current converters, phase shift oscillators, the Wienbridge oscillator, the Colpitts & Hartley oscillators, the crystal oscillator, Schmitt triggers, the 555 timer, monostable, bistable, and astable multi vibrators, switching circuits, introduction to thyristors, silicon-controlled rectifiers, diacs and triacs, Number systems, digital
circuit, Logic gates and Boolean algebra, arithmetic circuits, flip flops and latches, binary counters, Analog to Digital and Digital to analog conversion circuits.

**Recommended Books:**


<table>
<thead>
<tr>
<th>PHY-512</th>
<th>Lab Course-IV (Atomic &amp; Nuclear Physics)</th>
<th>3 (0 – 3)</th>
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</thead>
</table>

The candidate must perform at least Eight experiments from the list given below. 50% weightage must be given to viva-voce about apparatus, theory of experiments and estimation of errors.

1. To Expose the students to advance level experimentation in Physics
2. To make them familiar to such experiments where outcome can be used in developing future research capabilities and teaching skills
3. To make the students confident in their studies by showing and measuring parameters mostly used in their theoretical work.
4. To study the characteristics curves of GM counter.
5. To determine the absorption coefficient of lead for Gamma Rays using GM counter assembly.
6. To determine the maximum energy of Beta Particles using GM counter assembly.
7. To determine the range of an Alpha Particle and guess its energy using empirical relations using GM counter assembly.
8. To measure the half life of a radioactive nuclide.
9. To study of Random processes and fluctuations in Random processes (Gaussian distribution curve) using GM counter assembly.
10. To study radioactive equilibrium using Cs$^{137}$/Ba$^{137}$ mini generator using GM counter assembly.
12. Verification of inverse square law using GM counter assembly.
13. To study the wave characteristics of an electron. (electron diffraction experiment.)
14. Determination of Planck’s constant using He-Neon laser, and compare its results with Photo cell method.
15. Determination of velocity of light using He-Neon laser and compare it with other standard methods.

**Recommended Books:**

1. Gray T S. Applied Electronics (John-willey and Sons)
2. Higgings R J. Experimental Electronics (Mc Graw Hill)
4. Melissenson A C. Experiments in Modern Physics (Academic)

<table>
<thead>
<tr>
<th>PHY-601</th>
<th>Quantum Mechanics-II</th>
<th>3 (3 – 0)</th>
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and cross sections, Potential scattering, the method of partial waves, The Born’s approximation

Recommended Books:


<table>
<thead>
<tr>
<th>ENG-601</th>
<th>EFE (English for Employment)</th>
<th>3 (3 - 0)</th>
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<tbody>
<tr>
<td>What is your dream job?</td>
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<tr>
<td>Job searches: internal job market (newspapers, internet, job fair/talent hunt at universities)</td>
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<tr>
<td>Reading advertisement</td>
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<td>Researching the company and its ethos</td>
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<tr>
<td>Filling an application form</td>
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<tr>
<td>Introduction to resumes</td>
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<tr>
<td>Practicing with a resume</td>
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<tr>
<td>CV writing</td>
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<tr>
<td>Practicing with format 1 of a CV (no personal statement)</td>
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<tr>
<td>CV writing</td>
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<tr>
<td>Practicing with format 2 of a CV (with introductory persona statement)</td>
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<tr>
<td>Writing a cover letter</td>
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<tr>
<td>Preparing for interviews 1: content / questions</td>
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<tr>
<td>Preparing for interviews: 2 body language, comportment, grooming appearance</td>
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<tr>
<td>Preparing for interviews 3: practicing mock face-to face interviews</td>
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<tr>
<td>Preparing for interviews 4: practicing Skype and telephone interviews</td>
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<tr>
<td>Job searches: overseas job market</td>
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<tr>
<td>Writing resumes and CVs: overseas job market</td>
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<tr>
<td>Practicing with CVs: overseas job market</td>
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<tr>
<td>Job interviews (face-to-face and Skype / telephone): overseas job market</td>
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<tr>
<th>PHY-603</th>
<th>Nuclear Physics-II</th>
<th>3 (3 – 0)</th>
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<tbody>
<tr>
<td>Types of nuclear reaction, Conservation laws of nuclear reaction, Q-values of nuclear reaction, threshold</td>
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</table>
energy, transmutation by photons, protons, deuterons and α-particles, direct reactions, compound nuclear theory of nuclear reactions, limitation of compound nucleus, excited states of nucleus, bound and virtual energy levels, level width, cross-section for nuclear reactions, Breit-wigner formula. Liquid drop model, Semi-empirical mass formula, volume and surface energies, Shell model: magic numbers and closed shells, spin–orbit interaction, Collective nuclear model, nuclear deformations. The production and detection of neutrons, Fission and Fusion Reactions, discovery of nuclear fission, fission products, Bohr-wheeler theory of nuclear fission, mass and energy distribution of fission fragments, Description of nuclear fusion process, D-D and D-T reactions, Fusion processes in sun and stars, Nuclear fission and fusion as a source of energy, Basic of nuclear reactors, controlled nuclear fusion.

**Recommended Books:**


**PHY-605**  
**Solid State Physics-I**  
| 3 (3 − 0) |

Crystal structure in 2D and 3D, fundamental types of lattices, index system for crystal planes, simple crystal structures, X-ray diffraction, Brags law, Ewald Construction, reciprocal lattice, Diffraction of waves by crystals, scattered wave amplitude, Brillouin zones, crystal binding and elastic constants, Classification of Solids, ionic crystals, covalent crystals, Ionic Radii, II-VI and III-V compounds, Molecular crystals, metals, Cohesive energy, The Lenard Jones Potential, Density, Cohesive energy and Bulk Modulus of crystalline solids, The Madelung constant, Cohesion in Covalent crystals, elastic waves in cubic crystals. Brief Introduction to Defects in Solids, Color Center, Vibration of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, normal vibration modes and phonon, phonon momentum, inelastic scattering by phonons, Phonon heat capacity, lattice heat capacity, Einstein and Debye models.

**Recommended Books:**


**PHY-607**  
**Particle Physics-I**  
| 3 (3 − 0) |

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, isospin charge conjugation, time reversal, G parity, CPT theorem. The Electromagnetic Filed: Gauge invariance and Maxwell’s equations, polarization ad photon spin, angular momentum, parity and C parity of the photon. The Klein-Gordan Equation: Non relativistic quantum mechanics, Lorentz covariance and 4 vector notation, the Klein Gordon equation, the Feynman-Stuckelberg interpretation of E < O solutions, non
relativistic perturbation theory (brief review), rules for scattering amplitudes in the Feynman-Stueckelberg approach. The Dirac Equation: Covariant form of the Dirac Equation, Dirac γ-matrices, conserved current and the adjoint equation, free particle spinors, anti particles, normalization of spinors and the completeness relations, bilinear covariant, zero mass fermion, the two-component neutrino.

Books Recommended:


<table>
<thead>
<tr>
<th>PHY-609</th>
<th>Advanced Electronics*</th>
<th>3 (3-0)</th>
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<tbody>
<tr>
<td>Number Systems and codes, Logic Gates and Boolean algebra, Combinational logic, Sum of products form, Karnaugh maps method, Digital arithmetic operations and circuits, multiplexer and demultiplexer, decoders encoders, Sequential logic, Flip Flops, Synchronous Logic, basic binary ripple counter, modulus counters, BCD counter, synchronous/asynchronous counter, counter, parallel counters, up-down counter application as digital time (clock) shift registers, semi conductor, memory elements (simple concept), Digital Computer, Concept of computer system (CPU, input &amp; output devices, computer networking, software system and simulation software) and microprocessor, Communication systems, Modulation and Demodulation, Classification of signals, Analysis and transmission of signals, Amplitude modulation, Angle/Phase and Frequency modulations, Pulse code modulation.</td>
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<td>Recommended Books:</td>
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<tr>
<th>PHY-611</th>
<th>Environmental Physics-I*</th>
<th>3 (3-0)</th>
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<td>Recommended Books:</td>
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<tr>
<th>PHY-613</th>
<th>Health and Medical Physics-I*</th>
<th>3 (3-0)</th>
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</table>

Recommended Books:
2. RIEGLER W. 2008, CERN, Academic Training Course.

**PHY-615**  
Climatology and Metrology-I*  
3 (3 – 0)

Synoptic Meteorology: Composition & structure of atmosphere, ICAO standard atmosphere, weather elements, Air mass classification, Thermodynamic characteristics, General Circulation. Atmospheric thermodynamics, First law of thermodynamics and enthalpy; adiabatic processes and potential temperature. The second law of thermodynamics; entropy thermodynamics of water vapour and moist air thermodynamic properties of the water substance phase transition of water water vapour and most air Clausius- Clapeyron’s equation; Aerological diagram selection of coordinates choice of diagram analysis of tephigram. Methods of surface observations & codes: Reading of routine observation, barometric corrections & reduction, reading, setting * maintenance of thermometers, surface codes, aeronautical codes (Spec & Metar). Dynamic Meteorology: Circulation & vorticity, stokes theorem, vorticity equation, Rossby waves. Meteorological Instruments: Meterorological instruments used in thermometry, barometry, hygrometry, rainfall & snowfall measurement, wind measurement, cloud measurement, evaporation measurement, visibility measurement, sunshine measurement. Introduction to weather radar system, introduction to radiosonde equipment.

Recommended Books.

**PHY-617**  
Lab Course-V (Electronics)  
3 (0 – 3)

1. Design and measure the equivalent resistance and capacitance of parallel series resistive and capacitive circuits respectively.
2. Design a full-wave rectifier and study its output without and with a capacitor filter.
3. Design a full-wave rectifier and study its output with a \( \pi \) filter.
4. Design a regulated power supply using Zener diode and study its regulation.
5. Design clipper and clamping circuits and study the output wave shapes.
6. Design circuits for logic gates (NOT, OR, NOR, AND, NAND, XOR) using discrete components.
7. Design a CE amplifier and study its frequency response. Determine its low- and upper-limit
8. Design a common source FET amplifier and determine its input and output impedance.
9. Design an RC phase-shift oscillator and determine its frequency by Lissajous figures.
10. Design an astable multi vibrator and determine its frequency.
11. Design a transformer-coupled class A power amplifier and determine its ac power delivered to the load and percent efficiency.
12. Design inverting and non-inverting amplifiers using operational amplifiers using 741 IC’s.
13. Design differentiator and integrator circuits and study output wave shapes using 741 IC’s.
14. Design Half adder and full adder circuits
15. Design half subtractor and Full Subtractor circuits.

**Recommended Books:**


**PHY-602 Plasma Physics**


**Recommended Books:**


**PHY-604 Computational Physics**


**Recommended Books:**

1. Harvey M. Deitel and Paul J. Deitel, 2012, C++ How to Program, 8/e, Early Objects Version, Prentice Hall
2. Richard Fitzpatrick, 2011, Introduction to Computational Physics, University of Texas.
and Sons. N.Y..

PHY-606  
Solid State Physics-II  3 (3 – 0)

Solid state problem, Born-Oppenheimer approximation, free electron approximation, density of states, Fermi Dirac distribution, k-space, concept of Fermi energy and the Fermi surface, free electron description of Heat capacity, electrical conductivity of metals, Hall effect. Nearly free electron model, origin of the energy gap, Bloch functions, motion of electrons in electron in a periodic potential, crystal momentum, effective mass, physical interpretation of the effective mass, Augmented Plane Wave method, Semiconductors, intrinsic and extrinsic semiconductors, intrinsic carrier concentration, mobility, impurity conductivity donor states, acceptor states, thermal ionization of donors and acceptors, simple description of pn-junction and rectification.

Recommended Books:


PHY-608  
Laser and Optics  3 (3 – 0)

Review of quantum mechanics, interaction of radiation with matter, Spontaneous and stimulated emission, absorption, cavity, gain medium, population inversion, threshold condition, Three and four level laser, pumping mechanisms, properties of a laser beam, Modes of a rectangular cavity, Raleigh-Jeans and Planck radiation formula, mode density, homogeneous and inhomogeneous broadening of atomic transitions, amplitude fluctuations and spiking, Rate equation approach to Laser theory, stationary solution, time-dependent solution, lasing condition, hole burning effect, Matrix formulation of Geometrical optics, optical resonators, Q-switching and mode locking, active and passive mode-locking, fresnal number, types of laser, laser applications.

Recommended Books:


PHY-610  
Statistical Mechanics  3 (3 – 0)

Laws of thermodynamics, thermodynamic variables, reversible adiabatic changes. Entropy, Microstates and macrostates, ensembles and ensemble averaging, approach to equilibrium. Classical probability, Statistical probability, binomial and Gaussian probability distributions, central limit theorem. Microcanonical systems, quantum state, entropy and equilibrium in a microcanonical system, Canonical ensemble, partition function, entropy in canonical system, Boltzmann distribution, thermodynamical averages, applications to single particle, factorization of partition function. Equipartition theorem, free energy and its minimization, Gibbs and Helmholtz free energy and applications. Maxwell distribution of molecular speeds, classical probability of a state, Maxwell-Boltzmann probability distribution, density of states in k-space, distribution of speeds in a

Recommended Books

2. Huang K. 2001, Introductory Statistical Physics, 1st Ed. CRC

PHY-612

Hadrons Spectroscopy: Formation experiments, particle 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, heav meson spectroscopy, the quarkonium model. The Standard Model (qualitative treatment only): Unification of weak and electromagnetic interactions Glashow-Salam-Weinberg Model. Electrodynamics of spinless particles: An “electron” in an electromagnetic field A”, “spinless” electron – muon scattering, the cross section in terms of the invariant amplitude M, the decay rate in terms of M, “spinless” electron – electron scattering, electron – positron scattering: and application of crossing, invariant variables, the origin of the propagator. Electrodynamics of Spin ½ Particles: An electron interacting with an electromagnetic field A”, Moller scattering e- e- → e-e- the process e- μ- → e- μ- trace theorems and properties of γ matrices, e- μ- scattering and the process e- e- → μ+ μ- helicity conservation at high energies, survey of e- e+ → e- e+, μ- μ+ , e- μ- → e- μ- in the laboratory frame; kinematics relevant to the parton model, photons, polarization vectors, more on propagators, the electron propagator, the photon propagator, massive vector particles, real and virtual photons, Compton scattering γ e- → γ e- pair, annihilation e+ e- → γγ, the +ive prescription for propagators, Eeynman rules QED.

Books Recommended:


PHY-614

Advanced Electronics Lab Course*

1. Design of UJT relaxation oscillator of a variable frequency, measure frequency and amplitude of the output.
2. Design RF transistor oscillator, Convert into a transmitter, detect the transmitted wave by a radio receiver (Both for AM & FM).
3. Design and study the application of operational amplifier, (current to voltage converter instrumentation amplifier, buffer, voltage clamp, low and high pass filter, half wave rectifier etc.).
4. Design and study the Low/High pass active filters using 741 IC.
5. Design and study the application of 555 timers IC (mono-stable, astable and bi-stable multi-vibrators).
6. Design a fixed and self bias transistor binary and triggering of binary, using IC’s construct and study RS, JK (Master stave), T and D flip-flops.
7. Design and study of a half and full adder with different Boolean expression using IC’s.
8. Synchronous and asynchronous BCD counters, Memory shift register with IC’s.
10. Design and construct and analog to digital and digital to analog converters using IC’s.
11. Design and study of decoder, encoder, multiplexer and de-multiplexer circuits and compare the input output waveforms.
12. To construct and understand an operation of arithmetic logic unit and study of different arithmetic logic operations.
13. To construct and study of data storage and retrieved using semiconductor memory and understand the process of fetching an instruction and its operand with ALU.
14. Using microprocessor trainer’s study of microprocessor application working form host personal computers.
15. Design of Digital Clock.

**Recommended Books:**


**PHY-616 Environmental Physics Lab Course**  
| 3 (0 – 3) |

Students are required to study the functioning and data analysis obtained from various machines used in Atmospheric & Environmental Physics. The students have to work in some agencies where these facilities are available. The details of the activities performed in this lab are as under.

1. Solid Aerosols / soils sample collections
2. Physio chemical & mechanical properties of solid aerosols / soils samples.
3. Qualitative & Quantitative analysis solid aerosols / soils samples.
5. Climatological data analysis with respect to global warming & global cooling (whether trends)

**Recommended Books:**


**PHY-618 Health and Medical Physics -II**  
| 3 (3 – 0) |

derived air concentration, Gastrointestinal tract, Basis of radiation safety regulations

Recommended Books:

2. RIEGLER W. 2008, CERN, Academic Training Course.
3. Joran C. 2003, CERN, summer student lecturers

PHY-620  Climatology and Metrology-II*  3 (3 – 0)

Climatology: Climatic elements; principles of climate classification; world climate classification; climates of Asia; climates of the sub-continent; the climate of Pakistan. Climate Change: Meteorological factors affecting climate; greenhouse gases; El-Nino, La-Nina. Tropical Meteorology: Tropical general circulation, Diurnal variations of meteorological elements in the tropics, A survey of low-latitude weather disturbances easterly waves’ intertropical convergence zone. Monsoons, Tropical cyclones, structure and formation of cyclones. Aviation Meteorology: meteorological aspects of flight planning’s, aviation hazards and their association with synoptic patterns, aircraft icing, turbulence, fog, thunderstorms, dust storms, low-level vertical wind shear, jet stream formation & structure.

Recommended Books.


PHY-629  Seminar  1 (1 – 0)

PHY–630  Thesis **  6 (0-6)

PHY-631  Project***  3 (0–3)

The End