UNIVERSITY OF THE PUNJAB, LAHORE, PAKISTAN

University of the Punjab

BS (4 Years) physics degree program under semester system

DEPARTMENT OF PHYSICS, UNIVERSITY OF THE PUNJAB, LAHORE, PAKISTAN

20.08.2018

BACHELOR OF SCIENCE (BS) PHYSICS DEGREE PROGRAM

Duration of Degree Course	Four years
Teaching System	Semester System
Total number of Credit Hours	135
Session Starts	(Fall) September-October
Eligibility Qualification	As per university rules
Number of Student Enrollment	35 (Total) including all reserved seats

MISSION STATEMENT

The mission of the program is to prepare students with the latest developments in the subject of physics and its associated technologies. Moreover, it aims at helping the students to design and develop a strong background in fundamentals of physics such as quantum mechanics, solid-state physics, relativity, statistical mechanics and electrodynamics. Due to the diversity of options available to students, they will learn advanced-level physics courses in the emerging fields of physics.We wish to prepare our students to conduct an independent scientific and analytical investigation in the changing discipline and to develop critical and scientific thinking skills needed for a suitable career in academia and industry.

OBJECTIVES

The BS (Physics) degree program is offered by the Department of Physics as a full-time period of teaching. The main objectives of the program are

- to equip students with an understanding of fundamental concepts in physics, including: classical mechanics and electromagnetism, thermodynamics and statistical physics, principles of waves and optics, and quantum mechanics.
- to apply knowledge and techniques from physics to solve problems in other physical sciences.
- to identify problems for study, conduct independent studies and be effective members of collaborative teams
- to enhance student's expertise in setting up experiments, collecting and analyzing data.
- to enable students understand physical aspects of a problem, formulate a strategy for solution utilizing mathematical and computational methods, make appropriate approximations, and evaluate the correctness of their solution.
- to furnish an in-depth understanding of some specialized area of physics through choice of elective courses
- to prepare stundents to know and follow the high professional and ethical standards of scientific work
- to prepare students to join an appropriate and respectable level position in a physics related field, and to maintain their professional skills in rapidly evolving industry and academia.
- to develop research based scientific thinking and to enhance professional skills for teaching, research, managerial positions in wide range of professions in national and international organizations

Semester-wise breakup and outline of courses for this program are given as under. In addition to compulsory courses, elective courses of undergraduate level are offered in various specializations in the subject of Physics. The program meets the standards of international undergraduate programs in the subject of Physics. Teaching, laboratory work and examinations are held according to semester rules of University of the Punjab.

SCHEME OF STUDIES

COURSE CODE KEY

For the course code Phys xxxx, the first letter shows the year of degree course in the university (e.g. for first year course, it is written as 1xxx, for third year course it is 3xxx and for fifth year course it is 5xxx (first year of BS course), while second letter represents a number assigned to a specific subject area of physics (e.g. in general classification within the subject of Physics, a number is assigned to a set of similar subject titles i.e. for foundation courses, the number is 0 (Phys x0xx), for classical mechanics and related titles, the number is 1 (Phys x1xx), for electrodynamics and related titles, it is 2 (Phys x2xx), for quantum mechanics and related titles, it is 3 (Phys x3xx), for solid state physics and related titles, it is 4 (Phys x4xx), for mathematical physics and related titles, it is 5 (Phys x5xx), for experimental physics and labs, it is 6 (Phys x6xx), for electronics and related titles, it is 7 (Phys x7xx), for materials and nanotechnology, it is 8 (Phys x8xx) etc. The last two letters of the course code show the sequence of the course titles in the specific subject and range from 01-99 (e.g. for solid state physics-I offered in third year, course code is Phys 3401 and for solid state physics-II offered in the third year, it is Phys 3402, and for solid state physics-III offered in the fourth year, code is Phys 4403 etc.).

SCHEME OF STUDIES (BS PHYSICS)

	Course Code	Course Title	Cr. Hrs.	Course Type
YEAR-I		**SEMESTER-I**		
	Gen 1001	English-I (Reading and Writing Skills)	3	Comp-1
	Gen 1002	Pakistan Studies	2	Comp-2
	Gen 1003	Islamic Studies/Ethics	2	Comp-3
	Math 1001	Calculus-I	3	Comp-4
	Phys 1001	Mechanics	3	Found-1
	Phys 1002	Waves and Optics	3	Found-2
	Phys 1601L	Physics Lab-I	1	Found-3
	Credit Hours		**17**	
		SEMESTER-II		
	Gen 1004	English-II (Composition Writing)	3	Comp-5
	Math 1002	Calculus-II	3	Comp-6
	Phys 1003	Thermal Physics	3	Found-4
	Phys 1004	Electricity and Magnetism	3	Found-5
	Phys 1602L	Physics Lab-II	1	Found-6
	Math 1003	Probability and Statistics	3	Gen-1
	Credit Hours		**16**	
YEAR-II		**SEMESTER III**		
	Gen 2003/Gen 2004	Natural Science (Chemistry/ Biology)	3	Gen-2
	Phys 2001	Quantum Physics	3	Found-7
	Math 2003	Differential Equations	3	Gen-3
	Math 2004	Analytical Geometry	3	Gen-4
	Gen 2005	Introduction to Computing	3	Comp-7
	Phys-2603L	Physics Lab-III	1	Found-8
	Credit Hours		**16**	
		SEMESTER-IV		
	Phys 2002	Modern Physics	3	Found-9
	Phys 2003	Basic Electronics	3	Found-10
	Phys 2604L	Physics Lab-IV	1	Found-11
	Math 2005	Linear Algebra	3	Gen-5
	Gen 2006/Gen 2007	Humanities/ Social Science	3	Gen-6
	Math 2006	Applied Mathematics	3	Gen-7
	Credit Hours		**16**	

	Course Code	Course Title	Cr. Hrs.	Course Type
YEAR -III	**SEMESTER-V**			
	Phys 3101	Classical Mechanics	3	Maj-1
	Phys 3501	Mathematical Methods of Physics-I	3	Maj-2
	Phys 3401	Solid State Physics-I	3	Maj-3
	Phys 3701	Electronics-I	3	Maj-4
	Phys 3605L	Physics Lab-V	2	Maj-5
	Phys 3502	Computational Physics-I	3	Maj-6
	Credit Hours		**17**	
	SEMESTER-VI			
	Phys 3503	Mathematical Methods of Physics-II	3	Maj-7
	Phys 3402	Solid State Physics-II	3	Maj-8
	Phys 3301	Quantum Mechanics-I	3	Maj-9
	Phys 3504	Computational Physics-II	3	Maj-10
	Phys 3702	Electronics-II	3	Maj-11
	Phys 3606 L	Physics Lab-VI	2	Maj-12
	Credit Hours		**17**	
YEAR-IV	**SEMESTER-VII**			
	Phys 4302	Quantum Mechanics-II	3	Maj-13
	Phys 4403	Statistical Physics	3	Maj-14
	Phys 4201	Classical Electrodynamics-I	3	Maj-15
	Phys 4303	Nuclear Physics-I	3	Maj-16
	Phys xxxx	Elective-I	3	Elective
	Phys xxxx	Elective-II	3	Elective
	Credits Hours		**18**	
	Semester-VIII			
	Phys 4404	Solid State Physics-III	3	Maj-17
	Phys 4202	Classical Electrodynamics-II	3	Maj-18
	Phys 4304	Nuclear Physics-II	3	Maj-19
	Phys 4102	Relativity and Cosmology	3	Maj-20
	Phys xxxx	Elective-III	3	Elective
	Phys xxxx	Elective-IV	3	Elective
	Credit Hours		**18**	
	Total Credit Hours		**135**	

List of Elective Courses

Elective courses will be offered from the following list by the Department of Physics in view of availability of instructors and related resources. More titles in the list of elective courses can be added from time to time subject to approval by relevant academic bodies.

Course Code	Course Title	Cr. Hrs.	Course Type
Phys 4305	Introductory Particle Physics	3	Elective
Phys 4306	Relativistic Quantum Mechanics	3	Elective
Phys 4405	Topics in Solid State Physics	3	Elective
Phys 4406	Advanced Solid State Physics	3	Elective
Phys 4308	Quantum Information Theory	3	Elective
Phys 4703	Introduction to Photonics	3	Elective
Phys 4309	Quntum Solid State Magnetism	3	Elective
Phys 4310	Quantum Electronics	3	Elective
Phys 4103	Astrophysics	3	Elective
Phys 4607	Medical Physics	3	Elective

OUTLINES OF COURSES

Phys 1001	**MECHANICS**	**(CR3)**
Preq.	**FSc/A-Level (Physics) or equivalent**	

Objectives

At attending this course students will be able to understand classical concepts of motion and apply their knowledge to mechanical systems.

Syllabus

Vectors and vector algebra, inertial and non-inertial reference frames, Newton's laws of motion and their applications, Newton's Law of gravitation, gravitational potential energy, escape velocity, Kepler's laws, work done by constant and variable forces, gravitational and spring forces, power, conservative and non-conservative forces, work and potential energy, isolated systems and conservation of mechanical energy, work done by external forces including friction and conservation of energy, system of particles, motion of a system of particles and extended rigid bodies, center of mass and Newton's laws for a system of particles, linear momentum, impulse, momentum and kinetic energy in one and two dimensional elastic and inelastic collisions, rotation about a fixed axis and kinematical parameters, rotational inertia, parallel-axis theorem, torque and Newton's law for rotation, work and rotational kinetic energy, power, rolling motion, angular momentum for a single particle and a system of particles, conservation of angular momentum, Gyroscope motion, static equilibrium involving forces and torques, determination of moment of inertia of various shapes, effects of torque and its relation with angular momentum, non-inertial systems and fictitious forces, uniformaly accelerated systems, physics in rotating frame, coriolis effect.

Recommended Books

1. *Mechanics by C. Kittel, et al., Berkeley Physics Course Volume 1, Berkeley (1965) .*
2. *An Introduction to Mechanics, by D. Kelepner and R. Kolenkov, Cambridge, (2013)*

3. *Physics (Volume 1 & 2) by R. Resnick, D. Halliday and K. S. Krane (5th Edition), Wiley (2002).*
4. *University Physics with Modern Physics by H. D. Young, R. A. Freedman (14th Edition), Addison-Wesley (2015).*
5. *Fundamentals of Physics by D. Halliday, R. Resnick and J. Walker (9th Edition), JWiley (2011)*
6. *Physics: Classical and Modern by F. J. Keller W. E. Gettys and M. J. Skove (2th Edition), McGraw Hill (1992)*

Phys 1002	**WAVES AND OPTICS**	**(CR3)**
Preq.	**FSc/A-Level (Physics) or equivalent**	

Objectives

To introduce the ideas of harmonic motion in depth and concept of waves in physics with special attention on light waves.

Syllabus

Oscillations, simple and damped harmonic oscillations, Mass-spring system, Simple harmonic oscillator equation, Simple pendulum, Forced damped harmonic oscillations and Resonance. Waves, Transverse Standing Waves, Normal Modes, General Time Evolution of a Uniform String, Phase velocity, Group Velocity, Longitudinal Waves, Traveling waves, wave equation, Standing waves in a Finite Continuous Medium, Traveling waves in an infinite continuous medium, Electromagnetic waves. Doppler effect of sound waves. Optics, Propagation of Light and Image Formation: Huygens' Principle, Fermat's Principle, Laws of Reflection and Refraction, Refraction at a spherical surface, Thin Lenses, Newtonian Equation for a thin lens. Optical Instruments including simple magnifiers, Telescopes and microscopes, Chromatic and monochromatic aberrations, Spherical Aberrations. Superposition and Interference: Standing waves, Beats, Phase and group velocities, Two-beam and Multiple-beam interference, Michelson and Fabry-Perot interferometers, resolving power. Fraunhofer Diffraction: Diffraction from multiple slits, Diffraction grating, Dispersion. Polarization: Jones Matrices, Production of polarized light, description of polarization states, Dichroism, Brewster's law, Birefringence, Double refraction. Coherence and Holography: Temporal Coherence, Spatial Coherence, Holography.

Recommended Books

1. *The Physics of Vibrations and Waves, by J. Pain, Wiley, (6th edition) (2005).*
2. *A student's guide to waves, D. Fleish, and L. Kinnaman, Cambridge, (2015).*
3. *Vibrations and Waves, by P. French, CBS Publishers (2003).*
4. *Waves and Oscillations, by F. S. Crawford, Jr., Berkeley Physics Course, McGraw-Hill, (1968).*
5. *Physics Vol. I & II by Resnick, Halliday and Krane, 5th Edition, Wiley, (2002).*
6. *Introduction to Optics, by F. Pedrotti, L. S. Pedrotti and L. M. Pedrotti, Pearson, 3rd edition (2007).*
7. *Optics, by E. Hecht and A. Ganesan, Dorling Kindersley, 4th edition (2008).*
8. *Optics: Principles and Applications, by K. K Sharam, Academic Press, (2006).*

Phys 1003	**THERMAL PHYSICS**	**(CR3)**
Preq.	**FSc/A-Level (Physics) or equivalent**	

Objectives

The objective of this course is to develop an understanding about the laws and methods of thermodynamics and enable the student to apply their knowledge to practical systems.

Syllabus

Kinetic theory of the ideal gas, work done on an ideal gas, internal energy of an ideal gas, intermolecular forces. Statistical mechanics, statistical distribution and mean values, distribution of molecular speeds, distribution of energies, Brownian motion. Heat and Thermodynamics; heat, different theories of heat, specific heat, gram molecular specific heat, laws of thermodynamics, Zeroth law, first law, second law, third law of thermodynamics, reversible and irreversible processes, indicator diagram, entropy, law of increase of entropy, temperature-entropy diagram, Maxwell's thermodynamics relations, TDS equations, Clapeyron's equation, entropy and second law of thermodynamics, reversible and irreversible processes, second law of thermodynamics, Carnot Cycle, Carnot engine, thermodynamic temperature scale, entropy, low temperature physics, thermoelectricity, Seebeck effect, Peltier effect, thermocouple.

Recommended Books

1. *Physics (Volume 1 & 2) by R. Resnick, D. Halliday and K. S. Krane (5th Edition), Wiley (2002)*
2. *Concepts in Thermal Physics, by S. J. Blundell and K. M. Blundell, Oxford, (2009)*
3. *University Physics with Modern Physics by H. D. Young, R. A. Freedman (14th Edition), Addison-Wesley (2015).*
4. *Principle of Modern Thermodynamics by B. N. Roy, Institute of Physics, London (1995)*
5. *Physics for Scientists and Engineers by R. A. Serway and J. W. Jewett (8th Edition), Golden Sunburst Series (2010)*
6. *An Introduction to Thermal Physics, D. V. Schroeder, Pearson, (1999).*
7. *Heat and Thermodynamics by M. W. Zemansky (7th Edition), McGraw Hill (1999).*

Phys 1004	**ELECTRICITY AND MAGNETISM**	**(CR3)**
Preq.	**FSc/A-Level (Physics) or equivalent**	

Objectives

To develop an understanding of basic concepts of electricity and magnetism and to strengthen problem solving skills.

Syllabus

Electrostatics, electric charge, conductors and insulators, Coulomb's law, Electric fields due to a point charge and an electric dipole, Electric field of continuous charge distributions (cases of uniform line, ring and disk of charge), electric dipole in an electric field, electric flux, Gauss' law and its applications (planar, cylindrical and spherical symmetry). Electric Potential, Equipotential surfaces, Potential due to a point charge and a group of point charges, Potential due to an electric dipole, Electric potential of continuous charge distributions, Relation between electric field and electric potential energy. Calculating the capacitance, capacitors combinations (series and parallel), energy stored in an electric field, dielectrics and Gauss' law. Ohm's law, electric current and current density, resistance and resistivity, Resistors combinations (series and parallel), Ohm's law: a microscopic view, semiconductors and superconductors. magnetic force on a moving charge, Magnetic force on a current carrying wire, torque on a current loop, magnetic dipole moment, Magnetic field due to a current, force between two parallel currents, Ampere's law, Biot-Savart law: magnetic field due to a current, solenoids and toroids, current-carrying coil as a magnetic dipole, inductance, Faraday's law of induction, Lenz's law, motional EMF, Induced electric fields, Energy stored in a magnetic field. Magnetic properties and Alternating Fields, Gauss' law for magnetism, Spin and orbital magnetic dipole moment, magnetization, magnetic materials, Diamagnetism, Paramagnetism, Ferromagnetism, Hysteresis, Induced magnetic fields, Displacement current, electromagnetism and Maxwell's equations.

Recommended books

1. *Fundamentals of Physics (Extended), by D. Halliday, R. Resnick and J. Walker, Wiley, (10th Edition), (2013).*
2. *Physics Vol.II (extended) by Resnick, Halliday and Krane, 5th Edition, Wiley, (2001).*
3. *Electricity and Magnetism, by E. M. Purcell, D. J. Morin, Cambridge, (3rd Edition), (2013).*
4. *University Physics with Modern Physics, by R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), Addison-Wesley-Longman, 13th International edition, (2010).*
5. *Physics for Scientists and Engineers, by R. A. Serway and J. W. Jewett, Golden Sunburst Series, 8th Edition, (2010).*
6. *Physics for Scientists and Engineers, with Modern Physics, by D. C. Giancoli, Addison-Wesley, 4th Edition (2008).*

Phys 2001	**QUANTUM PHYSICS**	**(CR3)**
Preq.	**FSc/A-Level (Physics) or equivalent**	

Objectives

This course gives an elementary introduction to quantum physics, starting with a historical description of the developments of early last century.

Syllabus

Experimental basis of quantum physics, black body radiations,, photoelectric effect, Compton effect, photons, pair production, Franck-Hertz experiment, the Bohr atom, X-Rays, X-Ray diffraction, de Broglie waves, electron wave, electron diffraction, Davisson-Germer experiment and the wave-particle duality of matter and light, complementarity, Heisenberg uncertainty principle, probabilistic interpretation, atomic spectra, spontaneous and stimulated transitions, lasers, introduction to wave mechanics, Schrödinger's equation, linearity and superposition, wave functions, wave packets, probability amplitudes, expectation value, operators, Solutions to Schrödinger's equation in one dimension: transmission and reflection at a step,a barrier and a well, barrier penetration, potential wells, quantum tunneling and its applications in technology, quantum harmonic oscillator, space quantization, quantization of angular momentum and energy, hydrogen atom, quantum numbers, principal quantum number, orbital quantum number, magnetic quantum number, electron probability density, radiative transitions, selection rules, Zeeman effect, spinning electrons, spin-orbit coupling, exchange symmetry and exclusion principle.

Recommended Books

1. *Concepts of Modern Physics, A. Beiser, McGraw Hill, (6th edition), (2002)*
2. *Modern Physics, R. A. Serway,C. J. Moses, and C. A. Moyer, Cengage, (2004)*
3. *Physics (Volume 1 & 2) by R. Resnick, D. Halliday and K. S. Krane (5th Edition), Wiley (2002)*
4. *University Physics with Modern Physics by H. D. Young, R. A. Freedman (14th Edition), Addison-Wesley (2015)*
5. *Quantum Physics by E. H. Wichmann, Berkeley Physics Course Volume 4, Berkeley (1965)*
6. *Physics for Scientists and Engineers by R. A. Serway and J. W. Jewett (8th Edition), Golden Sunburst Series (2010)*
7. *Physics for Scientists and Engineers with Modern Physics by D. C. Giancoli (4th Edition), Addison-Wesley (2008)*

Phys 2002	MODERN PHYSICS	(CR3)
Preq.	Phys 1101, 1102, 1201	

Objectives

Modern Physics is a one-semester course covering major concepts of twentieth-century physics.

Syllabus

Special theory of relativity, space and time, Lorentz transformation, time dilation, length contraction, twin paradox, relativistic momentum, mass-energy relation, energy momentum relation. Nuclear atom, electron orbits, atomic spectra, Bohr atom, energy levels and spectra, nuclear motion, atomic excitations, lasers, many electron atoms, electron spin, exclusion principle, atomic structure, spin orbit coupling,molecular physics, molecular bond, electron sharing, hydrogen molecule, complex molecules, statistical distributions, Maxwell-Boltzman statistics, quantum statistics, Raleigh-Jeans formula, Plank's radiation law, specific heat of solids, free electrons in metals, nuclear structure, nuclear properties, binding energy, stable nuclei, radioactive decay, alpha decay, beta decay, gamma decay, nuclear reactions, nuclear fission, nuclear reactor, Electrons in solids, free electron gas, band theory of solids, semiconductors and insulators, semiconductor devices, superconductivity.

Recommended Books

1. *Concepts of Modern Physics, A, Beiser, McGraw Hill, (6th edition), (2002)*
2. *Physics (Volume 1 & 2) by R. Resnick, D. Halliday and K. S. Krane (5th Edition),Wiley (2002)*
3. *University Physics with Modern Physics by H. D. Young, R. A. Freedman (14th Edition), Addison-Wesley (2015).*
4. *Quantum Physics by E. H. Wichmann, Berkeley Physics Course Volume 4, Berkeley (1965)*
5. *Physics for Scientists and Engineers by R. A. Serway and J. W. Jewett (8th Edition), Golden Sunburst Series (2010)*
6. *Physics for Scientists and Engineers with Modern Physics by D. C. Giancoli (4th Edition), Addison-Wesley (2008).*

Phys 2003	BASIC ELECTRONICS	(CR3)
Preq.	Phys 1201	

Objectives

Course is designed to introduce fundamental principles of circuit theory and electronic devices.

Syllabus

Fundamental Solid-State Principles, Atomic theory, Metals, insulators and semiconductors, Conduction in Silicon and Germanium, doping, The forbidden energy gap, n and p type semiconductors. The Semiconductor Diode: Introduction to pn junction diode, Bias, the ideal diode, the practical diode model, other practical considerations, the complete diode model, voltage-current characteristics. Common Diode applications: Transformers and power supply, Half-wave rectifiers, full-wave rectifiers, full-wave Bridge rectifiers, wave shaping circuits using diode, voltage multiplier circuits. Special applications Diodes: Zener diodes, light emitting diodes, photodiodes, capacitance effects in the pn junction, other diodes. Circuit analysis: DC circuit analysis, single and multi-loop circuits, Kirchhoff's rules, RC circuits, Charging and discharging of a capacitor, RL circuits, AC circuit analysis using the *j*-operator, RLC circuits, superposition theorem, Thevenin's theorem, Norton's theorem, the hybrid parameter equivalent model, graphical depiction of hybrid-parameters, variation of transistor parameters. Bipolar Junction Transistors: Introduction to Bipolar Junction Transistors (BJTs), transistor construction and operation, transistor characteristics curves, concept of load line. Bipolar Junction

Transistors applications: Transistor as an amplifier, basic transistor configurations, transistor as a switch, concept of decibels, Feedback principle and circuits.

Recommended Books

1. *Introductory Electronic Devices and Circuits, by R. T. Paynter, Prentice Hall, 7th edition, (2005).*
2. *Introductory Electric Circuits, by R. T. Paynter, Prentice Hall, (1998).*
3. *Electronic Devices, by T. L. Floyd, Pearson, 10th Edition, (2017)*
4. *Grob's Basic Electronics, by M. E Schultz, McGraw-Hill Education, 12th edition, (2015)*
5. *Introductory Circuit Analysis, by R. L. Boylestad, Pearson, 13th Edition, (2015)*
6. *Electronic Principles, by A. P. Malvino, David J. Bates, McGraw-Hill, 8th Edition, (2015)*

Phys 3101	**CLASSICAL MECHANICS**	**(CR3)**
Preq.	**Phys 1001**	

Objectives

To introduce students with the basic concepts of dynamical systems and to develop Lagrangian and Hamiltonian formulations of mechanics.

Syllabus

Kinematics, description of motion, space, time and coordinate systems, displacement, velocity and acceleration, Newtonian mechanics, laws of motion, inertial and noninertial frames, work, energy and conservation theorems, system of particles and conservation theorems for system of particles. Lagrangian formulation in generalized coordinates, constraints, principle of virtual work, D'Alembert's principle, Lagrange equations of motion, cyclic coordinates, Routhian function and noncyclic coordinates, forces of constraints and Lagrange multipliers, velocity dependent potentials, charged particle in an electromagnetic field. Central force problem, reduction of two-body problem, reduced mass, conservation in central force field, Kepler laws, properties of motion in central force field, effective potential, calculations of orbits of planets, derivation of Kepler's laws, stability of circular orbits, Rutherford scattering, impact parameter and scattering angle, scattering cross section, derivation of Rutherford scattering formula. Methods in calculus of variations, Euler's equations, second form of Euler's equations, Beltrami identity, some examples of calculus of variations, Hamilton's principle of least action, Lagrange equations. Space time symmetries and conservation laws, homogeneity and isotropy, cyclic coordinates, integrals of motion, Noether's Theorem, Legendre's transformation, Hamiltonian and Hamilton's equations of motion, Poisson brackets and their properties, phase space and phase portrait. Canonical transformations and their properties, canonical transformation of the free particle Hamiltonian, invariance of Poisson's brackets under canonical transformations.

Recommended Books

1. *Classical Mechanics by H. Goldstein, C. P. Poole and J. L. Safko, Pearson New International Edition, (2014)*
2. *Classical Dynamics of Particles and Systems, S. T. Thornton and J. B. Marion, Cengage Learning, 5th Edition, (2012)*
3. *Classical Mechanics by T. L. Chow (2nd Edition), CRC Press (2013)*
4. *Classical Mechanics, D. Strauch, Springer (2009)*
5. *Classical Mechanics, M. J. Benacquista and J. D. Romano, Springer (2018)*

Phys 3501	MATHEMATICAL METHODS OF PHYSICS-I	(CR3)
Preq.	Math 1001, 1002, 2003, 2004	

Objectives
To understand the working knowledge of mathematical methods used in physics.

Syllabus
Series solutions about an ordinary point and regular singular point, Sturm-Liouville theory, self-adjoint ODEs, orthogonal functions, Hermitian operators, eigenvalue problems, completeness of eigenfunctions, Green's Functions, Green's function for one-dimensional problem, eigenfunction expansion of Green's function, special functions, Gamma Function, digamma and polygamma functions, Stirling's series, Beta function, Bessel functions of first kind, , orthogonality, Neumann functions, Bessel functions of the second kind, Hankel functions, modified Bessel functions, asymptotic expansions, sherical Bessel functions, Legendre functions, Legendre polynomials, orthogonality, generating function, recurrence relation, associated Legendre equation, spherical harmonics, orbital angular momentum operator, addition theorem for sherical harmonics, Legendre functions of the second kind, Hermite functions, Hermite equation as Schrodinger equation of quatum harmonic oscillator, Laguerre functions and associated Laguerre functions, Fourier series, properties of Fourier series, Fourier transform, properties of Fourier transforms, Fourier convolution theorem, Fourier transform, discrete Fourier transform, Laplace transforms, properties of Laplace transforms, Laplace transform of derivatives, Laplace Convolution theorem, inverse Laplace transform.

Recommended Books

1. *Mathematical Methods for Physicists (7^{th} Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
2. *A Guide to Mathematical Methods for Physicists by M. Petrini, G. Pradisi and A. Zaffaroni, World Scientific Press (2017)*
3. *Mathematical physics: A modern introduction to its foundations by S. Hassani, Sadri, Springer (2013)*
4. *Dennery, Philippe, and André Krzywicki, Mathematics for physicists, Dover Publications (2012)*
5. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambrige (1999)*
6. *Mathematical Methods for Physicists: A Concise Introduction by T. L. Chow, Cambridge (2000)*

Phys 3401	SOLID STATE PHYSICS-I	(CR3)
Preq.	Phys 2002	

Objectives
This course deals with basic principles and techniques of solid state physics.

Syllabus
Crystal structure, periodic arrays of atoms, fundamental types of lattices, index system for crystal planes, simple crystal structures, direct imaging of atomic structure, non-ideal crystal structures, reciprocal lattice, diffraction of waves by crystals, scattered wave amplitude, Brillouin zones, Fourier analysis of the basis, quasi crystals, crystal binding and elastic constants, crystals of inert gases, ionic crystals, covalent crystals, metals, hydrogen bonds, analysis of elastic strains, elastic compliance and

stiffness constants, elastic waves in cubic crystals, vibrations of crystals with monatomic basis, two atoms per primitive basis, quantization of elastic waves, phonon momentum, inelastic scattering by phonons, Phonon heat capacity, anharmonic crystal interactions, thermal conductivity, electronic heat capacity, noncrystalline solids, diffraction pattern, glasses, amorphous ferromagnets and semiconductors.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittle (8th Edition), Wiley (2012).*
2. *Solid State Physics by N. W. Ashcroft and D. Mermin, CBS Publishing (1987).*
3. *Solid State Physics by J. S. Blakemore, Cambridge (1991).*
4. *Solid State Physics by M. A. Wahab, Narosa Publishing House (1999).*
5. *Physics of Solids, by J. B. Ketterson, Oxford, (2016).*
6. *Elementary and Solid State Physics by M. A. Omar, Pearson (2000).*

Phys 3701	**ELECTRONICS-I**	**(CR3)**
Preq.	**Phys 2003**	

Objectives

To make students acquire a basic knowledge in solid state electronics including diodes, BJT, FET etc.

Syllabus

The Semiconductor Diode, P-type, N-type semiconductors, the junction diode (biasing and characteristics). 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, the capacitor filter, the π filter, the π -R filter, diode wave shaping circuits (clippers and clampers). Special Diodes: Zener Diode, Light Emitting Diode, Photodiode, Tunnel Diode, Shockley Diode, Other diodes. Circuit Theory and Analysis: Models for circuit, one-port and two-port networks, network theorems, hybrid parameters and 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 factors, the load line and Q point, the common emitter amplifier, the trans-conductance g_m, performance of a CE amplifier, relation between A_i and A_v, 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: introduction to field-effect transistor (FET), Junction field-effect transistor (JFET): operation and static characteristics. Metal oxide semiconductor Field Effect Transistor (MOSFET): operation in enhancement and depletion modes. FET configurations and biasing: Common drain, common source and common gate, load line, fixed bias, self-bias and voltage-divider bias.

Recommended Books

1. *Electronic Devices, by T. L. Floyd, Pearson, (10th Edition), (2017).*
2. *Electronics Fundamentals: Circuits, Devices and Applications, by T. L. Floyd, D. M. Buchla, Prentice Hall, (8th Edition), (2009).*
3. *Electronic Principles, by A. P. Malvino, D. J. Bates, McGraw-Hill, (8th Edition), (2015).*
4. *Solid State Electronic Devices, by B. Streetman and S. K. Banerjee, Pearson, (7th edition), (2015)*
5. *Grob's Basic Electronics, by M. E Schultz, McGraw-Hill, (12th edition), (2015)*
6. *Electronic Devices and Circuit Theory, by R. L. Boylestad, L. Nashelsky, Pearson, (11th Edition), (2012).*
7. *Introductory Electronic Devices and Circuits, by R. T. Paynter, Prentice Hall, (7th edition), (2005).*

Phys 3502	COMPUTATIONAL PHYSICS-I	(CR3)
Preq.	Gen 2005	

Objectives
To give students an understanding of various computational and numerical techniques used in physics.

Syllabus
Physics problems solving using numerical methods, basics of numerical analysis, Euler-Newton method for solving differential equations, Simpson method, Taylor expansion method, Runge-Kutta method, the trapezoidal rule for numerical quadrature, Newton-Cotes rule, Gauss-Legendre quadrature, numerical solution of problems in mechanics such as Kepler problem, numerical solution of double pendulum, applications of random number, brownian motion, solution of integral equations, linear algebra, solution of linear algebraic equations, matrix algebra, matrix inverse, sorting and curve fitting and best fit using linear and nonlinear least square fit, interpolation, splines and analysis of experimental and simulation data. Programming techniques in practical applications to advanced physics problems. Introduction to simulation techniques and computer graphics**,** use of computation and computer graphics to simulate the behavior of complex physical systems, computational techniques in investigating and visualizing fundamental physics, scientific packages, introduction to scientific work bench for problem solving in electronics and other branches of physics.

Recommended Books

1. *Introduction to Computational Physics, by T. Pang, Cambridge (2010)*
2. *Numerical methods for Physics, A. L.Garcia,Createspace,(2017)*
3. *Computational Methods in Physics, Chemistry and Biology by P. Harrison, Wiley, (2001).*
4. *More Physics with MATLAB, by D. Green, World Scientific, (2015)*
5. *Computational Physics by H. J. Gardner, World Scientific, Singapore (1997).*
6. *Numerical Recipes: The Art of Scientific Computing by W. H. Press, B. P. Flannery, Saul A. Teukolsky, and William T. Vetterling Cambridge University Press, (1988).*
7. *Mathematica for Physics: R. L. Zimmerman Addison Wesley Publishing Company, (1994.)*

Phys 3503	MATHEMATICAL METHODS OF PHYSICS-II	(CR3)
Preq.	Phys 3501	

Objectives
To understand mathematical tool such as tensor analysis, group theory and complex analysis.

Syllabus
Tensor analysis, some notations, Cartesian tensors, First- and zero-order Cartesian tensors, second- and higher-order Cartesian tensors, the algebra of tensors, the quotient law, Kronecker delta δ_{ij} and Levi Civita tensor ε_{ijk}, Isotropic tensors, improper rotations and pseudo tensors, dual tensors, physical applications of tensors, integral theorems for tensors, non-Cartesian coordinates, the metric tensor, General coordinate transformations and tensors, relative tensors, derivatives of basis vectors and Christoffel symbols, covariant differentiation, vector operators in tensor form, absolute derivatives along curves, Riemann curvature tensor, Complex Anaylsis Complex numbers, powers and roots, Sets in the Complex planes, Functions of a complex variables, Cauchy–Riemann equations, Exponential and Logarithmic functions, Contour Integrals, Cauchy-Goursat theorem, Independence of path, Cauchy's Integral formulas, Sequences and Series, Taylor series, Laurent Expansion , Zeros and Poles, Singularities, Residues and Residues Theorem, Evaluation of real Integrals, Groups Theory, Review of

groups, subgroup, cyclic groups, and permutation groups, isomorphism, Cayley's theorem, properties of isomorphism, automorphism, cosets, properties of cosets, Lagrange's theorem, an application of cosets to permutation groups, the rotation groups of a cube and soccer ball, conjugate classes and invariant subgroups, group representations, some special groups, the symmetry group D_2, D_3, one-dimensional unitary group $U(1)$, orthogonal groups $SO(2)$ and $SO(3)$, the $SU(n)$ groups, Homogeneous Lorentz group.

Recommended Books

1. *Mathematical Methods for Physicists (7th Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
2. *A Guide to Mathematical Methods for Physicists by M. Petrini, G. Pradisi and A. Zaffaroni, World Scientific Press (2017)*
3. *Mathematical physics: A modern introduction to its foundations by S. Hassani, Sadri, Springer (2013)*
4. *Mathematics for physicists, by P. Dennery and A. Krzywicki Dover Publications (2012).*
5. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambrige (1999)*
6. *Mathematical Methods for Physicists: A Concise Introduction by T. L. Chow, Cambridge (2000)*
7. *Contemporary Abstract Algebra by J. A. Gallian (8th Edition), Cengage Learning (2013)*

Phys 3402	**SOLID STATE PHYSICS-II**	**(CR3)**
Preq.	**Phys 3401**	

Objectives

To equip students with fundamental concepts of solid state physics.

Syllabus

Free Electron Fermi Gas: Energy levels in one dimension, effect of temperature on the Fermi-Dirac distribution, free electron gas in three dimensions, heat capacity of the electron gas, experimental electrical resistivity of metals, motion in magnetic fields, Hall effect, thermal conductivity of metals, ratio of thermal to electrical conductivity. Energy Bands: Nearly free electron model, origin of the energy gap, magnitude of the energy gap, Bloch functions, wave equation of an electron in a periodic potential, crystal momentum of an electron, solution of the central equation, empty lattice approximation, approximate solution near a zone boundary, number of orbital in a band, metals and insulators. Homogeneous Semiconductors: Band gap, equation of motion, effective mass, physical interpretation of the effective mass, effective masses in semiconductors, silicon and germanium, intrinsic carrier concentration, intrinsic mobility, impurity conductivity, donor states, acceptor states, thermal ionization of donors and acceptors.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittel (8th Edition), Wiley (2012).*
2. *Elementary Solid State Physics by M. A. Omar, Addison-Wesley (1987).*
3. *Physics of Solids, by J. B. Ketterson, Oxford, (2016).*
4. *Solid State Physics by N. W. Ashcroft and D. Mermin, Holt-Sanders (1976)*
5. *Solid State Physics by J. R. Hook and H. E. Hall (2nd Edition), Wiley (2013)*
6. *Solid State Physics by J. S. Blakemore, Cambridge (1991)*

Phys 3301	QUANTUM MECHANICS–I	(CR3)
Preq.	Phys 2001	

Objectives

This course offers a systematic introduction to fundamental non-relativistic quantum mechanics.

Syllabus

From classical mechanics to quantum mechanics, mathematical tools, Hilbert Space, dimension, bases, orthonormal set, Dirac notation, operators on Hilbert space, Hermition and unitary operators, representation in discrete bases, representation in continuous bases, position and momentum representation, postulates of quantum mechanics, the generalised uncertainty principle, evolution of state, Schrodinger equation and solutions, quantum simple harmonic oscillator, Hermite polynomials, Schrödinger's equation in three dimensions, central potentials and introduction to hydrogenic systems,energy eigenvalues and energy eigenstates, matrix representatio of various operators, angular momentum and spherical harmonics, spherical harmonics, matrix representation of angular momentum, spin angular momentom and Pauli matrices, eigenfunctions of angular momentum, Hydrogen atom and Laguerre polynomials, transformations of states and operators, spatial translations, rotations, translations around, rotation of diatomic molecules, orbital angular momentum, wavefunctions for orbital angular momentum eigenstates, spin SO(3), SU(2) and their representations, the Stern-Gerlach experiment, precession in a magnetic field, composite systems, the tensor product of Hilbert spaces, addition of angular momenta, spin-orbit coupling.

Recommended Books

1. *Introduction to Quantum Mechanics by D. J. Griffiths and D. F. Schroeter(3rd Ed),Cambridge, (2018)*
2. *Introductory Quantum Mechanics by R. Liboff (4th Edition), Addison-Wesley (2002)*
3. *Quantum Mechanics: Concepts and Applications by N. Zettili (2nd Edition), Wiley (2009)*
4. *Modern Quantum Mechanics by J. J. Sakuri and Jim J. Napolitano (2nd Edition), Pearson (2010)*
5. *An Introduction Quantum Mechanics by W. Greiner, Addison Wesley (1980)*

Phys 3504	COMPUTATIONAL PHYSICS-II	(CR3)
Preq.	Phys 3502	

Objectives

To make students understand how to program with MATLAB or PYTHON or MATHEMATICA in solving physical problems with numerical methods.

Syllabus

Advanced simulation techniques, problem solving using simulation, projectile motion, simple pendulum, motion of falling objects, motion in single and multi dimensions, programming techniques in quantum mechanics, statistical mechanics and nuclear physics, numerical solutions to Schrodinger's equations, normalization of wave function, orthogonality of eigenfunctions, certain calculations quantum mechanics, interpolation and extrapolation, Numerical integration, Monte Carlo methods, metropolis algorithm, some finite element methods, applications in statistical physics, Laplace transformation, solution of linear algebraic equations, sorting and curve fitting, special functions, Hermite polynomials and quantum harmonic oscillator etc. Stochastic methods, random number generation and Monte Carlo integration, random walk, Fourier transform spectral methods, orthogonal

functions, wavelet analysis, Gaussian quadrature, problems in electrodynamics, solution of Laplace equation.

Recommended Books

1. *Introduction to Computational Physics, by T. Pang, Cambridge (2010)*
2. *Numerical methods for Physics, A. L.Garcia,Createspace,(2017)*
3. *Computational Methods in Physics, Chemistry and Biology by P. Harrison, Wiley, (2001).*
4. *More Physics with MATLAB, by D. Green, World Scientific, (2015)*
5. *Computational Physics by H. J. Gardner, World Scientific, Singapore (1997).*
6. *Numerical Recipes: The Art of Scientific Computing by W. H. Press, B. P. Flannery, Saul A. Teukolsky, and William T. Vetterling Cambridge University Press, (1988).*
7. *Mathematica for Physics: R. L. Zimmerman Addison Wesley Publishing Company, (1994.)*

Phys 3702	**ELECTRONICS-II**	**(CR3)**
Preq.	**Phys 3701**	

Objectives

To be capable of designing rectifiers, amplifiers, oscillators, and multivibrators and to design circuits.

Syllabus

Cascade amplifier, The Amplifier pass band, the frequency plot (Bode plot), Low frequency analysis, Low frequency limit, the un-bypassed emitter resistor, high frequency equivalent circuit and analysis, The Miller Effect, high frequency limit of transistor, bandwidth of a cascade amplifier. Feedback Amplifiers, Positive and Negative feedback, Principle of feedback amplifier, stabilization of gain by negative feedback, Bandwidth improvement, Reduction of nonlinear distortion, control of amplifier output and input resistance, current series feedback circuit, voltage shunt feedback circuit. Oscillator operation and feedback principles, the oscillatory circuit and frequency stability, oscillators with LC, RC feedback circuits, Power Amplifiers, differential Amplifier Circuit, Common mode rejection ratio, operational amplifier (Op-Amp), Inverting and Non-inverting configuration, Op-Amp Applications, Basic types of Multivibrators, Astable Multivibrator, Mono-stable Multivibrator, Bi-stable Multivibrator, Flip-flop. Binary systems, octal and hexadecimal numbers and their conversions, complements, arithmetic addition and subtraction, binary codes "BCD", Excess-3", "Gray code", "ASCII characters code", boolean algebra and logic gates, basic theorems and properties of boolean algebra, boolean functions, canonical and standard forms, digital logic gates, digital logic functions, gate-level minimization, Karnaugh-map, product of sum and sum of products simplifications, NAND and NOR implementation.

Recommended Books

1. *Electronic Devices (Conventional Current Version), by T. L. Floyd, Pearson, 10th Edition, (2017)*
2. *Electronics Fundamentals: Circuits, Devices and Applications, by Thomas L. Floyd , David M. Buchla, Prentice Hall, 8th Edition, (2009)*
3. *Electronic Principles, by A. P. Malvino, D. J. Bates, McGraw-Hill, 8th Edition, (2015)*
4. *Solid State Electronic Devices, by B. Streetman and S.K. Banerjee, Pearson, 7th edition, (2015)*
5. *Grob's Basic Electronics, by M. E Schultz, McGraw-Hill Education, 12th edition, (201)5*
6. *Electronic Devices and Circuit Theory, by Robert L. Boylestad, Louis Nashelsky, Pearson, 11th edition, (2012)*
7. *Introductory Electronic Devices and Circuits (Conventional Flow Version), by Robert T. Paynter, Prentice Hall, 7th edition, (2005)*
8. *Digital Fundamentals, by T. L. Floyd, Pearson, 11th Edition, (2014)*

Phys 4302	QUANTUM MECHANICS-II	(CR3)
Preq.	Phys 3301	

Objectives
The second course provides a basis for further concepts of quantum mechanics.

Syllabus
Elements of Matrix Mechanics, matrix representation, Identical particles, many particle systems, and second quantization: indistinguishability of identical particles, systems of identical particles, quantum dynamics of identical particle systems, angular momenta and spin *1/2* boson operators, exchange degeneracy, symmetrization postulates, constructing symmetric and anti-symmetric wavefunctions, system of identical noninteracting particles, Exclusion principle approximate methods for stationary states, time independent perturbation theory for non degenerate levels and for degenerate levels, fine structure and anomalous Zeeman effect, the variational method, the WKB approximation, bound states for potential well with no rigid wall, bound states for potential well with one rigid wall, tunneling with potential barrier, time dependent perturbation theory, pictures of quantum mechanics, Schrodinger, Heisenberg and interaction picture, transition probability and Fermi Golden Rule, interaction of atoms with radiation, the theory of scattering, scattering experiments and cross sections, scattering amplitudes, potential scattering, the method of partial waves, the Born approximation.

Recommended Books

1. *Introduction to Quantum Mechanics by D. J. Griffiths and D. F. Schroeter(3rd Ed),Cambridge, (2018)*
2. *Introductory Quantum Mechanics by R. Liboff (4th Edition), Addison-Wesley (2002)*
3. *Quantum Mechanics: Concepts and Applications by N. Zettili (2nd Edition), Wiley (2009)*
4. *Modern Quantum Mechanics by J. J. Sakuri and Jim J. Napolitano (2nd Edition), Pearson (2010).*
5. *An Introduction Quantum Mechanics by W. Greiner, Addison Wesley (1980).*

Phys 4403	STATISTICAL PHYSICS	(CR3)
Preq.	Phys 3301, 3402	

Objectives
This course will develop basic knowledge of statistical mechanics at the undergraduate level and to use this knowledge to describe macroscopic systems, thermodynamic potentials and ensembles.

Syllabus
Concepts in classical laws of thermodynamics and their application, postulates of statistical mechanics, statistical interpretation of thermodynamics, Phase space description of physical systems, macrosystems and macrosystems, ensembles, entropy in statistical mechanics, microcanonical ensemble, canonical ensemble, the methods of statistical mechanics are used to develop the statistics for Bose-Einstein, Fermi-Dirac and photon gases; frequency spectrum of a black body and Planck's radiation law, Liouville's theorem, equality of probability for the perfect gas, energy distribution of conduction electrons in metals, Quantization effects in molecular gases; phonons, photons; density matrix formulation, Identical Particles, Degenerate quantum gases; Fermi liquids; Bose-Einstein condensation; superfluidity, selected topics from low temperature physics and electrical and thermal properties of matter.

Recommended Books

1. *Statistical Mechanics, by K. Huang, Pearson, (2008)*
2. *Statistical Mechanics, by R. K. Pathria and P. D. Beale, Academic Press, (3rd Ed.), (2011)*
3. *Quantum Statistical Thermodynamics, by K. N. Huang, Springer, (2018)*
4. *Fundamentals of Statistical and Thermal Physics, by F. Reif, Waveland, (2008)*
5. *Statistical Physics of Particles, by M. Kardar, Cambridge, (2007)*
6. *Elementary Statistical Physics by C. Kittle, Wiley (1958)*

Phys 4201	**CLASSICAL ELECTRODYNAMICS-I**	**(CR3)**
Preq.	**Phys 1004**	

Objectives

This course gives understanding of the basic concepts of classical electrodynamics.

Syllabus

The basic concepts (Electric charge, Coulomb's law, the electric field, the electrostatic potential, Gauss's law, application of Gauss's law etc) , the electric dipole, multipole expansion of electric fields, the Dirac delta function, Poisson's equation, Laplace's equation, Laplace's equation in one independent variable, solution to Laplace's equation, conducting sphere in a uniform electric filed, electrostatic images, Polarization in dielectrics, field outside a dielectric medium, the electric field inside a dielectric, Gauss's law in a dielectric: the electric displacement, electric susceptibility and dielectric constant, point charge in a dielectric fluid, boundary conditions on the field vectors, boundary-value problems involving dielectrics, method of images for problems involving dielectrics, Potential energy of a group of point charges, electrostatic energy of a charge distribution, energy density of an electrostatic field, related problems, Electric Current and Magnetostatics: Nature of the current, current density: equation of continuity, Ohm's law: conductivity, steady currents in continuous media, approach to electrostatic equilibrium, the definition of magnetic induction, forces on current-carrying conductors, the law of Biot and Savart, elementary applications of the Biot and Savart law, Ampere's circuital law, the magnetic vector potential, the magnetic field of a distant circuit, the magnetic scalar potential, magnetic flux, related problems.

Recommended Books

1. *Foundation of Electromagnetic Theory by J. R. Reitz, F. J. Milford and R. W. Christy (4thEdition), Addison-Wesley (2009)*
2. *Introduction to Electrodynamics, David J. Griffiths (4th Edition), Prentice Hall (2013).*
3. *Classical Electrodynamics, J.D. Jackson, third edition, John Wiley (2012)*
4. *Elements of Electromagnetics by M. N. O. Sadiku (5thEdition), Oxford (2009).*

Phys 4303	**NUCLEAR PHYSICS-I**	**(CR3)**
Preq.	**Phys 3301**	

Objectives

To describes the fundamental principles and concepts of Nuclear physics.

Syllabus

Basic Properties of Nucleus, nuclear size, mass, radius, binding energy and semi-empirical mass formula, Applications of semi-empirical mass formula, nuclear spin, magnetic dipole moment, electric quadrupole moment, parity, isobaric spin and nuclear statistics, nuclear level, nature of nuclear force between nucleons, the deuteron, Radioactive decay, radioactive decay law, quantum theory of radioactive decay, Basic alpha decay processes, quantum theory of alpha decay and explanation of

observed phenomena, angular momentum and parity in alpha decay, alpha decay spectroscopy, measurement of β-ray energies, Fermi theory of β-decay, angular momentum and parity selection rules, neutrino hypothesis, double beta decay, parity violation in beta decay, theory of gamma decay, multipolarity of gamma-rays, angular momentum and parity selection rules, Nuclear forces, Properties of the nuclear force, Nuclear Potential, Yukawa's theory of nuclear forces, Nuclear Models: Liquid drop model, Shell model, collective model.

Recommended Books

1. *Introductory Nuclear Physics by K. Krane, Wiley (1980)*
2. *Nuclear and Particle Physics by Burcham, E. E. and Jobes, M., Longman (1995)*
3. *Nuclear and Particle Physics by Martin, R. B., John Wiley (2006)*
4. *Nuclear Physics by I. Kaplan, Addison-Wesley (1980).*
5. *Nuclear Physics in a nutshell, by C.A. Bertulani, Princeton, (2007).*
6. *Nuclear Physics by A. Kamal, Springer, (2014)*
7. *Foundations of Nuclear and Particle Physics, T. W, Donnelly and J. A. Formaggio, Cambridge (2017)*
8. *Nuclear Physics: Principles and Applications by J. Lilley, John Wiley (2013)*

Phys 4404	**SOLID -STATE PHYSICS-III**	**(CR3)**
Preq.	**Phys 3402**	

Objectives

The course will provide a valuable introduction of quantum theory of solids.

Syllabus

Screening of the electron-phonon interaction, ionic crystals, the production and propagation of polarons, mirco-scopic theory of frequency-dependent dielectric constants, band gap sensitive optical properties of semiconductors, interaction of conduction electrons and their impact on conductivity, transport phenomenon, Boltzmann transport equation, relaxation time and conductivity equation in Boltzmann transport equation, solids in external magnetic fields: Free electron approximation in magnetic field and the formation of Landau levels, Landau diamagnetism in free electrons, Optical reflectance spectroscopy, Excitonic transitions, Types of excitons (Frenkel and Mott-Wannier Excitions), Excitation Condensation into the Electron-hole drops, Raman measurements of inelastic scattering in crystals, stokes and anti-stokes scattering, X-ray induced emission spectra in crystals, Electron energy loss spectroscopy.

Recommended Books

1. *Quantum Theory of the Solid by J. Callaway, 2nd Edition, Elsevier Science, (2013)*
2. *Solid-State Physics: Introduction to the Theory by J. D. Patterson, B. C. Bailey, 3rd Springer International Publishing (2018)*
3. *Introduction to Solid State Physics, 8th Edition, by C. Kittle, (2012).*
4. *Solid State Physics by N. W. Ashcroft and D. Mermin, Cengage, (2011).*
5. *Solid State Physics: An introduction by P. Hofmann, 2nd Edition, Wiley-VCH, (2015)*

Phys 4202	**CLASSICAL ELECTRODYNAMICS-II**	**(CR3)**
Preq.	**Phys 4201**	

Objectives

The second course provides some further topics of classical electrodynamics.

Syllabus

Magnetization, the magnetic field produced by magnetized material, magnetic scalar potential and magnetic pole density,magnetic intensity, magnetic susceptibility, permittivity and hysteresis, boundary conditions on the field vectors, boundary-value problems involving magnetic materials, related problems, Electromagnetic induction, the generalization of Ampere's law, energy density in the magnetic field, electromagnetic energy, the wave equation, monochromatic waves, boundary conditions, the wave equation with sources, vector and scalar potentials, gauge transformations (Lorentz gauge, coulombs gauge), pressure of radiations, retarded scalar and vector potentials, covariant formulation of electrodynamics, transformation laws of electro magnetic fields, related problems, Propagation of Electromagnetic Waves, plane monochromatic waves in non-conducting media, polarization of waves, energy density, plane monochromatic waves in conducting media, Reflection and refraction at the boundary of two non-conducting media: normal incidence, reflection and refraction at the boundary of two non-conducting media, oblique incidence, complex Fresnel coefficients: reflection from a conducting plane, waveguides, transverse electric and transverse magnetic waves, parallel-plate waveguide, dielectric waveguides, radiation from an oscillating dipole, related problems, Plasma Physics**: i**ntroduction, electrical neutrality in a plasma, particle orbits and drift motion in a plasma, magnetic mirrors, the hydromagnetic equations, plasma oscillations and wave motion.

Recommended Books

1. *foundation of Electromagnetic Theory by J. R. Reitz, F. J. Milford and R. W. Christy (4thEdition), Addison-Wesley (2009)*
2. *Introduction to Electrodynamics, David J. Griffiths (4th Edition), Prentice Hall (2013).*
3. *Classical Electrodynamics, J.D. Jackson, third edition, John Wiley (2012)*
4. *Elements of Electromagnetics by M. N. O. Sadiku (5thEdition), Oxford (2009).*

Phys 4304	**NUCLEAR PHYSICS-II**	**(CR3)**
Preq.	**Phys 4303**	

Objectives

This part deals with some additional topics of nuclear physics.

Syllabus

Nuclear Reactions, types of nuclear reactions and conservation laws, Coulomb scattering, nuclear scattering, Q-value of nuclear reaction, threshold energy, transmutation by photons, protons, neutrons and alpha particles, Cross section from nuclear reactions, compound nucleus theory of nuclear reactions, limitations of compound nucleus theory, direct reactions, Neutron Physics, Neutron sources, radioactive sources, photon neutron sources, charged particle sources, reactor as a neutron source, slowing down of neutron, neutron detectors, neutron capture, interference and diffraction with neutrons, Nuclear fission, Description of fission reaction, Mass distribution of fission fragments, Average number of neutrons released, Fission cross section, Chain reaction, Controlled fission reactions, Fission reactors. Nuclear Fusion, Basic fusion processes, Energy released in nuclear fusion, Solar fusion, p-p cycle, CNO cycle, controlled nuclear fusion, D-D and D-T reactions, accelerators, electrostatic accelerators, cyclotrons, synchrotrons, linear accelerators, colliding-beam accelerators.

Recommended Books

1. *Introductory Nuclear Physics by K. Krane, Wiley (1980)*
2. *Nuclear and Particle Physics by Burcham, E. E. and Jobes, M., Longman (1995)*
3. *Nuclear and Particle Physics by Martin, R. B., John Wiley (2006)*
4. *Nuclear Physics by I. Kaplan, Addison-Wesley (1980).*
5. *Nuclear Physics in a nutshell, by C.A. Bertulani, Princeton, (2007).*

6. *Nuclear Physics by A. Kamal, Springer, (2014)*
7. *Foundations of Nuclear and Particle Physics, T. W, Donnelly and J. A. Formaggio, Cambridge (2017)*
8. *Nuclear Physics: Principles and Applications by J. Lilley, John Wiley (2013)*

Phys 4102	RELATIVITY AND COSMOLOGY	(CR3)
Preq.	Phys 3503	

Objectives
The purpose of this course is to introduce the field of general relativity and cosmology.

Syllabus
Einstein's postulates of special relativity, Lorentz transformations, structure of spacetime, Minkowski spacetime tensors, the light-cone, line element, four-vectors, relativity of simultaneity, velocity transformation and velocity addition. Force equation in relativity, rest mass, kinetic and total energy, conservation of energy and momentum. Covariant form of Maxwell's equations, four vector potential and field strength tensor. Elements of Tensor Calculus, Manifolds and coordinates, curves and surfaces, tensor fields, geodesics, Riemann tensor, Bianchi identity, metric tensor, Ricci tensor, Einstein's tensor. General Relativity, Principles of general relativity, weak and strong equivalence principle, equation of geodesics deviation, Einstein's field equations, tests of general theory of relativity, Cosmology, Newtonian cosmology, cosmological redshift, luminosity and redshift relation, Hubble's law, microwave background, the Big Bang, Friedmann models and cosmological constant, FRW metric.

Recommended Books

1. *Dynamics and Relativity by W. D. McComb, Oxford (1999)*
2. *Introduction to Cosmology by J. V. Narlikar, Cambridge (2002).*
3. *Introduction to Cosmology by B. Narlikar, Cambridge (2016).*
4. *Special Relativity: For the Enthusiastic, CreateSpace, (2017).*
5. *Introduction to General Relativity,C. Bambi, Springer, (2018)*
6. *Introducing Einstein's Relativity, by R. D'Inverno, Oxford (1992).*

OPTIONAL COURCES

Phys 4305	INTRODUCTORY PARTICLE PHYSICS	(CR3)
Preq.	Phys 3301	

Objectives
This course will provide an introductory survey of modern particle physics.

Syllabus
Particle Classification, Quantum numbers, leptons, quarks, hadrons, baryons, mesons, strange particles, the eightfold way, the fundamental interactions: Primitive vertices for EM, strong and weak interactions, Feynman Diagrams, The electromagnetic coupling, the strong coupling, the weak coupling, Vacuum Polarization, Symmetry Transformation and Conservation Laws, Translation in space, Rotation in space, The group SU (2), isospin, extended Pauli principle, consequence of isospin conservation, Systems of identical particles, Parity, Charge conjugation, Time reversal, G parity, CPT theorem, polarization and photon spin, gauge invariance and Maxwell's equations, angular momentum, parity and C-parity of photons,. The quark model, The group SU (3) and its representations, notion of colour, quarks, hadrons (baryons, mesons in quark model).

Recommended Books

1. *Introduction to Elementary Particles by D. Griffiths (2nd Edition), Wiley, (2008).*
2. *Nuclear and Particle Physics by E. E. Burcham, and M. Jobes, Longman, (1995).*
3. *Nuclear and Particle Physics by R. B. Martin, Wiley, (2006)*
4. *Concepts of Particle Physics by K. Gottfried, and F. Weisskopt, Vol. 1, Oxford, (1986).*
5. *Nuclear and Particle Physics by W. S. C. Williams, Oxford, (1995).*
6. *A Modern Introduction to Particle Physics by Fayyazudding and Riazuddin, World Scientific, (1992)*
7. *Quarks and Leptons by F. Halzen and A. D. Martin, Wiley, (1984).*

Phys 4306	**RELATIVISTIC QUANTUM MECHANICS**	**(CR3)**
Preq.	**Phys 3301**	

Objectives

To provides an understanding of the effects of special relativity in quantum mechanics.

Syllabus

The Klein-Gordan Equation, Nonrelativistic quantum mechanics, Lorentz covariance and 4 vector notation, the Klein Gordon equation, the Feynman-Stuckelberg interpretation of E < 0 solutions, nonrelativistic perturbation theory (brief review), rules for scattering amplitudes in the Feynman-Stukelberg 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 covariants, zero mass fermion, Weyl and Majorana spinors, Weyl equation, Weyl and Majorana representation of the Dirac equation, the two-component neutrino, V-A interaction, Fermi interaction, unitary and anti-unitary symmetries, CPT symmetries, Dirac particles in external fields, brief introduction to QED: Feynman Rules in QED, Invariant amplitude, Invariant variables.

Recommended Books

1. *Quarks and Leptons by F. Halzen, and A. D. Martin, Wiley, (1984).*
2. *Introduction to Elementary Particles by Griffiths, D., 2nd Edition, Wiley, (2008).*
3. *Relativistic Quantum Mechanics by J. D. Bjorken, and S. D. Drell, McGraw-Hill, (1964)*
4. *Quantum Mechanics by Riazuddin and Fayyazuddin, World Scientific(1990).*

Phys 4405	**TOPICS IN SOLID STATE PHYSICS**	**(CR3)**
Preq.	**Phys 3402**	

Objectives

To study selected topics in solid state physics such as quantum theory of magnetism and superconductivity.

Syllabus

Diamagnetic and paramagnetic solids, magnetic susceptibilities of diamagnetic and paramagnetic substances, Quantum theory of paramagnetism, Pauli paramagnetism of conduction electrons, Types of superconductors, BCS theory, magnetic field induced superconducting to normal state transitions, parameters evidencing the superconducting phase transitions, free energy change during superconducting transition, London relations and coherence length of superconductor, Quantized flux due to cooper pairs flowing in a ring, calculation of the sustaining time of supercurrents, fabrication of junctions for Josephson effects, principle and theory of SQUIDS, high-temperature superconductors,

electric polarization, calculation of macroscopic electric field, dielectric constant and polarizability, phase transitions in ferroelectric crystals, Landau description of the order of phase transitions, differentiation of anti-ferroelectric, piezoelectric and ferroelastic materials. Quantization of free electron orbits in a magnetic field, De Haas-van Alphen effect, the quantum Hall effect, Quantum dots, Quantum dot crystals, Kondo effect, Epitaxial hetero- and quantum structures, Coulomb blockade.

Recommended Books

1. *Quantum Theory of the Solid by J. Callaway, 2nd Edition, Elsevier, (2013)*
2. *Solid-State Physics: Introduction to the Theory by J. D. Patterson, B. C. Bailey (3rdEdition), Springer (2018)*
3. *Introduction to Solid State Physics by C. Kittle (8th Edition), Wiley (2012)*
4. *Solid State Physics by N. W. Ashcroft and N. D. Mermin, Cengage (2011)*
5. *Solid State Physics: An introduction by P. Hofmann (2nd Edition), Wiley-VCH (2015)*

Phys 4406	**ADVANCED SOLID STATE PHYSICS**	**(CR3)**
Preq.	**Phys 3402**	

Objectives

This course will provide an introduction to magnetic phenomena in solids.

Syllabus

Ferromagnetism and Antiferromagnetism: Ferromagnetic order, Curie point and the exchange integral, temperature dependence of the saturation magnetization, saturation magnetization at absolute zero, magnons, ferromagnetic magnons, quantization of spin waves, thermal excitation of magnons, neutron magnetic scattering, ferromagnetic order, Curie temperature and susceptibility of ferrimagnets, antiferromagnetic order, susceptibility below Neel temperature, antiferromagnetic magnons, ferromagnetic domains, anisotropy energies, transition region between magnetic domains, origin of domains, hysteresis curve, single domain particles, superparamagnetism, magnetic force microscopy. Magnetic resonance: Magnetic resonance phenomenon's in magnetism, nuclear magnetic resonance (NMR), equations of motion, line width, motional narrowing, hyperfine splitting, nuclear quadrupole resonance, ferromagnetic resonance (FMR), shape effects in FMR, spin wave resonance, antiferromagnetic resonance, electron paramagnetic resonance, exchange narrowing, zero-field splitting.

Recommended Books

1. *Introduction to Solid State Physics by C. Kittle, 8th Edition (2012).*
2. *Magnetic Materials: Fundamentals and Applications by N. A. Spaldin, 2nd Ed. (2011).*
3. *Quantum Theory of the Solid State by J. Callaway, 2nd Edition (1991).*
4. *Introduction to Magnetic Materials by B. D. Cullity & C.D. Graham, 2nd Ed. (2008).*

Phys 4308	**QUANTUM INFORMATION THEORY**	**(CR3)**
Preq.	**Phys 3301**	

Objectives

To understand the fundamental concepts of quantum information, communication, computation, and physical protocols for quantum computation

Syllabus

Review of Quantum Mechanics and overview of Quantum information: Postulates of quantum mechanics, quantum states and observables, Dirac notation, projective measurements, density operator,

pure and mixed states, entanglement, tensor products, no-cloning theorem, mixed states from pure states in a larger Hilbert space, Schmidt decomposition, generalized measurements, (CP maps, POVMs), qualitative overview of Quantum Information. Quantum Communication: Dense coding, teleportation, entanglement swapping, instantaneous transfer of information, quantum key distribution. Entanglement and its Inseparability of EPR pairs, Bell inequality for pure and mixed states, entanglement witnesses, Peres- Horodecki criterion, properties of entanglement measures, pure and mixed state entanglement, relative entropy as entanglement measure, entanglement and thermodynamics, measuring entanglement. Quantum Information: Classical information theory (data compression, Shannon entropy, von Neumann entropy), fidelity, Helstrom's measurement and discrimination, quantum data compression, entropy and information, relative entropy and its statistical interpretation, conditional entropy, Holevo bound, capacity of a quantum channel, relative entropy and thermodynamics, entropy and erasure, Landauer's erasure.

Recommended Books

1. *Introduction to Quantum Information Science by V. Vedral, Oxford (2007)*
2. *Quantum Computation and Quantum Information by M. Nielsen and I. Chuang (10th Edition), Cambridge (2010)*
3. *Problems and Solutions in Quantum Computing and Quantum Information by W. Steeb and Y. Hardy (3rd Edition), World Scientific Publishing (2011)*

Phys 4703	INTRODUCTION TO PHOTONICS	(CR3)
Preq.	Phys 3402	

Objectives

To study the application of light, studying the photonic devices including detectors.

Syllabus

Guided Wave Optics: Planar slab waveguides, Rectangular channel waveguides, Single and multi-mode optical fibers, waveguide modes and field distributions, waveguide dispersion, pulse propagation Gaussian Beam Propagation: ABCD matrices for transformation of Gaussian beams, applications to simple resonators Electromagnetic Propagation in Anisotropic Media: Reflection and transmission at anisotropic interfaces, Jones Calculus, retardation plates, polarizers Electro-optics and Acousto-optics: Linear electro-optic effect, Longitudinal and transverse modulators, amplitude and phase modulation, Mach-Zehnder modulators, Coupled mode theory, Optical coupling between waveguides, Directional couplers, Photoelastic effect, Acousto-optic interaction and Bragg diffraction, Acousto-optic modulators, deflectors and scanners Optoelectronics: p-n junctions, semiconductor devices: laser amplifiers, injection lasers, photoconductors, photodiodes, photodetector noise.

Recommended Books

1. *Fundamentals of Photonics by B. E. A. Saleh and M. C. Teich (2nd Edition), John Wiley (2007)*
2. *Photonic Devices by J-M. Liu, Cambridge (2009)*
3. *Photonics: Optical Electronics in Modern Communications by A. Yariv and P. Yeh, Oxford (2006)*
4. *Optics by E. Hecht (4thEdition), Addison-Wesley (2001)*

Phys 4309	QUANTUM SOLID-STATE MAGNETISM	(CR3)
Preq.	Phys 3402	

Objective

Learn the modern theoretical foundations used to describe and study collective magnetic phenomena in the Solid State.

Syllabus

Magnetic response and correlation functions, analytic properties, fluctuation-dissipation theorem, experimental methods to measure static and dynamic correlations, magnetic response and correlations in metals, diamagnetism and paramagnetism, magnetic ground states: ferromagnetism, spin density waves, excitations in metals, spin waves, experimental examples, magnetic response and correlations of magnetic ions in crystals: quantum numbers and effective Hamiltonians, application of group theory to classifying ionic states, experimental case studies, magnetic response and correlations in magnetic insulators, effective Hamiltonians, magnetic order and propagation vector formalism., the use of group theory to classify magnetic structures, determination of magnetic structures from diffraction data, excitations: spin wave theory and beyond, Triplons, measuring spin wave spectra.

Recommended Books

1. *Quamtum Theory of Magnetism, by W. Nolting, Springer, (2009)*
2. *Quantum Theory of Magnetism, by R. M. White, Springer, (2006)*
3. *Quantum Magnetism, U. Schollwöck and J. Richter, Springer, (2004)*
4. *Introduction to Magnetic Materials by B. D. Cullity & C. D. Graham, 2nd Ed. (2008).*

Phys 4310	QUNTUM ELECTRONICS	(CR3)
Preq.	Phys 3402, 3702	

Objective

Develop a basis for understanding the quantum mechanical aspects of modern electronics (lasers, quantized Hall effect, field effect transistors, optical tweezers, etc.)

Syllabus

Time-independent Schrodinger equation, quantum mechanical tunneling, bound states and scattering transmission electron microscopy, the energy spectrum of diatomic and aromatic molecules, the band structure of one-dimensional crystalline and disordered solids, the scattering time for electron transport in a crystal, the quantized and fractional Hall effect in a two-dimensional electron gas, perturbation theory and field quantization, two-state lasers, light pressure forces on atoms, quantization of LC circuits, Casimir forces, field effect transistor, optical tweezers, quantum devices, single electron transistor,

Spontaneous and stimulated transitions, Einstein coefficients, coherence of stimulated emission, Light matter interaction, transition probability Spectral line shape, inhomogeneous and homogeneous broa dening Absorption and amplification, gain medium, saturation Laser oscillations, feedback, lasing th reshold, resonant conditions interaction of electromagnetic radiations with resonant atomic transitions, density matrix treatment, Rabi oscillations.

Recommended Books

1. *Quantum Theory Of The Optical And Electronic Properties Of Semiconductors (5Th Edition), H. Haug and S. W. Koch, World Scientific, (2009)*

2. *Quantum Electronics, by A. Yariv,Wiley, (2013)*
3. *Principles of Quantum Electronics, D. Marcuse, Academic Press, (2012).*

Phys 4310	ASTROPHYSICS	(CR3)
Preq.	Phys 3402, 3702	

Objective

To give an introduction to theory of star formation and to understand large scale structure of the universe.

Syllabus

Astronomy is an observational science, measuring time, angle, and distance, luminosity, brightness and telescope, temperature, colour and spectral properties of stars, basic physics of stars, The interstellar medium and the birth of stars; protostars and evolution to the main sequence; star clusters, The death of stars - white dwarfs, the late evolution of massive stars, supernovae and supernova remnants Neutron stars, pulsars and black holes, Galaxies: the Milky Way galaxy, rotation curves and dark matter, other galaxies and the Hubble classification scheme, Galaxies: active galaxies, galaxy environments and large scale structure, galaxy clusters and dark matter, galaxy formation, Cosmology: Hubble's law, the Big Bang, the cosmic microwave background, Expanding Universe, Hubble's law, red shift, Big Bang and Inflation, Cosmic Microwave Background, Nucleosynthesis, Dark Matter and Dark Energy.

Recommended Books

1. *An Introduction to Modern Astrophysics by B. W. Carroll and D. A. Ostlie, (2nd Edition), Cambridge (2017)*
2. *Introduction to Astrophysics: The Stars by J. Dufay and O. Gingerich, Dover (2012)*
3. *An Introduction to Stellar Astrophysics by F. LeBlanc (1st Edition), Wiley (2010)*

Phys 4310	MEDICAL PHYSICS	(CR3)
Preq.	Phys 3402, 3702	

Objective

To give an introduction to various applications of physics in medical sciences and health care sector.

Syllabus

Interactions of ionizing Radiation with Matter: Introduction; Beta-rays, range-energy relationship, mechanism of energy loos, ionization and excitation, Bremsstrahlung, Alpha-rays, Rang-energy relation – ship, Energy transfer, Gamma-rays, exponential absorption, interaction mechanisms, Pair production, Compton scattering, photoelectric absorption, photodisintegration, Combined effect, Neutrons, Production classification, interaction, Scattering, Absorption. Radiotherapy, development of radiotherapy, Radiotherapeutic aims, External beam therapy, Brachytherapy, Unsealed source therapy, Requirements for accuracy and precision, Quality assurance, The role of medical physics. Medical Imaging, Diagnostic X-rays, Production of X-rays, Absorption of x-ray to other planes, Partial volume effect, Artifacts, Contrast agents in conventional radiography and CT, Diagnostic Ultrasound, Doppler effect, Radionuclide imaging, positron emission tomography (PET), Magnetic resonance imaging (MRI), Contrast agents for MRI.

Recommended Books

1. *Introduction to Health Physics by H. Cember. 3rd Ed. McGraw Hill, (1996).*
2. *Diagnostic Imaging, by Peter Armstrong and Martin L. 4th Ed., Blackwell, (1998).*
3. *Radiologic Science of Technologists by S. C. Bushong, 5th Ed. Mosby, (1993).*

4. *Fundamentals of Radiation Dosimetry, by J. R. Greening, 2nd Ed. Adam Hilger, (1985).*
5. *Radiation Detection and Measurement, by Knol G.F., 2nd Ed. Willey, (1980).*
6. *Physics of Medical Imaging, by Edwin G. A. Aird, Heinemann, (1988).*

LABORATORY COURSES

Phys 1601L	PHYSICS LAB-I	(CR1)
Courses	Phys 1001, 1002	

Objectives
To prepare students in performing experiments related to mechanics, waves and optics.

Syllabus

To measure the moments of inertia of different bodies, To determine surface tension by capillary rise, To determine elastic constant by spiral spring and coupled pendulum, The study of harmonic oscillation of helical springs connected in parallel and series, Laws of gyroscope, Measurement of speed of sound in air, Interference and diffraction of water waves with ripple tank, Interference of light by Fresnel biprism, Study of the diffraction intensity using double slit system.

Recommended Books

1. *Physics laboratory experiments by Jerry D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, (2015)*
3. *Physics Lab Experiments by Matthew French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 1602L	PHYSICS LAB-II	(CR1)
Courses	Phys 1003, 1004	

Objectives
To enable students in performing experiments related to electicity, magnetism and thermodynamics.

Syllabus
Electric fields and potential in the plate capacitors, Magnetic field outside a straight conductor, Magnetic field of a pair of coils in the Helmholtz configuration, To study the Acceptor and Rejecter circuits, The principle of thermocouple, thermoelectric *emf* and temperature diagram, Verification of Stephen-Boltzmann's law of radiation, Determining the specific heat capacities of solids, Thermal expansion of solids and liquids, Thermal and electrical conductivity of metals.

Recommended Books

1. *Physics laboratory experiments by J. D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by K. Clara Castoldi, Kendall Hunt, (2015)*
3. *Physics Lab Experiments by M. French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 2603L	PHYSICS LAB-III	(CR1)
Course	Phys 2001	

Objectives
To train students in performing experiments related to modern physics.

Syllabus
To determine wavelengths of sodium D lines by Newton's rings, To determine wavelength of light, by Fresrel's biprism, To determine wavelength of light by diffraction grating, Characteristics curve of a solar cell, To determine the excitation potential of mercury, To study magnetic resonance imaging (MRI), diffraction at a slit and Heisenberg uncertainty principle.

Recommended Books

1. *Physics laboratory experiments by Jerry D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, (2015)*
3. *Physics Lab Experiments by Matthew French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 2604L	PHYSICS LAB-IV	(CR1)
Courses	Phys 2002, 2003	

Objectives
To train students in performing experiments related to modern physics.

Syllabus
To study the photoelectric effect, To determine the resolving power of a diffraction grating, To study Zeeman Effect, To determine the Band gap of Ge crystal, To study the Lissajous figures by using C.R.O, Determination of dielectric constant of solids, To study the diode rectifier circuits.

Recommended Books

1. *Physics laboratory experiments by Jerry D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, (2015)*
3. *Physics Lab Experiments by Matthew French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 3605L	PHYSICS LAB-V	(CR2)
Course	Phys 2002	

Objectives
To give students training in perfoerming experiments that led to great discoveries in physics.

Syllabus
Measurement of wavelengths of laser light by using Michelson interferometer, The determination of Cauchy's constants using spectrometer, To determine e/m of an electron using a fine beam tube, To measure Planck's constant by studying photoelectric effect, To measure the critical potential of mercury by Frank-Hertz method, To study some aspects of Ferromagnetism by drawing B. H. curve. (a)To

determine the characteristic of G. M. tube and measure the range and maximum energy of β particles. (b) Measurement of half-life of a radioactive source (c) Characteristics of G.M. counter and study of fluctuations in random process.

Recommended Books

1. *Physics laboratory experiments by J. D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, 2015*
3. *Physics Lab Experiments by Matthew French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014)*

Phys 3606L	**PHYSICS LAB-VI**	**(CR2)**
Courses	**Phys 3701**	

Objectives

To enable students in performing experiments related to advanced topics in electronics and semiconductor physics.

Syllabus

(a) To construct a power supply by using Bridge rectifier and study its output without and with a capacitor filter, (b) Design a full-wave rectifier and study its output with a π-filter, (c) Design a regulated power supply using Zener diode and study its regulation. To construct clipper and clamping circuits and study the output waveshapes. Design differentiator and integrator circuits and study output waveshapes. Design a CE amplifier and study its frequency response. Determine its low- and upper-limit frequencies and also the bandwidth. Design an emitter amplifier and determine its input and output impedance. Design an RC phase-shift oscillator and determine its frequency by Lissajous figures. Design an astable multivibrator and determine its frequency. To construct from discrete components OR, AND, NOT, NAND, NOR Circuits and verify their truth tables.

Recommended Books

1. *Physics laboratory experiments by Jerry D. Wilson, Cengage Learning (2014)*
2. *General Physics Laboratory I Experiments by Kapila Clara Castoldi, Kendall Hunt, 2015*
3. *Physics Lab Experiments by Matthew French, Mercury Learning & Information, (2016)*
4. *Experiments And Demonstrations In Physics: Bar-ilan Physics Laboratory by Kraftmakher Yaakov, World Scientific (2014).*

COMPULSORY COURCES

Gen 1001	**ENGLISH-I (READING AND WRITING SKILLS)**	**(CR3)**
Preq.	**FSc/A-Level (English) or equivalent**	

Objectives

To enable students to identify main, topic sentences and to teach them to use effective strategies while reading texts. To acquaint students with cohesive devices and their function in the text.

Syllabus

Reading Skills, Topic sentences, Skimming, Scanning, and Inference, Find Specific and General Information Quickly, Distinguish Between Relevant and Irrelevant Information, according to Purpose for Reading, Recognise and Interpret Cohesive Devices, Distinguish Between Fact and Opinion, Guess the Meanings of Unfamiliar Words Using Context Clues, Use the Dictionary for Finding out Meanings and Use of Unfamiliar Words, Practice Exercises with Every Above Mentioned Aspect of Reading, Writing Skills, Parts of Speech, Phrase, clause and sentence structure, Combining sentences, Tenses:

meaning and use, Modals, Use of active and passive voice, Reported Speech, Writing good sentences, Error Free writing, Paragraph writing with topic sentence, Summary writing Note: Teachers need to include practice activities, exercises and worksheets on the provided topics.

Recommended Books

1. *Oxford English for Undergraduates, by D. H. Howe, T. A. Kirkpatrick and D. L.Kirkpatrick, Oxford, Karachi, (2014).*
2. *English Practice Grammar (New edition with tests and answers), by J. Eastwood, Oxford, Karachi, (2004).*
3. *Grammar in Use. by R. Murphy, Cambridge (2003)*

Gen 1002	**PAKISTAN STUDIES**	**(CR2)**
Preq.	**FSc/A-Level or equivalent**	

Objectives

To develop vision of historical perspective, government, politics, contemporary Pakistan, and ideological background of Pakistan.

Syllabus

Syllabus and books approved by Higher Education Commission of Pakistan, for BS Programs

Gen 1003	**ISLAMIC STUDIES/ETHICS**	**(CR2)**
Preq.	**FSc/A-Level or equivalent**	

Objectives

To provide basic information about Islamic Studies and to enhance understanding of the students regarding Islamic Civilization and Islamic science and thought.

Syllabus

Syllabus and books approved by Higher Education Commission of Pakistan, for BS Programs.

Gen 1004	**ENGLISH-II (COMPOSITION WRITING)**	**(CR3)**
Preq.	**Gen 1001**	

Objectives

To assist students identify the audience, message, and the purpose of writing, develop rhetorical knowledge and critical thinking, to enable them express themselves in a variety of writing styles.

Syllabus

Writing Process, Invention, Generating Ideas (collecting information in various forms such as mind maps, tables, lists, charts etc), Identifying Audience, Purpose, and Message, Ordering Information, Chronology for a narrative, Stages of a process, From general to specific and vice versa, From most important to least important, Advantages and disadvantages, Comparison and contrast, Problem solution pattern, Drafting, Free Writing, Revising, Editing, Paraphrasing, Cohesion and Coherence, Cohesive Devices, Paragraph unity, Summary and Precis Writing, Creative Writing, Essay Writing, developing a thesis, organizing an essay, writing effective introduction and conclusion, different types of essays, use of various rhetorical modes including exposition, argumentation and analysis, basic communication and presentation skills.

Recommended Books

1. *Critical Reading and Writing: An Introductory Course, by A. Goatly, Taylor and Francis, London (2000)*
2. *A Writer's Reference. 2nd ed. By D. Hacker, St. Martin's, (1992)*
3. *Study writing: A course in written English for academic and professional purposes, by L. Hamp-Lyons, and B. Heasley, Cambridge (1987)*
4. *Oxford English for Undergraduates, by D. H. Howe, T. A. Kirkpatrick and D. L.Kirkpatrick, Oxford, Karachi, (2014).*

Math 1001	**CALCULUS-I**	**(CR3)**
Preq.	**FSc/A-Level (Math) or equivalent**	

Objectives

The objective of this course is to acquaint students with the fundamental concepts of limit, continuity, differential and integral calculus of functions of one variable

Syllabus

Functions, limit of a function, graphical approach, properties of limits, theorems of limits, limits of polynomials, rational and transcendental functions, one-sided limits, continuity, derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions, the chain rule, implicit differentiation, rates of change in natural and social sciences, related rates, linear approximations and differentials, higher derivatives, Leibnitz's theorem, applications of derivatives, increasing and decreasing functions, relative extrema and optimization. first derivative test for relative extrema, convexity and point of inflection, the second derivative test for extrema, curve sketching, mean value theorems, indeterminate forms and L'Hopitals rule, inverse functions and their derivatives, integration, anti-derivatives and integrals, Riemann sums and the definite integral, properties of Integral, the fundamental theorem of calculus, the substitution rules, Integrals of elementary, hyperbolic, trigonometric, logarithmic and exponential functions, integration by parts, substitution and partial fractions, approximate integration, improper integrals, Gamma functions, Applications (area between curves, average value, arc length, area of a surface of revolution), parameterized curves and polar coordinates, curves defined by parametric equations, calculus with parametric curves (tangents, areas, arc length), polar coordinates (polar curves, tangents to polar curves), areas and arc length in polar coordinates.

Recommended Books

1. *Calculus by Thomas (11th Edition), Addison Wesley (2005)*
2. *Calculus by H. Anton, I. Bevens, S. Davis (8th Edition), Wiley (2005)*
3. *Calculus Single and Multivariable by D. H. Hallett,* A. *M. Gleason,* W. *G. McCallum (3rd Edition) Wiley (2002)*
4. *Calculus and Analytic Geometry by C. H. Edward and E. D Penney, Prentice Hall (1988)*

Math 1002	**CALCULUS-II**	**(CR3)**
Preq.	**Math 1001**	

Objectives

The students would be presented to the vector calculus, the calculus of multivariable functions and double and triple integrals along with their applications.

Syllabus

Vectors and analytic geometry in space, coordinate system, rectangular, cylindrical and spherical coordinates, the dot product, the cross product, equations of lines and planes, quadric surfaces, vector-valued functions and space curves, derivatives and integrals of vector valued functions, arc length, curvature, normal and binormal vectors, functions of several variables, limits and continuity, partial derivatives, composition and chain rule, directional derivatives and the gradient vector, implicit function theorem for several variables, maximum and minimum values, optimization problems, lagrange multipliers, double integrals over rectangular domains and iterated integrals, non-rectangular domain, double integrals in polar coordinates, triple integrals in rectangular, cylindrical and spherical coordinates, applications of double and triple integrals, change of variables in multiple integrals.

Recommended Books

1. *Calculus by Thomas (11th Edition), Addison Wesley (2005)*
2. *Calculus by H. Anton, I. Bevens, S. Davis (8th Edition), John-Wiley (2005)*
3. *Calculus Single and Multivariable by D. H. Hallett,* A. *M. Gleason,* W. *G. McCallum (3rd Edition) John Wiley (2002)*
4. *Calculus and Analytic Geometry by C. H. Edward and E.D Penney, Prentice Hall (1988)*

Math 1003	**PROBABILITY AND STATISTICS**	**(CR3)**
Preq.	**Math 1001**	

Objectives

To give students an introduction to basic methods of statistics and probability theory.

Syllabus

Introduction to Statistics, Descriptive Statistics, Statistics in decision making, Graphical representation of Data Stem-and Lead plot, Box-Cox plots, measures of central tendencies and dispersion, moments of frequency distribution; Counting techniques, introduction to probability, sample space, events, laws of probability, Conditional probability, sample space, methods of counting, permutations, combinations, fundamental probability theorems, random variables and probability distributions, random variables, probability distributions, expectation and variance, special probability distributions, the binomial distribution, the Poisson distribution, the Gaussian (or normal) distribution, continuous distributions, the Gaussian (or normal) distribution, the Maxwell-Boltzmann distribution, Statistics Error propagation, fitting curves to data, the χ^2 distribution, student t distribution, confidence interval.

Recommended Books

1. *Probability and Statistics for Engineers and Scientists by W. Ronald, Y. Myers, 8th edition. Prentice Hall (2008)*
2. *Probability and Statistics for Engineering and the Sciences by L. Lay, L. Devore, Duxbury (2003)*
3. *Statistical Data Analysis by G. Cowan, Oxford, (1998)*
4. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambrige (1999)*

Math 2003	DIFFERENTIAL EQUATIONS	(CR3)
Preq.	Math 1001, 1002	

Objectives
The objectives of this course are to understand different techniques solve the differential equations.

Syllabus
Definitions and terminology, Initial-value problems, Linear and nonlinear equations, general solution, Particular solution, explicit solution, implicit solution, First order differential equation, Separable variables, linear differential equations, exact equations, Solution by substitution, Higher-order differential equations, linear equations (Initial-value and Boundaryvalue problems, homogeneous equations, non-homogeneous equations), Reduction of order, Homogeneous linear equations with constant coefficients, Undetermined coefficients (Superposition approach, Annihilator approach), Variation of parameters, Cauchy-Euler equations, Solving systems of linear equations by elimination, 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), nonlinear equations Bernoulli's equation, first order non-linear ordinary differential equation, Clairaut's equation, Riccati equation, higher order exact linear equations, series solutions, series solutions about ordinary points, power series solution, solution about singular points, method of Frobenius series solutions, Legendre's equation, Bessel's equations, 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.

Recommended Books
1. *Mathematical Methods for Physicists (Seventh Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
2. *A First Course in Differential Equations with Modeling Applications (10th Edition) by D. G. Zill, Jones and Bartlett (2013)*
3. *Elementary Differential Equations and Boundary Value Problems by W. E. Boyce, R. C. DiPrima and D. B. Meade, Wiley (1992).*
4. *Mathematical methods for physics and engineering, Cambridge University Press (1999)*
5. *Elementary Differential Equations with Boundary Value Problems by C. H. Edwards and D. E. Penney, Prentice Hall (1989).*

Math 2004	ANALYTICAL GEOMETRY	(CR3)
Preq.	Math 1001, 1002	

Objectives
To give students an introduction to the use of calculus in geometry.

Syllabus
Curves in the Cartesian plane, parametric representations, the roulettes, polar coordinates, tangents and normal, conic sections properties of parabola, ellipse and hyperbola, polar equations of conic, change of axes, the general equation of the second degree, extreme values of a function, concavity and convexity, singular points, investigation of singular points by second partial derivatives, asymtotes, curve tracing, Arc lengths, intrinsic equations, curvature, circle of curvature, involutes and evolutes, properties of evolute, areas in rectangular and polar coordinates, analytical geometry of three

dimensions, rectangular, spherical polar and cylindrical polar coordinates, direction consines, direction components, projections, angle between two lines, perpendicular lines, equations of a plane in various forms, perpendicular line to a plane, parallel planes, perpendicular planes, equations of straight line in various forms, point slop, plane through a line, perpendicularity and parallelism of lines and planes, equation of locus, shortest distance between two lines, examples of surfaces, intercepts, traces, symmetry, sketching by parallel plane sections, surfaces of revolution, quadric surfaces, spheres, ellipsoids, paraboloids, hyperboloids, cylinders, cones, curves in space, ruled surfaces, volumes of solids revolution, area of surfaces of revolution.

Recommended Books

1. *Calculus by Thomas (11th Edition), Addison Wesley (2005)*
2. *Calculus by H. Anton, I. Bevens, S. Davis (8th Edition), John-Wiley (2005)*
3. *Calculus Single and Multivariable by D. H. Hallett,* A. *M. Gleason,* W. *G. McCallum (3rd Edition) John Wiley (2002)*
4. *Calculus and Analytics Geometry by C. H. Edward and E.D Penney, Prentice Hall (1988)*

Gen 2005	**INTRODUCTION TO COMPUTING**	**(CR3)**
Preq.	**FSc/A-Level or equivalent**	

Objectives

To acquaint the students with the structure, operation, programming, and applications of computers.

Syllabus

Fundamentals of a digital computer, computer operations, components of a computer, hardware and software, operating systems, processing and storing data, network basis, database management, devices, physical and logical storage, data organization, file storage, programs and software, application software, problem specification, flow chart, variables and constants, arrays, input/output, termination, social impact of computer age, computers in office, industry and education, networking devices, use of flow charts, introduction to office tools including spreadsheet, word processing and presentation, introduction to mathematical software such as MATLAB, MATHEMATICA, MAPLE, overview of different browsers, coding, executing and debugging simple programmes, the future of computing, application, algorithm development and writing flowcharts, flow control and loops, programming languages, software development methodologies, data types, string and operators, introduction to writing documents in MS office and PowerPoint presentation, introduction to a scientific language (C/C++).

Recommended Books

1. *Discovering Computers, by M. E. Vermaat, S. L. Sebok, S. M. Freund, J. T. Campbell, M. Frydenberg, Cengage, (2017)*
2. *Software Engineering Concepts, by R. Fairely, McGraw-Hill (2001)*
3. *Introduction to Computers, by G. B. Shelly, S. M. Freund, M. E. Vermaat, Cengage, (2010)*
4. *Introduction to Computers, by P. Norton, Career Education, (2002).*

Math 2005	**LINEAR ALGEBRA**	**(CR3)**
Preq.	**Math 1001, 1002**	

Objectives

The aims of this course are to introduce the basic ideas of linear algebra.

Syllabus

Matrix algebra, addition and transposition, linearity, matrix multiplication, properties of matrix multiplication, matrix inversion, inverses of sums and sensitivity, elementary matrices and equivalence, the LU factorization, vector spaces, subspaces, four fundamental subspaces, linear independence, basis and dimension, more about rank, classical least squares, linear transformations, change of basis and similarity, invariant subspaces, norms, inner products and orthogonality, vector norms, matrix norms, inner-product spaces, orthogonal vectors, Gram–Schmidt procedure, unitary and orthogonal matrices, orthogonal reduction, discrete Fourier transform, complementary subspaces, range-null space decomposition, orthogonal decomposition, singular value decomposition, orthogonal projection, least squares, angles between subspaces, determinants, additional properties of determinants, eigenvalues and eigenvectors, properties of Eigen systems, diagonalization by similarity transformations, functions of diagonalizable matrices, systems of differential equations, normal matrices, positive definite matrices, nilpotent matrices and Jordan structure, Jordan form, functions of non-diagonalizable matrices.

Recommended Books

1. *Elementary linear algebra: applications version (11th Edition) by H. Anton and C. Rorres, Wiley (2010)*
2. *Mathematical Methods for Physicists (7th Edition) by G. B. Arfken, H. J. Weber and F. E. Harris, Academic Press (2012)*
3. *Mathematics for Physicists by P. Dennery and A. Krzywicki, Dover Publications (2012)*
4. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3rd Edition), Cambrige (1999)*

Math 2006	**APPLIED MATHEMATICS**	**(CR3)**
Preq.	**Math 1001, 1002**	

Objectives

The main objectives of this course is to introduce students with some applied mathematical methods.

Syllabus

Vector Analysis, Vectors in 2-space and 3-space, lines and planes in 3-space, vector spaces, Gram-Schmidt orthogonalization process, vector functions, motion on a curve, curvature and components of acceleration, partial derivatives, directional derivatives, tangent planes and normal lines, curl and divergence, line integrals, independence of the path, double integrals, double integrals in polar coordinates, Green's theorem, surface integrals, Stokes' theorem, triple integrals, divergence theorem, change of variables in multiple integrals, vector operators acting on sums and products, combinations of grad, div and Curl, general curvilinear coordinates. Group Theory, Symmetry of a square, the dihedral group, definition and examples of groups, elementary properties of groups, finite groups, subgroups, tests of subgroups, examples of subgroups, cyclic groups, properties of cyclic groups, classifications of subgroups of cyclic groups, permutation groups, properties of permutations, a check-digital scheme based on D_5.

Recommended Books

1. *Contemporary Abstract Algebra by J. A. Gallian (8th Edition), Cengage Learning (2013)*
2. *Mathematical Methods for Physicists by G.B. Arfken, , H. J. Weber and F. E. Harris (7^{th}Edition), Academic Press (2012)*
3. *Advanced Engineering Mathematics by D. G. Zill and W. S. Wright (6th Edition), Jones and Bartlett (2018)*
4. *Mathematical methods for physics and engineering by K. F. Riley, M. P. Hobson, and S. J. Bence (3^{rd} Edition), Cambrige (1999)*

5. *Advanced Engineering Mathematics by E. Kreyszig (9th Edition), John Wiley & Sons (2006)*
6. *Mathematical Methods for Physicists: A Concise Introduction by T. L. Chow, Cambridge (2000)*

Gen 2003	NATURAL SCIENCE (Chemistry)	(CR3)
Preq.	FSc/A-Level or equivalent	

Objectives
To make students understand basic principles of science of chemistry.

Syllabus
Atomic structure, Periodic table and Atomic properties, Types of Chemical Bonding Gaseous and Liquid states of matter, Nature of covalent bond, Lewis structure, bond length, bond angles and bond energies, localized and delocalized bonding resonance valence bond theory and molecular orbital concepts, hybridizations, Sp3, Sp2, and Sp orbital, dipole moments, inductive and resonance effects, rules for relative contribution from different resonance structures, Modern concepts using mathematics for understanding the principles, Fundamental laws, Atomic molecular structure, states of matter, Equilibrium, Kinetic and elementary inorganic, organic and nuclear chemistry, physical chemistry.

Recommended Books
1. *Chemistry: the central science, by T. E. Brown et. al. Pearson, (2017)*
2. *Chemistry, by S. S. Zumdahl and S. A. Zumdahl, Cengage, (2017)*
3. *Chemistry: structure and properties, by N. J. Tro, Pearson, (2017)*

OR

Gen 2004	NATURAL SCIENCE (Biology)	(CR3)
Preq.	FSc/A-Level or equivalent	

Objectives
To give students an introduction to basic concepts of modern biology.

Syllabus
Life and second law of thermodynamics, natural history of cell, life and periodic table, water and life, small molecules of the living machine, Nucleic acids, proteins, enzyme catalysis, metabolic pathways, mitochondrion, nucleus and the storage and transmission of information, ribosomes, ground substances and conversion of chemical energy into work, membrane system, development and control of cell structure and function. Structure and duplication of genetic material, chromosome duplication and division, segregation of genes, independent assortment, sex-linked inheritance, linkage and recombination of genes, cytoplasm in heredity, transmission of genetic material in bacteria and bacterial virus, mutation gene action and synthesis of proteins, genetic units of recombination, mutation and function.

Recommended Books
1. Biology: the core, by E. J. Simon, Pearson, (2016)
2. Campbell Biology, by L. A. Urry and M. L. Cain, Pearson, (2016)

Gen 2006	Humanities/Social Sciences (Introduction to Philosophy)	(CR3)
Preq.	FSc/A-Level or equivalent	

Objectives:

1. *Understand nature of philosophy and the main problems of philosophy*
2. *Differentiate between philosophy in general sense and philosophy as academic discipline*
3. *Explain the demarcation line between rational and irrational thinking*
4. *Demonstrate knowledge of main schools of thoughts in various branches*

Syllabus

What is definition of Philosophy? What is Philosophy as an academic discipline?, What is importance of philosophy?, Epistemology, What is Knowledge?, What are sources of justification and knowledge?, Empiricism (John Lock), Rationalism (Descartes), Skepticism, Metaphysics. What is reality(substance)?, Idealism (Plato), Materialism, What are time and space?, Free will and determinism, Ethics, What is moral philosophy?, What is good?, Utilitarianism (J.S. Mill), Deontological Ethics (Kant), Political Philosophy, What is Political Philosophy?, Social Contract Theory, Plato's Political Thought, Logic, What is Logic?, What is an argument?, Inductive Argument, Deductive Argument, Symbolic Logic, Philosophy of Science, What is Philosophy of Science?, Methodology of Science (Bacon), Hume's Critique on Induction, Karl Popper, Logical Positivism, Thomas Kuhn, Paul Feyerabend, Philosophy of Social Science, Methodology of Positivism, Positivism, Individualism and Holism, Philosophy of Art, What is Philosophy of Art?, Representation in art, Art and craft, Social role of art, History of Philosophy, Ancient Greek Era, Medieval Era, Modern Era (Analytic and Continental Traditions), Philosophy in Practice, Philosophy and Trial of Greek Philosopher Socrates

Recommended Books:

1. *Philosophy: the basics by Nigel Warburton, Routledge (2012)*
2. *What is this thing called knowledge by D. Pritchard, Routledg (2018)*
3. *Metaphysics: a contemporary introduction by M. Loux, Routledg (2017)*
4. *What is this thing called science by A.F. Chalmers, Hackett (2013)*
5. *Introduction to logic by I. Copi, Routledge (2001)*
6. *Story of philosophy by B. Magee, DK (2001)*
7. *The Blackwell Dictionary of Western Philosophy Nicholas Bunin, Wiley –Blackwell (2009)*