Physics GenEd Courses offered as part of Bachelor of Science:

(1) Space, Time and the Universe (PHYS-0131) [50 lectures]

Four elements and quintessence; Plato and Aristotle's Universe; Sun signs, Solstice, Equinox and the Seasons; Indian and Arabic Astronomy.

Geocentric study of the Heavens; The puzzle of the planets; Retrogade motion. Visual representations of the Universe from earliest times to the Aristotle-Ptolemaic model;

Copernicus, Solar magic and Giordano Bruno; Almanacs and the question of infinity; Donne and the "new philosophy"; The new stars and 17th century poetry; Milton's Universe; Newton and 18th century poetry.

How does Science progress? A discussion of Kuhn's Theory of paradigm shift; A comparison of patterns of creativity in the Arts and the Sciences.

Tycho Brahe and Kepler: the new Astronomy; Galileo's discoveries; Newton and the new physics.

Universal gravitation; Newton's mechanics: conservation laws; Weighing the Earth and the Sun; Kant's island universes; Discovery of Uranus and Neptune.

Einstein's view of space and time; Testing Relativity: Pulsars and Black holes; Finding our way in the Milky Way Galaxy.

The origin of the Universe: The steady state Universe vs The Big Bang; The curvature of space; Hawking and the future of the Universe.

(2) Classical Mechanics and Relativity (PHYS-0132) [50 lectures]

Requirement: Students are expected to have a good background in Plus 2 level Physics and Mathematics

Classical Mechanics [35 lectures]

Vectors: Basic vector algebra and introduction to vector analysis. (8)

Mechanics of a particle: Newton's laws of motion; Principle of conservation of linear momentum; Time and Path integral of force; Conservative force field and the concept of potential; Conservation of total mechanical energy; Study of a system with time-varying mass; Rotational motion; Radial and cross-radial components of velocity and acceleration. (10)

Dynamics of rigid bodies: Moment of inertia and radius of gyration and their calculation for simple symmetric bodies; Parallel and Perpendicular axes theorems; Torque and the fundamental equation of rotational motion; Principle of conservation of angular momentum; Rotational kinetic energy. (9)

Gravitation: Newton's law of Universal gravitation; Kepler's laws of planetary motion; Direct calculation of gravitational potential and intensity due to simple symmetric bodies; Gauss' theorem of gravitation; Poisson's equation; Gravitational self-energy; Concept of escape velocity. (8)

Special Theory of Relativity [15 lectures]
Frame of reference; Galilean transformation; Basic postulates of special relativity; Lorentz transformation and its consequences – length contraction, time dilation, velocity addition formula, variation of mass and mass-energy equivalence; Relativistic dynamics; Experimental verification of special relativity.

(3) Physics of Everyday Life (PHYS-0231)

Aim: This course is offered in Semester 2 as a GenED course for both students with science and non-science majors. This will qualify as a "Science" GenEd for Humanities students.

The course is meant to introduce the scientific principles behind real life situations for a contemporary urban citizen, including the working of common gadgets. Students will be also be taught how to make simple quantitative calculations related to these situations.

Topics covered:

1) Making quantitative estimates in real-life situations, including Fermi problems in real life, and the use of dimensional analysis
2) Energy Conservation and the use and generation of electricity
3) Working principle of Refrigerators
4) How do Microwave ovens work?
5) The Physics of Digital Cameras
6) The use of the Global Positioning System (GPS)
7) Mobile phone communication

(4) Waves and Oscillations (PHYS-0232)

Oscillations
Simple Harmonic Oscillators, Complex Representation, Energy, The Damped Oscillator: Underdamped Oscillations, Overdamped Oscillations, Critical Damping, Oscillator with external forcing, Resonance: Electrical Circuits, Sinusoidal Waves, Superposition of waves, Huygens' Principle, Phase velocity, Group Velocity

Elastic Waves
The wave equation, Longitudinal elastic waves, Transverse waves in stretched strings, Solving the wave equation, Plane waves, Spherical waves, Standing Waves, Waves in three dimensions

Electromagnetic Waves
Electromagnetic Radiation, Electric dipole radiation, Sinusoidal Oscillations, Energy density, flux and power, The vector nature of electromagnetic radiation: Linear polarization, Circular polarization, Elliptical polarization, Electromagnetic Spectrum, Maxwell's Equations, plane wave solutions.

Interference
Young's Double Slit Experiment, coherence, Interference by division of wavefront and division of amplitude
Diffraction
Single slit Diffraction Pattern, resolution, Chain of sources, Phased array, Diffraction grating
Polarization
Natural Radiation, Producing polarized light, Scattering, Reflection, Birefringence or double refraction, Quarter wave plate, Partially polarized light

(5) Quantum Reality (PHYS-0332)

Requirement: Student must be very comfortable with +2 level Physics and Mathematics. It is preferable that the student has taken either of PHYS-0132 or PHYS-0232.

Objective: The course starts with a semi-historical narrative of the failure of classical physics to explain the microscopic world and the eventual birth of quantum mechanics. The course then gradually develops the conceptual and mathematical tools to deal with the problems of the quantum world and finally provides few applications from the real world where quantum mechanics has been widely used. In addition to the theoretical developments, students will also perform experiments related to the concepts of quantum mechanics.

Syllabus:
Historical Perspective [10]
Photoelectric effect, Bohr atom, Black body radiation, Planck's formula, de Broglie hypothesis, Compton effect, Electron double experiment, Davisson-Germer experiment, Heisenberg's uncertainty principle.
Basics of Wave Mechanics [20]
Concept of wave function, Wave packets, Group and phase velocities, Principle of superposition, Schrodinger equation, Probabilistic interpretation of the wave function, Copenhagen interpretation, Quantum philosophy, Stationary states, Solutions of Schrodinger equation in one dimensional simple potentials (infinite square well and rectangular barrier potential), Quantum Tunneling.
Applications of Quantum Mechanics [20]
3 - 4 applications from the list below will be discussed based on the interests of the students.
Hydrogen atom: Central force problem, Reduction to 1 dimension, solutions of Schrodinger equation, shapes of orbitals, Rotation of diatomic molecules: Model as a linear harmonic oscillator, energy quantization and normal modes of oscillations. Scanning Tunneling Microscope: Basic working principle and estimation of tunnel current, Radioactive decay:
Estimation of lifetime, alpha decay, Biophysical systems, Astrophysical applications, Basics of spin and 2 state system with applications to quantum computation.

(6) Physics of Materials (PHYS-0431)

Aim: This course is meant for science majors only. Comprehensive knowledge of HS level mathematics and some basic knowledge of quantum mechanics is needed.

1. Crystal Binding and structure: [5]
Classification of solids by binding forces, Group theory and crystallography, some typical crystal structure, Miller indices. Bragg and von Laue diffraction. Structure determination. Neutron and electron diffraction in crystals.
2. Electrons in periodic potentials and Energy Bands in solids: [6]
One electron model, the Kroning Penney model, band structure, metal, insulator and semiconductor. Effective mass, DOS, concept of holes.
3. Lattice Vibration and Thermal Properties: [5]
Elastic waves, DOS of a continuous medium. Specific heat-models of Einstein and Debye. Thermal conductivity. Microwave ultrasonic. Lattice optical properties in the infrared.
4. Electrical, Magnetic and superconducting Properties of Materials: [12]
The free electron model-electrical and thermal conductivity in metals. The AC conductivity and optical properties. Semiconductors-carrier concentration, impurity states, electrical conductivity and mobility. Optical properties and absorption processes in semiconductors. Dielectric and optical properties of solids-sources of polarizibility,piezoelectricity and ferroelectricity. Magnetic properties-magnetic susceptibility, classification of materials. Dia, para and ferromagnetism. Ferrites. Super conductivity-zero resistance, Meissner effect, the critical field, electrodynamics of super conductors, Transition temperature, High T_C superconductors.
5. Defects in solids: [5]
Important defects in solids, shallow and deep impurity levels in semiconductors, colour centers, diffusion, edge and screw dislocations, cold-field emission.
6. Non-crystalline materials: [6]
Microstructure and imperfections. Diffusion in solids. Non-crystalline and glassy materials-structure, thermodynamics, glass transition and related models. Amorphous semiconductors-electrical and optical properties, magnetic properties, switching and device applications.
7. Soft Condensed Matter: [5]
Liquid Crystals-classification, orientation order and intermolecular forces, elasticity, magnetic effects, optical properties & applications. Polymers – effect of temperature, mechanical and electrical properties.
8. Nano-materials: [6]
Properties of individual nanoparticles, quantum wells, wires and dots. Preparation and characterization of nanomaterials. Carbon nanotubes and fullerenes.