Department of Physical Sciences
School of Engineering and Computer Science
Independent University; Bangladesh

A Proposal for Bachelor of Science with Honors (B. Sc. Hons) Program in Physics

Physics is the most basic and fundamental science and it helps us to understand how the world around us and the world beyond our visible range work. Physics gives us powerful tools to help us to express our creativity; to see the world in new ways and then to change it. The students of Physics are problem solvers. Their analytical skills make them versatile and adaptable so they work in interesting places. Physics provides quantitative and analytic skills needed for analyzing data and solving problems in the sciences; engineering and medicine; as well as in economics; finance; management; law and public policy. Physics is the basis for most modern technology; and for the tools and instruments used in scientific; engineering and medical research and development. Manufacturing is dominated by physics-based technology. Studying physics provides excellent preparation for graduate students not just in physics; but in all engineering and information/computer science disciplines; in the life sciences including molecular biology; genetics and neurobiology; in earth; atmospheric and ocean sciences, in finance and economics; and in public policy and journalism. To give an opportunity to acquire knowledge about the most exciting and interesting branch of science the following undergraduate major in **Physics** is proposed in the Department of Physical Sciences, School of Engineering and Computer Science.

Bachelor of Science (B.Sc.) Honors in Physics

The detailed format of each of the proposed courses is described below.

Overall Requirements for Degrees

All students who wish to major in Physics must complete **38** credits in University Foundation Courses; **53** credits in Physics Core Courses; **18** credits in Physics Elective Courses; **15** credits in Minor Courses; **6** credits in a Project Course; and **3** credits in the University's Live-in Field Experience.

Theory Courses: 3 credits = 26 lectures in one semester, each lecture is 1 hour 30 minutes duration
Lab Courses: 1 credit = 13 lectures in one semester, each lecture is 1 hour 30 minutes duration

The total number of credits required for graduation is **133 c**redits; distributed as:

♦	**University Foundation Courses**	**38 credits**
♦	**Major Courses (Physics Core 53 credits and Elective 18 credits)**	**71 credits**
♦	**Minor Courses (Electives for Tracks/Concentrations)**	**15 credits**
♦	**Project in Physics**	**6 credits**
♦	**Live-In Field Experience LFE**	**3 credits**
	Total Credits for Graduation =	**133 credits**

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Foundation Courses (including LFE) **41 Credits**

I : Communicating Skills **9 credits**

II : Computer Skills **4 credits**

- CSC 101 Introduction to Computer Science
- CSE 101L Lab work for Computer Science

III : Numeracy **6 credits**

- MAT 104 Calculus and Analytical Geometry
- MAT 212 Basic Probability and Statistics for Science and Engineering

IV : Natural Sciences **7 credits**

- PHY 101 Physics-I (3 credits)
- PHY 101L Physics Lab-I (1 credit)
- CHE 101 Concepts in Chemistry (3 credits)

V : Social Sciences **6 credits**

VI : Humanities **6 credits**

VII : Live in Field Experience **3 credits**

Minor Courses **15 Credits**

Every Physics major will choose 15 credits minor with approval of the head of the major department.

Major Core Courses **(Theory 48; Lab 5 = 53 credits)**

PHY 102 : Physics II (Electricity & Magnetism)	(3 credits)
PHY 102L Physics Lab-II	(1 credit)
PHY 103 : Waves; Oscillations and Optics	(3 credits)
PHY 103 L : Waves; Oscillations and Optics Lab-III	(1 credit)
PHY 104 : Heat and Thermodynamics	(3 credits)
PHY 104L : Heat and Thermodynamics Lab-IV	(1 credit)
PHY 201 : Perspectives of Modern Physics	(3 credits)
PHY 202 : Atomic; Molecular and Laser Physics	(3 credits)
PHY 203: Solid State Physics - I	(3 credits)
PHY 204 : Nuclear Physics - I	(3 credits)
PHY 207: Basic Electronics	(3 credits)
PHY 207 L : Basic Electronics Lab-V (will be co-offered with ECR 207 L)	(1 credit)
PHY 301: Classical Mechanics – I	(3 credits)
PHY 302: Classical Electrodynamics	(3 credits)
PHY 303: Radiation and Statistical Mechanics	(3 credits)
PHY 304: Quantum Mechanics –I	(3 credits)
PHY 305 : Digital Electronics	(3 credits)
PHY 305 L : Digital Electronics Lab-VI (will be co-offered with ECR 205 L)	(1 credit)
PHY 306 : Calculus of Several Variables	(3 credits)
PHY 307 : Linear Algebra and Differential Equations	(3 credits)
PHY 308: Mathematical Methods for Physicist	(3 credits)

Major Elective Courses **(18 credits)**

Students will choose 18 credits (6 courses) with prior approval of major advisor

PHY 430: Relativity: Special & General	(3 credits)
PHY 431: Particle Physics	(3 credits)
PHY 432: Introduction to Astrophysics	(3 credits)
PHY 433: Computational Physics	(3 credits)
PHY 434: Atmospheric Physics and Meteorology	(3 credits)
PHY 435: Nuclear Physics-II	(3 credits)
PHY 436: Solid State Physics-II	(3 credits)
PHY 437: Non-linear Optics	(3 credits)
PHY 438: Quantum Mechanics-II	(3 credits)
PHY 439 : Classical Mechanics - II	(3 credits)

Course Descriptions

Foundation Courses

PHY 101: University Physics- I (Mechanics and Properties of Matter)

(3 credits = 26 lectures)

Mechanics

1. Mathematical preliminaries: Vector Analysis: Components of Vector; Dot and Cross Product; Gradient; Divergence and Curl of Vectors. Integral theorem: Green's theorem; Stoke's theorem and Divergence theorem – applications.

2. Introduction; Particle Kinematics; Motion in One-dimension and Two-dimensions : Introduction; Fundamental quantities; Dimension and units; velocity; acceleration; Motion with constant acceleration; free falling bodies; Circular motion; Motion of a projectile.

3. Newton’s Laws of Motion and Gravitation : Introduction to the equilibrium and the force; The equilibrium condition of a body; Newton’s first law of motion; Newton’s third law of motion; Newton’s second law of motion; Concept of inertial mass; Newton’s law of gravitation; Concept of gravitational mass; Weight; Derivation of Kepler’s Laws of planetary motion from Newton’s Law; Escape velocity; Application of Newton’s laws.

4. Work; Energy and Momentum: System of Particles : Momentum and Impulse; Conservation law for momentum; Center of mass and its motion; Rocket motion; Collision : Elastic and Inelastic Collision; Definition of work; Work done by a varying force; Kinetic and Potential energy; Power; Work-Energy theorem; Conservation law for momentum and energy.

5. Rotation : Concept of rotational equilibrium; Rotational Kinematics; Angular velocity and acceleration; Rotation with constant angular acceleration; Kinetic energy of rotation— moment of inertia; Radius of Gyration; Parallel-axis theorem; Perpendicular-axis theorem; Work and Power in rotational motion; Relation and comparison between linear and angular quantities; Conservation of angular momentum.

Properties of Matter

6. Elasticity: Hooke’s Law; Elastic Moduli and their interrelation; Bending of a cantilever; Torsion.

7. Surface Tension: Adhesive and Cohesive Forces; Molecular origin of surface tension; Excess pressure due to surface tension at an interface;

8. Viscosity: Capillarity. Newton's Law of Viscosity; Poiseulle's Formula; Stoke's Law.

9. Introduction to Fluid Dynamics: Steamline Flow; Bernoulli's equation; Equation of continuity; Euler's Equation.

References

1. *Fundamentals of Physics*: David Halliday; Robert Resnick; Jearl Walker : John Wiley & Sons, Inc. : 9th edition.
2. *University Physics*: Sears; Zemansky and Young; Addition Wesley Publishing Company: 10th edition.
3. *Properties of Matter*: Newman and Searle: Edward Anorld, London: 10th edition.

CHE 101: Concepts in Chemistry (3 credits = 26 lectures)

1. Matter and Energy.
2. Modern concept of the structure of the atom.
3. Concept of the Periodic Table of elements.
4. Concept of chemical bonds: Concept of mole, chemical reactions and ideal gas laws.
5. Modern concept of acids and bases. Energetic and chemical equilibrium.
6. Chemical kinetics: rate, order, rate constant and Arhenius equation.
7. Concept of catalysis and photochemical reactions.
8. Organic chemistry: Concepts of saturated hydrocarbons, unsaturated hydrocarbons, alcohols, fatty acids and aromatic hydrocarbons.
9. Thermodynamics
10. Thermochemistry

References

1. *General Chemistry*: Darrel Ebbing, Steven D. Gammon: 10th edition.
2. *Essential Chemistry: Raymond Chang, Jason Overby* : The Mc-Graw Hill Corporation 6th edition.

MAT 104: Calculus and Analytical Geometry (3 credits = 26 lectures)

1. Functions: Functions and their visualization, Shifting curves
2. limits and continuity
3. Differentiation: Differentiation; geometric interpretation, differentiation rules, Chain rule of differentiation, Implicit differentiation, Successive differentiation
4. Application of Derivatives: Interpretations of derivative, applications of derivative to geometry; tangent and normal lines, Rates of change, Optimization; maximum and minimum values, Indeterminate forms
5. Integrations: Indefinite Integral, integration techniques, Definite integral, interpretations and properties of the definite integral
6. Fundamental theorem of Calculus
7. Applications of Integrals: Applications of the definite integral to geometry and mechanics

8. Differential equations : First order differential equations: Separation of variables, First order linear equations
9. Infinite series: Taylor series and Taylor polynomial, Convergence of series

References

1. Thomas, G.B., Finney R.L., *Calculus and Analytic Geometry (9th edition),* Addition-Wesley Publishing Company.
2. Anton, Bivens and Davis, *Calculus (10th edition),* Wiley Publishing Company.
3. Calculus: Schaum's Outlines Series.

MAT 212: Basic Probability and Statistics for Science and Engineering

(3 credits = 26 lectures)

1. Review of set theory, review of mathematics(factorial, permutation and combination)
2. Descriptive Statistics: Target population, random sample, drawing random samples from target population, describing data sets, frequency table and graph, relative frequency table and graph, stem and leaf plot, grouped data, histogram, ogive, summarizing data sets (sample mean, median, mode, percentiles, variance, standard deviation, percentiles, box plots), Chebyshev's inequality, paired data sets and sample correlation coefficients.
3. Probability: Event, sample space, definition of probability, axioms of probability, simple and compound events, complimentary event, mutually exclusive events, equally likely events, conditional probability, Bayes rule.
4. Random variable: Concept, types of random variables, jointly distributed random variables, Independent random variable, conditional distributions, expectation, properties of expectation, varience, and moment generating functions.
5. Special Random variable: Special discrete random variables, binomial distribution, Poisson distribution, solving real life problems, Geometric distribution, Continuous random variables: General nature of continuous distributions, uniform, exponential and normal distribution, negative binomial distribution, solving real life problems
6. Statistical Inference: estimation of population mean and variance; confidence levels; Determination of sample size, small sample estimation of mean and variance, hypothesis testing.
7. Simulation: Concept, Random number generation, Markov model.
8. Linear Regression: Probabilistic models, least square approach, coefficient of determination, prediction, estimation of variance, goodness of fit.

References:

1. Ronald E. Walpole, Raymond Myers, Sharon L. Myers and Keying E. Ye, *Essentials of Probability and Statistics for Engineers and Scientists*, Pearson, 2011.
2. Jay L. Devore, *Probability and Statistics for Engineering and Sciences*, 8th edition, Cengage Learning, 2009.

3. Sheldon Ross, *Introduction to Probability and Statistics for Engineers and Scientists*, 4th edition, Academic Press, 2009.
4. Bhisham C. Gupta and Irwin Guttman, *Statistics and Probability with Applications for Engineers and Scientists*, Wiley, 2013.
5. Montgomery, D.C and Runger G.C. (2011), *Applied statistics and probability for Engineers* (5th edition), John Wiley & Sons, Inc.

Major Core Courses (Theory) (48 credits)

PHY 102: University Physics - II (Electricity and Magnetism) (3 credits = 26 lectures)

1. Introduction; Coulomb's law; Electric Field and Gauss's Law : Concept of charge; Coulomb's law; Concept of electric field and its calculation; Electric dipole; Gauss's law in electrostatic and its application. Electric field due to dipole, Torque on a dipole in uniform E-field, Gausses law in differential form.

2. Electric Potential: Electric potential and its calculation; Electric potential energy; Relationship between Field and Potential; Equipotential surface; Potential gradient.

3. (i). Capacitance and Dielectric : Capacitors; Capacitors in series and parallel; Energy of charged capacitors; Electrical energy density in terms of electric field; concept of electron volt.

   (ii). Dielectric media, polarization vector & displacement vector. Capacitor with a dielectric material. Gausses law with dielectric.

4. Current; Resistance; Electromotive force: Current and current density; Resistance and Resistivity; Ohm's law; EMF Power; Resistance in series and parallel; Kirchhoff's Rules.

5. Magnetic Field : Magnetic field; Magnetic flux; Lorentz Force; Gauss's law for magnetism; Motion of a charged particles in magnetic field : Hall effect; Magnetic field intensity; Biot-Savart Law; Ampere's law and its applications; Magnetic properties of matter; paramagnet; diamagnet and ferromagnet; Magnetization vector; Hysteresis..

6. Inductions and Inductance : Induced emf and Faraday's law of induction; Lenz's law; Mutual inductance ; Self inductance; Energy in an inductor; Transformers.

7. Direct Current (DC) Circuits : R-C circuit; R-L circuit; L-C circuit; R-L-C circuit.

8. Alternating Currents (AC) : Introduction; Circuit containing resistance (R), inductance (L) or capacitance(C) ; The R-L-C Series circuit; Average and rms values; Power in AC circuits; Series resonance.

9. Electromagnetic Waves : Introduction; Speed of an electromagnetic wave; Energy in electromagnetic waves; Properties of electromagnetic waves; Maxwell equations.

References

1. *Fundamentals of Physics*: David Halliday; Robert Resnick; Jearl Walker: John Wiley & Sons, Inc. : 9th edition.

2. *University Physics*: Sears; Zemansky and Young: Addition Wesley Publishing Company: 10th edition.
3. *Foundation of Electromagnetic Theory*: J. Reitz; F. Milford and R. Christy: Addison-Wesley: 4th edition.

PHY 103: Waves, Oscillations and Optics (3 credits = 26 lectures)

Waves & Oscillations

1. Oscillations : Periodic and Oscillatory Motion with examples; Elastic restoring force; Simple harmonic motion (SHM); Mass-Spring System; Energy conservation Mass-Spring System; Differential equation of SHM & its solutions with explanation; Examples of SHM; Damped SHM; Forced Oscillation; Resonance; Combinations of simple harmonic oscillation : Lissajous Figures.

2. Mechanical Waves and Vibrating Bodies : Waves in elastic media : Transverse and Longitudinal Waves; Periodic Waves; Mathematical description of a wave; Phase velocity and group velocity; Principle of Superposition; Boundary condition for a string; Standing waves; Huygens principle; Vibration of a string fixed at both ends.

3. Acoustic Phenomena: Sound Waves; Intensity level and loudness; Quality and pitch; Beats; the Doppler effects; Application of acoustic Phenomena.

Optics

4. Nature and propagation of Light: : Nature; Reflection and Refraction; Total internal reflection; Reflection at a plane surface; Reflection at a spherical surface; Focal point and focal length; Lenses: Thin lens; Diverging and Converging lenses.

5. Interference : Coherent sources; Conditions for Interference; Mathematical derivation of Interference; Young's Experiment; Fringe width; Fresnel bi-prism; Newton's Ring; Michelson interferometer.

6. Diffraction : Fresnel and Fraunhofer Diffractions; Fraunhofer Diffraction at a single slit and double slit; diffraction grating; Transmission and reflection gratings.

7. Polarization: Definition of Polarization; Plane; Circular and Elliptic Polarizations; Malus Law; Polarization by polarizer and by reflection. Full wave, half-wave & quarterly wave plates; Nicol & Wollaston prisms.

8. Dispersion and Scattering: Normal and anomalous dispersion; Cauchy and Sellmeir equation; Rayleigh scattering; polarization log scattering, the blueness of sky and the sunset and sunrise.

9. Fourier Optics: Fourier transformation in two dimensions, inverse Fourier transformation, examples, Dirac delta function, optical applications, convolation and covolution theorem, Fourier methods in diffraction theory, lens as a Fourier transformations.

References

1. *Vibrations and Waves*: A. P. French: CRC Press: 6th edition.
2. *Fundamental of Optics*: F. A. Jenkins and H. E. White, McGraw-Hill: McGraw-Hill Science/Engineering/Math: 4th edition.

PHY 104: Heat & Thermodynamics (3 credits = 26 lectures)

1. Introduction and the Kinetic theory of gas : Concept of temperature and heat; Absolute Scale Temperature; Quantity of heat; Equations of state; Zeroth Law; Microscopic model of an ideal gas and gas laws; real gases ; Van der Waal's equation; critical constants; concept of pressure and temperature in kinetic theory; mean free path; molecular collisions and transport phenomena; limitations of kinetic theory.

2. The First Law of Thermodynamics : Heat as energy and work; Work and heat in volume changes; Internal energy; Reversible and irreversible process; First Law of Thermodynamics; Calculation of Work; Heat and Internal Energy for Adiabatic; Isothermal; Isobaric and Isochoric process.

3. The Second Law of Thermodynamics : Heat engines; Efficiency of Heat engines; Carnot's cycle and Carnot's Theorem; concept of Entropy; Change in entropy in reversible; irreversible and cyclic processes; Different statements of the Second law of thermodynamics. Kelvins statement of 2nd law.

4. Applications of thermodynamics: i) Cooling of gasses by free expansion and Throttling (Joule-Thomson Process); ii) Adiabatic demagnetization; iii) Heat pumps and refrigerators; iv) Thermoelectric phenomena; Seebeck; Peltier and Thompson effects.

5. The Third Law of Thermodynamics and Thermodynamic Potentials: The Third Law of Thermodynamics; Thermodynamic Potentials; Enthalpy; Helmholtz and Gibbs free energies; Heat capacities and their interrelation.

6. Phase transition : Classification of Phase transitions. First order and second order phase transitions and their examples. Clausius-Clapeyron's equation; Chemical potential. Gibb's phase rule.

References

1. *Heat and Thermodynamics*: M. Zemansky and Dittman; McGraw-Hill: McGraw-Hill Companies: 6th edition.
2. *Fundamentals of Physics*: David Halliday; Robert Resnick; Jearl Walker : John Wiley & Sons: 10th edition.
3. *Physics*: David Halliday; Robert Resnick; K. Krane: John Wiley and Sons: John Wiley & Sons, Inc: 5th edition.
4. *Equilibrium Thermodynamics*: Adkins, C.J: Cambridge University Press: 3rd edition.
5. *Fundamental of statistical and thermal Physics*: F.Reif; McGraw-Hill: Waveland Pr Inc: 3rd edition.

PHY 201: Perspectives of Modern Physics (3 credits = 26 lectures)

1. Relativity : The Special theory of Relativity & its Postulates; The Galilean Transformation; The Lorentz Transformation; The Lorentz-FitzGerald Contraction (Length Contraction); Time Dilation; Space-Time; The Relativity of Mass (Mass Addition); Mass and Energy; Introduction to General Relativity.

2. Particle Properties of Wave: Concept of quanta; The Photoelectric Effect; The Quantum Theory of Light; The Compton Effect.

3. Wave Properties of Particles: De Broglie Waves; Wave Function; The Uncertainty Principle and its applications.

4. Atomic Structure : Thompson's Model; Rutherford Model; Bohr Model; Electron's Orbits; Nuclear Dimension; Failure of Classical Physics; Atomic Spectra.

5. SchrÖdinger Equation : SchrÖdinger Equation; Wave Function and its Physical Interpretation; Operator; Eigenvalues and Eigenfunctions; Particle in a Box; Square Potential Well; The Harmonic Oscillator; Quantum Theory of Hydrogen Atom; Quantum Numbers; Pauli Exclusion Principle; Statistical Mechanics : Maxwell-Boltzmann Distribution; Fermi-Dirac Statistics; Bose-Einstein Statistics.

References

1. *Perspectives of Modern Physics*: Arthur Beiser : McGraw Hill Publishing Company: 6th edition.
2. *Concepts of Modern Physics*: Arthur Beiser; McGraw Hill Book Company: 6th edition.
3. *Lectures on Physics*: Richard P. Feynman: Feynman: Addison Wesley Longman: 2nd edition.

PHY 202: Atomic; Molecular and Laser Physics (3 credits = 26 lectures)

1. Introduction: Contents and Importance of Atomic Physics; Molecules: Building Blocks of Nature; Experimental and Theoretical Proofs for the Existence of Atoms; Can One See Atoms? The Size of Atoms; the Electric Structure of Atoms; the Quantum Structure of Atoms

2. Atomic Structure: Thompson's Model; Rutherford Experiment and Model; Nuclear Dimension; Bohr Model and Atomic Spectra; Energy levels and Spectra; Electron's Orbits; Failure of Classical Physics; Atomic Excitation and Franck-Hertz Experiment.

3. Many Electron Atoms : Electron Spin; Stem-Gerlach Experiment; Pauli's Exclusion Principle; Quantum Numbers; Selection Rules; Allowed and Forbidden Transitions; Symmetric and Antisymmetric Wave function; Periodic Table; Vector Atom Model.

4. Hydrogen atom and Fine Structure : Schrodinger equation for one electron system; Fine Structure; Fine Structure and Spin-Orbit Coupling; Hyperfine structure; Magnetic Moment of the Orbital Motion; Spin and Magnetic Moment of the Electron; The normal Zeeman effect; The anomalous Zeeman effect; Stark effect; Pashen-Back Effect.

5. X-rays : Production of X-rays; Origin of X-rays; X-ray spectrum; Mosley's Law; Absorption; Diffraction and Scattering of X-rays; Wave nature of X-rays; Bragg's Law.

6. Molecules : Molecular Bonds; Electron Sharing by atoms of molecules; H_2 molecules; Complex molecules; Rotation and vibration of molecules : Energy consideration; Molecular Spectra; Hund's rule; Raman Effect and its application.

7. The Laser : Concepts of Laser & classification; Rate Equations and Lasing Conditions; Amplitude and Phase of Laser Light.

References

1. *Perspectives of Modern Physics*: Arthur Beiser; McGraw Hill Publishing Company: 6th edition.
2. *Concepts of Modern Physics*: Arthur Beiser : McGraw Hill Book Company: 6th edition.
3. *Modern Physics*: Theraja B.L: New Delhi : S. Chand & Company Ltd: 16th edition.

4. *Laser physics*: Hooker S and Webb C: Oxford University Press: 5th edition.

PHY 203: Solid State Physics - I (3 credits = 26 lectures)

1. The Crystalline State : Primitive and convectional unit cell; Basis; Crystal Symmetry; Bravais Lattice; Reciprocal lattice; Crystal planes and Miller indices; Some Crystal Structures; X-ray Diffraction; Bragg's law; Laue Diffraction; Structure Factor.

2. Classification of Crystals: Interatomic Force; Classification of Solids : Covalent; Ionic; Metal; Valance and Vander Waals Crystals; Lattice energy of Ionic Crystal; Madelung Constant and energy.

3. Lattice Vibrations: Failure of Classical theory of specific heat capacity; Phonons; Normal Modes of vibration in Monoatomic and Diatomic Linear Chains; Einstein Model and Debye theory of specific heat.

4. Defects in Crystals: Consequences of defects on mechanical properties; Schottky and Frenkel type of defects concentration; Dislocations.

5. Free Electron Theory of Metals: Classical Electron theory; Sommerfield theory; Box quantization; Density of States; Fermi Surface; Fermi Energy; Electrical conductivity; Wiedemanns Franz Law.

6. Introduction to Semiconductor : Energy Levels and Energy Bands, Classification of solids in terms of energy bands; Bonds in semiconductor; Intrinsic & Extrinsic semiconductor; n-type & p-type semiconductor; p-n junction; semiconductor diode; forward/reverse bias; I-V curve.

7. Band theory of Solids: Electron in periodic potential: Kroning-Penney model; Schrodinger's Equation; Bloch Function; Brillouin Zones; Reduced Zone Scheme.

References

1. *Solid State Physics:* Philadelphia.: N.Y. Ashcroft and K. D. Mermin; Sauncers Co.: Lott et al.: 2nd edition.
2. *An introduction to Solid State Physics*: C. Kittle; John Wiley and Sons; N.Y: John Wiley & Sons:8th edition.
3. *Introduction to Solid State Physics*: A. J. Dekker; Prentice-Hall N.J: L.V. Azaroff, Tata McGraw-Hill Publishing Company Ltd
4. *Introductory Solid State Physics*: H. P. Myers: CRC Press: 2nd edition.

PHY 204: Nuclear Physics - I (3 credits = 26 lectures)

1. Basic properties of Nuclei : Constituents of Nuclei; Nuclear mass; charge and size; Nuclear density; Nuclear spin and Angular momentum; Nuclear moments; Dipole moments; Magnetic moments; Nuclear binding energy; Liquid drop model; Weizsacker semi-empirical mass formula; Shell model corrections; Nuclear stability; Nuclear forces; Meson theory of nuclear forces.

2. Radioactivity : Radioactive decay; Decay law; Transformation law of successive changes; Measurement of Decay constant. Artificial radioactivity; Radioisotopes: production and uses; Units of radioactivity; carbon dating.

3. Alpha particle Emission : Alpha instability; Measurement of energy of Alpha particle and nuclear size; Alpha capture; Tunnel theory of alpha decay.

4. Gamma radiation : Origin of gamma rays; energy measurement; pair spectrometer; Theory of gamma emission; Idea of selection rules; Internal conversion; Mossbaur effect.

5. Beta decay : Energy measurement; Conservation of energy and momentum; Fermi theory of beta decay (allowed transition); Neutrino hypothesis; Orbital electron capture; Positron emission.

6. Nuclear reactions : Fission and Fusion; Discovery; production and properties of neutron. Elastic and Inelastic scattering; Q-value; nuclear Cross-section; Elementary kinematics; Fission of the nucleus; Nuclear reactor; Nuclear Fusion; Fusion reactor.

7. Elementary Particles : Detection of charged particles; photons; neutrons; Elementary Particles : Definition; Classifications: Bosons and Fermions; Leptons and Hadrons; Quantum Numbers; Different types of interactions; Antiparticles; Particle lifetimes; Basic quark model; Quark composition of mesons and hadrons; Symmetry transformations and conservation laws.

References

1. *Introductory Nuclear Physics*: Kenneth S. Krane; John; Wiley and Sons: Wiley: 3rd edition.
2. *Introduction to Nuclear Physics*: H. A. Enge; Addisin-Wesley; Mass Addison- Wesley Publishing Company: 2nd edition.
3. *Concepts of Nuclear Physics*: B.L. Cohen; McGraw-Hill; N.Y: H.A. Enge, Addison Wesley, Publishing company
4. *Fundamentals of Nuclear Physics*: N.A. Gelly: Oxford University Press: 4th edition.
5. *Nuclear and particle Physics*: W.S.C Williams: Oxford University Press: 2nd edition.
6. *Particles and Nuclei- An Introduction to the Physical Concepts*: B. Povh; K. Rith; C. Scholz; F. Zetsche: 6th edition.

PHY 206: Calculus of Several Variables (3 credits = 26 lectures)

1. Calculus of Vector Functions: Change of Parameter; Arc Length; Unit Tangent and Normal Vectors; Curvature; Motion along a Curve.

2. Functions of Several Variables; Visualization; Limit and Continuity; Partial Derivatives; Differentiability and Chain Rules; Jacobians; Tangent Planes; Total Differentials.

3. Exact Differentials Equations; Directional Derivatives and Gradients; Optimization.

4. Double and Triple Integrals; Change in Variables; Double Integrals in Polar Coordinates; Triple Integrals in Cylindrical and Spherical Polar Coordinates; Surface Area and Volumes.

5. Vector Calculus: Vector Fields; Divergence and Curl; Line Integrals; Independence of Paths; Conservative Vector Fields; Green's Theorem; Surface Integrals; Divergence and Stokes's Theorems.

Prerequisite: MAT 104

References

1. *Calculus*: Howard Anton, Irl Bivens and Stephen Davis: Wiley: 10th edition.
2. *Elementary Differential Equations & Boundary Value Problems*: Boyce, Diprima: Wiley: 9th edition.

3. *Calculus*: Thomas/ Finney: Addison-Wesley Pub. Co.: 9th edition.
4. *Advanced Engineering Mathematics*: Erwin Kreyszig: Wiley: 10th edition.

PHY 207 : Basic Electronics (3 credits = 26 lectures)

1. Semiconductors Diode : Semiconductors diode; p-n junction; forward/reverse bias; I-V curve; Breakdown: Avalanche and Zener Mechanism; DC & AC resistance; Zener diode; concepts of LED; Photodiode & Solar Cell.

2. Diode Applications : Applications in reverse voltage protection or auto polarity (using bridge) OR gate in instant emergency power supplies. Half wave & full wave rectification of sinusoidal AC; average voltage; capacitor smoothing; ripple voltage & factor; diode conduction period. Zener voltage regulator.

3. Bipolar Junction Transistor (BJT) : npn & pnp configurations; transistor action; CB; CE & CC configuration; alpha & beta characteristics load line & operating points. Cut- off and saturation transistor as a switch. Active region for linear amplification; Q-point; graphical analysis; class A; B & C amplifiers. Transistors biasing: fixed bias; collector feedback and voltage dividers bias.

4. Equivalent Models and Circuits : Constant Voltage and Constant Current sources; the Thevenin's and Norton's theorems and determination of equivalent circuits for a known and unknown network. Superposition theorem. Two-port network equations; Z; Y & H equivalent circuits & parameters. Ebers Moll model & h-equivalent model for a transistor; ideas on the variability of h-parameters.

5. CE Amplifier : Small signal analysis of a CE amplifier with voltage divider bias (voltage gain; input & output impedances) using Ebers Moll & approximate h- equivalent circuits. Typical CB and CC (Emitter Follower) amplifier circuits. Comparison of important features of CB; CE & CC amplifiers. BJT constant current source. Maximum voltage; current and power transfer between stages of networks. RC coupled cascaded CE amplifier; equivalent circuit and analysis, Identification of low pass and high pass elements in CE amplifier including stress capacitance and Miller effect capacitance.

6. Operation amplifier : Basic concepts on different amplifier (double ended input; single ended input) as the input stage of an op-amp. Analysis of single & doubly tuned amplifier. Differential and Common mode operation; Ideal op-amp approximations. Inverting amplifier Non-inverting amp. Adder. Subtractor; Comparator; Integrator; Differentiator (all analysis based on ideal approximation). Frequency Response; Gain-bandwidth product; active filters; Application in millivolt meters.

7. Negative Feedback : Basic concepts-on four types of negative feedback; advantage of negative feedback Analysis for gain; distortion; bandwidth; input impedances for Voltage series feedback using an op-amp.

8. Modulation and demodulation

References

1. *Electronic Devices and Circuit theory*: Boylestad; R. and Nashelsky L: Prentice-Hall of India; 5th edition.
2. *Basic Electronics for Scientists*: Brophy; J.J: McGraw-Hill: 3rd Edition.

3. *Electronic Devices and circuits*: Milllman; J. and Halkias: C.C : McGraw Hill.
4. *Electronic Principles*: Malvino; A.P.: Tata McGraw Hill; 3rd ;4th Edition.

PHY 301: Classical Mechanics (3 credits = 26 lectures)

1. Review of Newtonian Mechanics

2. Lagrangian Mechanics: Generalized coordinates; constraints; degrees of freedom; D'Alamberts principle; Lagrange's equation from D'Alambert principle; variational principle; Lagrange's equation from Hamilton's principle; applications of Lagrange's equation.

3. Motion under a central force: Two body central force problem --reduction to equivalent one-body problem; equations of orbits; scattering problem and laboratory co-ordinates.

4. Rigid bodies: Kinematics and dynamics of rigid bodies; degrees of freedom; matrix representation of rotations; Euler's angles; force-free motion; Euler's equation of motion; symmetric top.

5. Hamilton's equations of motion: Legendre transformation and Hamilton equations; conservation theorem; derivation from variational principle; principle of least action and its applications.

6. Canonical Transformations: Equations of canonical transformation; integral invariance of Poincare; Lagrange and Poisson brackets. Hamilton-Jacobi Theory : The Hamilton-Jacobi Equation for Hamilton's Principal Function.

7. The Harmonic Oscillator.

References

1. *Classical Mechanics*: Goldstein; G.: Addison-Wesley: 3rd edition.
2. *Mechanics*: Symon; K. R.: Addison-Wesley Publication: 3rd edition.
3. *Theoretical Mechanics*: Spiegel; M. R.: Schaum Outline Series: 1st edition.
4. *Lagrangian Dynamics*: Wells; D.A.: New York: McGraw-Hill: 1st edition.
5. *Introduction to Special Relativity*: Resnick; R.: Wiley: 1st edition.

PHY 302: Classical Electrodynamics (3 credits = 26 lectures)

1. Multipole expansion of the potential due to a localized charge distribution; dipole and quadripole moments; Field inside dielectrics; Boundary value problems.

2. Electromagnetic Field Equation: Maxwell's equations; E.M. energy--Poynting vector; scalar and vector potentials; Gauge transformation; the wave equations.

3. Propagation of E.M. Waves: Plane waves in non- conducting media; waves in conducting media; reflection and refraction at boundaries of two non-conducting media; boundary conditions; total internal reflections; Fresnel's equation; Polarization by reflection and total internal reflections.

4. Propagation of E.M. Waves in Bounded Region: Propagation between parallel conducting plates; wave guides (rectangular).

5. Radiation from an Accelerated Charge: Dipole radiation; the Lienard and Wiechart potentials; field of charge in uniform motion; fields of an accelerated charge; radiation at low velocities.

6. Scattering and Dispersion: Scattering by individual free electron; scattering by a bound electron; absorption of radiation by an oscillator; Rayleigh scattering.

References

1. *Classical Electrodynamics:* Griffiths; D.J.: Addison-Wesley Educational *Publishers* Inc: 4th edition.
2. *Foundation of Electromagnetic Theory:* Reitz; J.R. and Milford; F.J.: Addison-Wesley: 4th edition.
3. *Introduction to Electromagnetic Field & Waves:* Corson; D.R. and Lorrain; P.: W.H.Freeman & Co Ltd: 3rd edition.
4. *Electrodynamics:* Jackson; J.D.: Classical *Electrodynamics:2nd edition.*

PHY 303: Radiation and Statistical Mechanics (3 credits = 26 lectures)

1. Thermal radiation: Black body radiation; Kirchhoff's law; Stefan-Boltzmann laws; Wein's law; Rayleigh-Jean's law and Planck's law; Transport phenomenon.

2. Temperature and entropy.

3. Classical Statistical Mechanics : Phase space; average properties of an assembly; Boltzmann probability distribution; Maxwell velocity distribution; Equipartition of energy; Entropy and disorder.

4. Quantum statistical mechanics: Schrodinger equation; Free particle in a box; Volume of a state in phase space; quantum indistinguishability and the uncertainty principle.

5. Bose-Einstein distribution; Photon gas; Derivation of Planck's radiation law.;

6. Fermi-Dirac distribution; Electron gas in metal and electronic specific heat.

7. Application of statistical thermodynamics.

8. Transport Phenomena; Boltzmann transport equation; H-theorem; Mean free path; Viscosity and Diffusion; Electrical conductivity; Brownian motion.

9.Phase transition.

References

1. *A treatise on heat*: Saha and Srivastava: Indian Press: 4th edition.
2. *Statistical Mechanics*: Mandl; F.: Wiley: 2nd edition.
3. *Fundamental of Statistical and Thermal Physics*: Reif; F.: Waveland Pr Inc: 4th edition.
4. *Statistical Mechanics*: Singh and Singh: New Age International: 1st edition.

PHY 304: Quantum Mechanics - I (3 credits = 26 lectures)

1. Introduction and Review of the Historical Background : Concept of quanta; Max Planck's Theory; The Quantum Theory of Light; The Photoelectric Effect; Photons; Franck-Hertz experiment; The Compton Effect; De Broglie Waves; Wave-particle duality of matter and light; Electron diffraction; Davison-Germer experiment.

2. Introduction to wave mechanics :Concept of Wave equation; Postulates of Qunatum Mechanics; Wave function and its interpretation; Wave function for particles having a definite momentum; Wave packets; The Heisenberg uncertainty principle; Stern-Garlech experiment.

3. Schrödinger's equation : Schrödinger's equation: time-dependent and time-independent; Solutions to Schrödinger's equation in one dimension; Stationary states; Energy quantization; Schrödinger's equation in momentum space;

4. Application of Schrödinger’s equation : Particle in a box; Transmission and reflection at a barrier; Barrier penetration; Potential wells; The simple harmonic oscillator; Measuring a particle’s momentum;

5. Operator formalism : Momentum operator; Expectation values; Inner products; Hermitian adjoint; Eigenstates and eigenvalues

References

1. *Introduction to Quantum Mechanics*: David J. Griffiths; Prentice-Hall; 2004.
2. *Introduction to Quantum Mechanics*: B. H. Bransden; Langman.

PHY 305: Digital Electronics (3 credits = 26 lectures)

1. Digital electronics; Numbers: (a) Decimal; binary; octal and hexadecimal binary coded decimal;

2. Logic operation: NOT; OR; NOR; AND; NAND; EX-OR operation; Combinational logic operation; Parity generator; Laws of Boolean algebra; De-Morgan’s theorem; Sum of product; Product of sum; k-maps; Multiplexer; demultiplexer; decoder; encoder; half-adder; full-adder; adder-subtracter.

3. Logic circuits: DTL; TTL;CMOS; ECL. Flip-flops; registers & counters: R-S; D-type; Edge-triggered; J-K and J-K master slave flip-flops; serial and parallel shift registers; Synchronous and asynchronous counters; Up & down counters; Mod-3 and Mod-5 counters; decade counters. Memory: Matrix addressing; typical memory cell. Digital computer: Basic computer system; microcomputer; microprocessor – Intel 8085 and Intel 8086.

4. Pulse circuit: Pulse characteristics; RC differentiators & intregrators; Astable; Monostable and bistable multivibrators and Schmitt trigger.

5. Radio : Basic Concepts

6. Television : Basic Principles

References

1. *Pulse, Digital and Switching Waveforms*: Millman and Taub : McGraw-Hill Education: 1st edition.
2. *Digital Integrated Electronics:* Taub and Schilling : McGraw-Hill Inc: 1st edition.
3. *Digital Computer Fundamentals*: Bartee; T.: Mcgraw-Hill College:6th edition.
4. *Digital Principles and Applications* : Malvino and Leach: McGraw-Hill : 2nd edition.
5. *Digital Electronics*: An Introduction to Theory and Practice: Gothman ; W. H.:
6. *Digital Design*: Maurice Mano: Prentice Hall: 5th edition.

PHY 307: Linear Algebra and Differential Equations (3 credits = 26 lectures)

1. Systems of linear equations and matrices, vector spaces and subspaces, linear dependence and independence, dimensions and bases,
2. Linear transformations and matrices, eigenvalues and eigenvectors, changes of coordinates, orthogonality, diagonalization,
3. First order ordinary differential equations (existence and uniqueness of solutions, solution techniques, direction field and stability, modeling applications).
4. Second and higher order linear equations (existence and uniqueness, fundamental set of solutions of homogeneous equations, Wronskian, reduction of order, equations with constant coefficients, method of undetermined coefficients, method of variation parameters, solution in series, Laplace transform method, modeling applications).
5. Systems of linear differential equations (existence and uniqueness of solutions, eigenvalue method for homogeneous systems, method of variation of parameters for systems, Laplace transform method for systems, modeling applications).
6. Introduction of nonlinear systems.

References

1. *A First Course in Differential Equations with Modeling Applications:* Dennis G. Zill: Cengage Learning: 10 th edition.
2. *Elementary Linear Algebra*: Howard Anton and Chris Rorres: Wiley: 9th edition.

PHY 308: Mathematical Methods for Physicist (3 credits = 26 lectures)

1. Review of Vector Analysis: Green's theorem; Stoke's theorem and Divergence theorem – applications; Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical Polar & Cylindrical Polar coordinate system.

2. Complex variable: Definition of general rules; Geometric aspects of complex variables; Cauchy-Riemann equations; Contour integral (Residue theorem); Cauchy-Goursat theorem; Evaluation of integrals of real functions.

3. Special Functions: Fourier and Laplace's transform; Dirac delta function and its properties; Legendre and associated Legendre function and spherical harmonics with application in atomic physics; Hermite polynomials with application to quantum oscillator; Laguerre and associated Laguerre polynomials; Green's function; Hypergeometric function with application; Bessel functions.

4. Special Functions in Physics : Gamma and Beta Funnction.

5. Introduction to Tensors.

References

1. *Mathematical Methods for Physicists*: Arfken and Weber: Academic Press:7th edition.
2. *Mathematical Physics for Physicists and Engineers*: Pipes: Interscience Publishers, Inc., New York: 3rd edition.
3. *Mathematical Physics*: Margenau and Murphy: H. W. Wyld. Perseus.
4. *The special functions of Mathematics for Engineers*: Luke; Y.L.: Chelsea Publishing Company: 2nd edition.
5. *Vector Analysis*: Spiegel; Schaum Series: McGraw-Hill: 2nd edition.

6. *Differential Equations*: Ross; S.L.: Wiley; 4th edition.

Major Elective Courses

Students will choose 18 credits (6 courses) with prior approval of major advisor

PHY 430: Relativity: Special & General Theory (3 credits = 26 lectures)

1. Special Relativity: Galilean relativity and Newtonian mechanics; Michelson-Morely experiment; Postulates of the special theory of relativity; Lorentz transformations; Length contraction and time dilation; Proper time; Transformation of velocities; Twin paradox; Space-Time and four vectors.

2. Relativistic Mechanics: The principle of least action; Relativistic Lagrangian; Energy and momentum; Decay of particles; Invariant cross-section; Elastic collisions of particles; Four-tensor of angular momentum; Magnetism as relativistic phenomenon; invariance of electric charge; covariant form of electrodynamic equation; Four-potential of electromagnetic field.

3. General Relativity: Particle in Gravitational Field; The principle of equivalence; Gravitational field in relativistic mechanics; Curvilinear coordinates; Distance and time intervals in general relativity; Covariant differentiation; Motion of a particle in a gravitational field; The constant gravitational field; The Gravitational Field Equations: The curvature tensor; The Einstein equations.

References

1. *Classical Theory of Fields*: Landau; L.D. and Lifshitz; E.M.: Butterworth-Heinemann: 4th edition.
2. *Special Relativity*: French; A.P.: CRC Press: 1st edition.
3. *Gravitation*: Weinberg; S.: John Wiley & Sons, Inc.: 1st edition.
4. *Mathematical Theory of Black Holes*: Chandrasekhar; S.: Oxford University Press: 1st edition.
5. *An Introduction to General Relativity*: Hartle; J.B.: Gravity: Addison-Wesley: 1st edition.

PHY 431: Particle Physics (3 credits = 26 lectures)

1. Elementary Particles : Definition; Classifications: Bosons and Fermions; Leptons and Hadrons; Quantum Numbers; Different types of interactions; Antiparticles; Particle lifetimes; Basic quark model; form factors; structure functions; Quark composition of mesons and hadrons; Symmetry transformations and conservation laws; deep inelastic scattering; parton model.

2. Introduction to Particle Accelerators: Accelerator Survey; Thomas cyclotron; Linear optics; Periodic lattices; Acceleration; Phase stability.

3. Electron Injectors: The physics of space-charge dominated beams; emittance compensation; injector designs; Technology of electron sources**.**

4. RF Acceleration and Beam Loading: Coupling power to the beam; Mode excitation; RF cavities for acceleration**.**

5. Superconducting RF: Superconductivity fundamentals; Electrodynamics of conductors and superconductors; Multipacting; RF control and frequency issues.

6. Beam Dynamics: Wake fields and impedances; Instabilities in linacs; Instabilities in storage rings; Instabilities in recirculating linacs; The Vlasov treatment; Radiation from relativistic electrons.

7. Applications of Electron Accelerators: Linacs; Storage rings; Recirculating and Energy Recovery Linacs (ERLs)

References

1. *Handbook of Accelerator Physics and Engineering*: A. W. Chao and M. Tigner*:* World Science *Publishing* Co.: 2nd edition.
2. *Particle Accelerator Physics*: H. Wiedemann: B. Wolf, ed: 3rd Edition.

PHY 432: Introduction to Astrophysics (3 credits = 26 lectures)

1. Overview of the Universe : Scale of Universe; Nomenclature; Celestial Sphere; An overview of the main ideas in our current view of the universe; and how they came about. Galaxies; quasars; stars; pulsars; and planets.

2. The Big Bang; Elements and Radiation - The Big Bang; Formation of Elements; Different Kinds of Radiation; Discovery of the Galaxy and the Vastness of Space -Discovery of the Galaxies; Expansion of the Universe

3. The Solar System : Age and Origin of the Solar System -Discovery of the Solar System; Age of the Solar System; Clues from Meteorites; Clues from Comets; Properties of the solar system; the sun; Motion of the Sun; Seasons; Lunar and Planetary Phases; Eclipses; Planetary Motions; Gravitation; solar system exploration; the physical nature of the Earth and the other planets; comets and asteroids; origin of the solar system; Building From a Cloud to the Whole Solar System; The Moon and Terrestrial Planets (Mercury; Venus; Earth; Mars); The Giant Planets (Jupiter; Saturn; Uranus; Neptune)

3. The Stars : Star Formation; Structure of Stable Stars; Energy Sources; Mass vs. Luminosity; Stellar Lifetimes; Star Clusters; supernovae. Stages of a star's life : Main Sequence Evolution; Red Giants; Planetary Nebulae; Neutron Stars; White Dwarfs; Pulsars; Black Holes; Planet and constellation identification.

4. Galaxies : The Milky Way Galaxy; Other Galaxies; Galaxy Clusters; Peculiar Galaxies; Exotic (violent) Galaxies; Cosmology Observations; Where and When did it begin? Cosmology Theory.

5. Cosmology : and High Energy Astrophysics : An introduction to modern cosmology and extragalactic astronomy. Topics include the origin of the universe; The Big Bang Theory; The Expanding Universe; The Large-Scale Structure of the Universe; dark matter; properties of galaxies and active galactic nuclei; and very energetic phenomena in our own and other galaxies.

6. Physical Cosmology : A physical examination of our evolving universe: the Big Bang model; simple aspects of general relativity; particle physics in the early universe; production of various background radiations; production of elements; tests of geometry of the universe; and formation

and evolution of galaxies and large-scale structure. Universe Endgame - Predictions for the Future of our Universe; the Ultimate Fate of the Universe;

References

1. *Astrophysics for Physicists*; Arnab Rai Choudhuri: Cambridge University Press: 2nd edition.
2. *Introductory Astronomy and Astrophysics:* Michael Zeilik & Stephen A. Gregory: Cengage Learning: 4th edition.
3. *An Introduction to Modern Astrophysics*: Carroll and Ostlie: Addison-Wesley; 2nd edition.
4. *Stellar Structure and Evolution*: R. Kippenhahn and A. Weigert: Springer; 1st edition.
5. *Physical Principles: Stellar Interiors: Physical Principles; Structure; and Evolution*: C. J. Hansen; S. D. Kawaler; and V. Trimble: pringer Science+Business Media, LLC: 2nd edition.
6. *Principles of Stellar Evolution and Nucleosynthesis*: D.D.Clayton: University Of Chicago Press: 2nd edition.
7. *Horizons: Exploring the Universe*; Michael A.: Seeds: Cengage Learning: 12th edition.

PHY 433: Computational Physics (3 credits = 26 lectures)

[A sound basis on any of the Computer languages ForTran77/ForTran90/C++ is the prerequisite for the Course.]

1. Introduction: Physics and Computational Physics
2. System of linear equations: Gaussian elimination; partial and complete pivoting; LU decomposition method; iterative techniques; tridiagonal and sparse systems.
3. Numerical integration: Rectangular and trapezoidal rule; Simpson's rule with equal and unequal segments; Spline quadrature; adaptive quadrature routines.
4. Overview of use of computer computation in Classical and Quantum Physics: Introduction to computer algorithms and languages.
5. Partial differential equations: Partial differential equations in Physics; Separation of variables; Discretization of the equation; The matrix method for differential equations; Initial value problems
6. The Monte Carlo method: Introduction; Monte Carlo integration; Monte Carlo for the Ising model; Monte Carlo simulation of a monatomic gas; Renormalization with Monte Carlo simulation; Variational quantum Monte Carlo simulations; Green's function Monte Carlo simulations; Path-integral Monte Carlo simulations; Quantum lattice model. Symbolic computing: Symbolic computing systems; Basic symbolic mathematics; computer calculus; linear system; non-linear system; differential equations; computer graphics.
7. High-performance computing: The basic concepts; High-performance computer systems; Parallelism and parallel computing; Data parallel computing; Distributed computing and message passing.

References

1. *An Introduction to Computational Physics:* Tao Pang: Cambridge University Press: 2nd edition.
2. *Computational Physics:* Thijssen; I.M.: Cambridge University Press: 2nd edition.
3. *An introduction to Computer Simulation Methods part 1 & 2:* Harvey Gould and Jan Tobochnik: Addison-Wesley: 3rd edition.
4. *The Mathematica Book:* Wolfram; S.: Addison-Wesley *Publishing* Company: 5th edition.
5. *A Comparison of Several Symbol Manipulating Programs; Part I & 2:* Cook; D.M. and others:

PHY 434: Atmospheric Physics and Meteorology (3 credits = 26 lectures)

1. Structure of the atmosphere; Elementary ideas about the sun and the laws of radiation; definitions and units of solar radiation. Depletion of solar radiation in the atmosphere. Terrestrial radiation; Radiation transfer; heat balance in the atmosphere ; heat budget. Vertical temperature profile; Radiation charts and their uses.

2. Composition of the atmosphere mean molecular weight; Humidity; mixing ratio; density and saturation vapor pressure.

3. Dynamic Meteorology : Units and dimension of parameters used in the dynamic meteorology. Fundamental forces governing the motion of the atmosphere. Pressure gradient force; gravitational force. Apparent forces in non-inertial frame of references; centrifugal force; coriolis force; structure of the static atmosphere. Hydrostatic equation.

4. Different frames and coordinates. Physical meaning of total and partial differentiation in meteorology. The basic conservation laws. The vector form of momentum equation in rotating coordinates. The component equation in spherical coordinates. Continuity equation .The thermodynamic energy equation. Thermodynamics of dry atmosphere. Applications of the basic equations. Balanced flow. Trajectories and streamlines; Thermal wind; vertical motion circulation and vorticity. Elementary ideas of planetary boundary layer.

5. Condensation; precipitation and atmospheric electricity. Microphysical processes: Condensation nuclei; curvature and solute effects; Cloud Classification; general features.

6. The general circulation of the atmosphere; elementary ideas; Fronts; Cyclones.

7. The Tephigram: Tropical Meteorology: Definition of the region; zones of convergence; vertical structure of the winds; Monsoon; Depressions; tropical cyclones; Elementary ideas about forecasting. Synoptic charts. Satellite meteorology.

References

1. *An Introduction to Dynamic Meteorology:* J.R. Holton: Academic Press: 5th edition.
2. *Essentials of Meteorology:* D.H. McIntosh and A.S. Thorn:
3. *The Monsoons:* P.K. Das: NATIONAL BOOK TRUST-NEW DELHI: 3rd
4. *General Meteorology:* H.B.Byers.: McGraw-Hill. Book Co: 3rd edition.
5. *An Introduction to Atmospheric Physics:* R.G. Fleagle.: Academic Press: 2nd edition.
6. *Tropical Meteorology:* H.Riehl.: DEEPAK.
7. *Notes on Satellite Meteorology:* P.Menzel.: Blaisdell *Publishing* Company.

PHY 435: Nuclear Physics-II (3 credits = 26 lectures)

1. General Properties of Nucleus: Nuclear density distribution; isospin; magnetic moments; g-factor.

2. The Deuteron : Ground state of deuteron; deuteron ground state wave function; magnetic and quadrupole moments of the deuteron; Tensor forces and the deuteron problem;

3. Two- body Problems at Low Energy: Scattering of a beam of particles by a Centre of force; Partial wave analysis; Neutron-proton scattering at low energies; Scattering length; spin dependence of n-p scattering; Effective range theory in the n-p scattering; Coherent and incoherent scattering; Salient features of the n-p scattering at intermediate and high energies.

4. Nuclear Force: Central and non-central forces; Exchange forces; Nuclear stability conditions; Symmetry and charge effects; Charge independence of nuclear force; mirror nuclei and Coulomb energy.

5. Nuclear Reactions : Reaction cross-section; Breit-Wigner dispersion formula for l=0 state; Compound nucleus reaction; Optical model;

6. Direct reactions: Definition and classification; the methods of direct reaction theory: Analysis of stripping and pick-up reactions;

7. Nuclear Models: Salient aspects of different nuclear models; Magic numbers and nuclear shell model; Single particle potential; Harmonic oscillator well; Spin-orbit potential; Shell model predictions; Spin and magnetic moments; Nordheim's rule; Total spin for various configurations; Individual particle model; L-S coupling scheme; J-J coupling scheme; Collective model-Vibrational and rotational states; Nuclear deformation; Nilsson potential.

8. Transitions: Gamma-ray energies and lifetime of excited states; Theory of gamma emission; Internal conversion.

References

1. *Nuclear Physics : Theory and Experiment;* Roy; R. R. and Nigam *;* B. P.*:* John Wiley & Sons Ltd: 1st Edition.
2. *Structure of the Nucleus* : Preston and Bhaduri : Wesley *Publishing* Co: 1st edition.
3. *Nuclei and Particles* : Segre; E.: Benjamin-Cummings *Publishing: 1st edition.*
4. *Introduction to Nuclear Physics:* Enge; M. A.:
5. *Concepts of Nuclear Physics:* Cohen ; B. L.: McGraw-Hill Inc: 1st edition.
6. *Theoretical Nuclear Physics:* Blatt; J.M. and Weisskopf ; V.F.: Addison-Wesley *Publishing* Co.
7. *Introductory Nuclear Physics:* Elton; L.R.B.: Benjamin *Elton.*
8. *Introductory Nuclear Physics:* Waghmare;B.: Tata Mc Graw Hill.
9. *Theory of Nuclear Structure:* Pal; M.: Aff. East-West Press Ltd: 1st edition.
10. *Introductory Nuclear Physics:* Hodgson P.E.*; Gadioli; E and Erba; E.G. :* Oxford University Press: 1st edition.
11. *Introduction to Nuclear Theory:* MacCarthy; I.E.: Wiley.
12. *Nuclear Structure I and II:* Bohr; A. and Mottelson; B.R.: World Scientific: vol-02.
13. *Collective Motion in Nuclei:* Macfarlane M.H. and Elliot J.P.: Rochester, N.Y.
14. *Theory of Direct Nuclear Reactions:* Tobocman W.: Oxford University Press.
15. *Direct Nuclear Reactions:* Satchler G.R.: Clarendon Press.

PHY 436: Solid State Physics-II (3 credits = 26 lectures)

1. Electrical properties in metals: electrical conductivity at high frequencies; dielectric response of an electron gas; motion in magnetic fields; electron in a periodic potential; approximate solution near a zone boundary ; number of orbital in a band; construction of Fermi surface.

2. Semiconductor: (review)

3. Dielectric Properties: Macroscopic electric field; Local field; Dielectric constant; Electronic; ionic and orientation polarizabilities; Clausius-Mossotti relation; Measurement of dielectric constant; general properties of ferroelectric materials; dipole theory of ferroelectricity; spontaneous polarization; ferroelectric domain; piezoelectricity & pyroelectricty; relaxation and dielectric losses; electromechanical transducers.

4. Magnetic properties of solids : Langevin's dia- and paramagnetism; quantum theory of paramagnetism; paramagnetic susceptibility of conduction electron; ferri and ferromagnetism; anti-ferromagnetism; ferrites; Curie-Weiss law; Heisenberg model; spin waves; magnetic relaxation and resonance phenomena.

5. Superconductivity : Basic properties of superconductors; Type-1 and Type-2 superconductors; critical field; Meissner effect; thermodynamics of superconductors; London equations; penetration depth; coherence length; superconductors; modern theory. of superconductivity; high T_C superconductors.

6. Optical phenomena in solids: color of crystal; excitons; photoconductivity; phosphorescence; excitations and emission; electro-luminescence. Defects in solids: Point defects; lattice vacancies; diffusion; dislocations.

References

1. *Introduction to Solid State Physics:* Kittel; C.: Wiley: 8th edition.
2. *Solid State Physics:* Dekker; A.J.: MACMILLAN.
3. *Solid State and Semiconductor Physics:* McKelvey; J.P.: Joanna Cotler Books:
4. *Introduction to Solid State Physics:* Madelung; O.: Springer.
5. *Physics of Solids*: Wart; C. A. & Thomson; R.M. : Holt, Rinehart, and Winston.
6. *The Theory of Solids:* Seitz; F.: N.Y.: McGraw-Hill: 2nd edition.
7. *The Modern theory of Solids:* Blakemore; J. S.: Cambridge University Press; 1st edition.
8. *Solid State Theory:* Sachs; M. : North Holland *Publishing* Company: 1st edition.

PHY 437: Non-linear Optics (3 credits = 26 lectures)

1. The Non-linear Optical Susceptibility: Introduction to Non-linear Optics; Description of non-linear optical interactions; Formal definition of non-linear susceptibility; Non-linear susceptibility of a classical anharmonic oscillator.

2. Wave-Equation Description of Non-linear Optical Interactions: The wave equation for non-linear optical media; the coupled wave-equations for sum-frequency generation; The Manley-Rowe relations; Sum-frequency generation; Difference-frequency generation and parametric amplification; Second-harmonic generation; Phase- matching considerations.

3. Dependent Refractive Index: Description of the intensity-dependent refractive index; Non-linearities due to molecular orientation.

4. Process Resulting from the Intensity-Dependent Refractive Index: Optical phase conjugation; Self-focusing of light; Optical bistability;

5. Two-beam coupling; Pulse propagation and optical solitons. The Electro-optic and Photo-refractive Effects: Introduction to the electro-optic effect; Linear electro-optic effect;

References

1. *Non-linear optics:* Boyd; R.W.: Academic Press: 3rd edition.
2. *The Elements of Non-linear Optics:* Butcher; P.N. and Cotter; D.: Cambridge University Press:
3. *The Principles of Non-linear Optics:* Shen; Y.R.: Wiley-Interscience: 1st edition.
4. *Non-linear Optics:* Newell; A.C. and Moloney; J.V.: Addison Wesley *Publishing* Co: 2nd edition.
5. *Modern Optics:* Guenther; R.: W. H. Freeman and Company: 3rd edition.
6. *Non-linear Optics:* Bloembergen; N.: *North*-Holland *Publishing* Co: 2nd edition.
7. *An Introduction to Non-linear Optics:* Baldwin; G.C.: Springer: 2nd edition.

PHY 438: Quantum Mechanics-II (3 credits = 26 lectures)

1. Matrix formulation of quantum mechanics: State vectors in Hilbert space; bra and ket notations; operators and their representation; transformation theory; Schrodinger; Heisenberg; and Dirac representations. Theory of angular momentum: Angular momentum operators and their commutation relations; eigenvalues and eigenvectors of angular momentum operators; parity operation on the angular momentum vectors; addition of angular momenta; Clebsch-Gordon coefficients; Pauli's exclusion principle and spin matrices.

2. Theory of scattering : Two-body systems; scattering by spherically symmetric potentials; partial-wave analysis; Born approximation and its applications.

3. Approximate methods: Stationary perturbation theory; time dependent perturbation theory; variational method; WKB approximation.

4. Identical particle : Symmetric and antisymmetric wave functions; exclusion principle; spin and statistics; spin matrices; scattering of identical particles.

5. Relativistic wave equations : Klein-Gordon and Dirac's relativistic wave equations; solution of free particle equations; negative energy states and hole theory.

References

1. *Quantum Mechanics:* Schiff; L. I.: Mcgraw-Hill College: 3rd edition.
2. *Text book of Quantum Mechanics*: Mathews; P. M. & Vankatesan; K.: Tata McGraw-Hill Education.
3. *Introduction to Quantum Mechanics*: Dicke; K. H. & Whittke; J. P.: *Dicke*, R. H., and *J. P. Wittke.*
4. *Quantum Mechanics -an Introduction:* Greiner; W.: Addison-Wesley *Publishing* Co; 2nd edition.
5. *Quantum Mechanics Vol I and Vol II:* Messiah; A.: North Holland *Publishing* Company:1st edition.
6. *Principles of Quantum Mechanics*: Dirac; P. A. M.: Oxford University Press: 4th edition.
7. *Quantum Mechanics:* Sherwin; C. W.: Holt, Rinehart and Winston
8. *Basic Quantum Mechanics:* Ziock; C.: John Wiley & Sons Inc: 1st edition.
9. *Quantum Mechanics:* Sakurai; J.J.: Addison-Wesley: 2nd edition.
10. *Quantum Mechanics:* Powell; J.L. and Craseman; B.: Addison-Wesley Pub.

PHY 439: Classical Mechanics – II (3 credits = 26 lectures)

1. Newton's law and the Kepler Problem; The gravitational two-body problem; reduction of two-body problem into one-body problem; Kepler problem in time; Kepler's equation.

2. Perturbation Theory: General statement of perturbation theory; the Lindstedt-Poincare perturbation theory and its application to the theory of orbits; Canonical perturbation theory and its use in the Doffing oscillator; Floquet theory and its use in the Sitnikov problem.

3. The Restricted Three-Body Problem: The problem; Jacobian integral; Lagrange points; Motion of Trojan asteroids. Order and Chaos: Definition of order and chaos; Determination of presence of chaos in orbital motion; Liapunov exponents; deterministic chaos.

4. Relativity: Special & General: Lorentz transformations; Special relativistic kinematics; the general theory of relativity; the Schwarzschild and Kerr metrics.

5. Geodetic Motion: Geodetic equation of motion and its solution in Schwarzschild field; the Carter's equations and dynamics of test particle orbits around rotating stars.

6. Post-Newtonian Celestial Mechanics: Bending of star light; perihelion shift of Mercury; photon orbit.

References

1. *Analytical Mechanics:* Hand and Finch: Cambridge University Press:2nd edition.
2. *Classical Dynamics:* Jose and Saletan: Cambridge University Press.
3. *Theory of Orbits:* Boccaletti and Pocacco: Kluwer Academic.
4. *Theory of Orbits:* Szebehely: Academic Pr
6. *Classical Theory of Fields:* Landau L.D.; and Lifshitz E.M.: Landau L.D.: 4th edition.

The following corrections have been made according to the comments and suggestions of the expert committee of UGC who visited IUB at 20/11/2015.

1. Total credit hours have been increased from 130 to 133.

2. **CHE 101** (Concepts in Chemistry) is included as one of the foundation courses according to the suggestion. Detail of the course is given also.

3. **PHY 101** and **PHY 102** are renamed as **Physics-I** and **Physics-II** respectively according to the suggestion.

4. **PHY 102** is shifted to the **core course** group from foundation group according to the suggestion.

5. Chapter 1 of PHY 102 (Mathematical preliminaries) is now included as Chapter 1 of PHY 101 according to the suggestion.

6. **PHY 439: Orbital Mechanics** has been renamed as **PHY 439: Classical Mechanics -II** according to the suggestion.

7. PHY 401 has been renumbered as PHY 308 to cover in Level 2 according to the suggestion

Theory Courses: 3 credits = 26 lectures in one semester, each lecture is 1 hour 30 minutes duration
Lab Courses: 1 credit = 13 lectures in one semester, each lecture is 3 hours duration