Syllabus of Associate Degree in Physics

Associate Degree in Physics Syllabus

Programme: Associate Degree in Physics
Duration: 2years
Number of semesters: 4
FSc Pre-Engineering/A-Level Cambridge (with Maths and Physics) / Three year polytechnic degree

Course Code	Course Title	Credit Hours
PHY-501	Mechanics-I	4 (3 – 1)
PHY-502	Electricity & Magnetism	4 (3 – 1)
PHY-503	Heat & Thermodynamics	3 (3 – 0)
PHY-504	Waves and Oscillation	4 (3 – 1)
PHY-505	Modern Physics-I	3 (3 – 0)
PHY-506	Properties of Matter	4(3 – 1)
PHY-507	Circuit Theory	4 (3 – 1)
PHY-508	Optics	3 (3 – 0)
PHY-509	Modern Physics-II	4 (3 -1)
Total		**33**

PHY-501 MECHANICS: Credit Hours: 4(3-1)

Objectives:

The main objective of this course is to understand the different motions of objects on a macroscopic scale and to develop simple mathematical formalisms to analyze such motions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Basic Concepts: Scalars and Vectors, Multiplication of Vectors: Dot and Cross Products. Vector triple product, scalar triple product, Del Operator, Divergence theorem, stokes theorem, Coordinate systems: Cartesian system, spherical, cylindrical system of coordinates.

Motion in One, Two and Three Dimensions: Position & Displacement, Velocity and Acceleration, Motion under Constant Acceleration, Projectile Motion, Uniform Circular Motion, Relative Velocity and Acceleration in One and Two Dimensions, Inertial and Non-Inertial Reference Frames.

Newton's Laws: Newton's Laws of Motion and their Applications involving some particular forces including Weight, Normal Force, Tension, Friction, and Centripetal Force, Newton's Law of Gravitation, Gravitational Potential Energy, Escape Velocity, Kepler's Laws, Satellite Orbits & Energy.

Work and Kinetic Energy: 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 & Kinetic Energy in One and Two Dimensional Elastic and Inelastic Collisions.

Rotational Motion: Rotation about a Fixed Axis, Angular Position, Angular Displacement, Angular Velocity and Angular Acceleration, Rotation under Constant Angular Acceleration, relationship between Linear and Angular Variables, 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, Precession of a Gyroscope, Static Equilibrium involving Forces and Torques, Determination of moment of inertia of various shapes i.e. for disc, bar and solid sphere.

Angular Momentum: Angular Velocity, Conservation of angular momentum, effects of Torque and its relation with angular momentum.

Simple Harmonic Motion (SHM): Amplitude, Phase, Angular Frequency, Velocity and Acceleration in SHM, Linear and Angular Simple Harmonic Oscillators, Energy in SHM, Simple Pendulum, Physical Pendulum, SHM and Uniform Circular Motion, Damped Harmonic Oscillator.

PRACTICALS:

1. To determine the value of "g" by simple pendulum.
2. To determine the value of "g" by compound pendulum/ Kater's Pendulum.
3. To study the damping features of an oscillating system using simple pendulum of variable mass.
4. To study the dependence of Centripetal force on mass, radius, and angular velocity of a body in circular motion.

5. Determination of moment of inertia of a solid/hollow cylinder and a sphere etc

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010.
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed. 2008.

PHY-502-ELECTRICITY AND MAGNETISM Credit Hours: 4(3-1)

Pre-requisite: Mechanics, Calculus I

Co-requisite: Calculus II

Objectives:

The main objective of this course is to understand the Physics of Electromagnetism and to develop simple mathematical formalisms to analyze the electromagnetic fields and interactions. This is a calculus-based introductory course with maximum emphasis on applying the acquired knowledge to solving problems.

Electrostatics: Electric Charge, , Conductors and Insulators, Coulomb's Law, Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to different Charge Distribution (line, disc, ring), Electric Dipole in an Electric Field, Electric Flux, Gauss' Law and its Applications in Planar, Spherical and Cylindrical Symmetry.

Electric Potential: Electric potential, Electric potential energy**,** Equipotential Surfaces, Potential due to a Point Charge and a Group of Point Charges, Potential due to an Electric Dipole, Potential due to a Charge Distribution, Relation between Electric Field and Electric Potential.

Magnetic Field and Magnetic Force: Crossed Electric and Magnetic Fields and their Applications, Hall Effect, 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, Long Straight Wire carrying Current, Solenoids and Toroids, A current-carrying Coil as a Magnetic Dipole,

Electro Magnetic Induction: Inductance, Faraday's Law of Induction, Lenz's Law, Induction and Energy Transfers, Induced Electric Fields, Inductors and Inductances, Self Inductance, RL Circuits, Energy Stored in a Magnetic Field, Energy Density, Mutual Induction.

Alternating Fields and Currents: LC Oscillations, Damped Oscillations in an RLC circuit, Alternating Currents, Forced Oscillations, Resistive, Capacitive, and Inductive Loads, RLC series Circuit, Power in AC Circuits, Transformers, Gauss' Law for Magnetism, Induced Magnetic Fields, Displacement Current, Spin & Orbital Magnetic Dipole Moment, Diamagnetism, Paramagnetism, Ferromagnetism, Hysteresis.

Practicals:

1. Measurement of high resistance using a neon flash bulb and a capacitor.
2. Measurement of low resistance coil by a Cary Foster Bridge.
3. Conversion of a moving-coil galvanometer into voltmeter.
4. Conversion of a moving-coil galvanometer into ammeter.

5. Calibration of an ammeter using a potentiometer.
6. Calibration of a voltmeter using a potentiometer.
7. Charge sensitivity of a ballistic galvanometer.
8. Comparison of capacities of two capacitors by a ballistic galvanometer.
9. To determine the self inductance of a coil by Rayleigh's Method.
10. To determine the self inductance of a coil by Anderson's Method.
11. To determine the coefficient of mutual inductance of a pair of a coils.

Recommended Text Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9th ed. 2010.
2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8th ed. 2010.
3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13th International ed. 2010.
4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2nd ed. 1992.
5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4th ed. 2008.

PHY-503-HEAT AND THERMODYNAMICS Credit Hours: : 3(3-0)

Pre-requisites: Mechanics

Co-requisites: Calculus-II

Objectives: To understand the fundamentals of heat and thermodynamics.

Basic Concepts and Definitions in Thermodynamics: Thermodynamic system, Surrounding and Boundaries. Type of systems. Macroscopic and microscopic description of system. Properties and state of the substance: Extensive and Intensive properties, Equilibrium, Mechanical and Thermal Equilibrium. Processes and Cycles: Isothermal, Isobaric and Isochoric. Zeroth Law of Thermodynamics, Consequence of Zeroth law of Thermodynamics. The state of the system at Equilibrium.

Heat and Temperature: Temperature, Kinetic theory of ideal gas, Work done on an ideal gas, Review of previous concepts. Internal energy of an ideal gas: Equipartition of Energy, Intermolecular forces, Qualitative discussion, The Virial expansion, The Van der Waals equation of state.

Thermodynamics: First law of thermodynamics and its applications to adiabatic, isothermal, cyclic and free expansion. Reversible and irreversible processes. Second law of thermodynamics, Carnot theorem and Carnot engine. Heat engine, Refrigerators. Calculation of efficiency of heat engines. Thermodynamic temperature scale: Absolute zero, Entropy, Entropy in reversible process, Entropy in irreversible process. Entropy and Second law of thermodynamics, Entropy and Probability. Thermodynamic Functions: Thermodynamic functions (Internal energy, Enthalpy, Gibb's functions, Entropy, Helmholtz functions), Maxwell's relations, TdS equations, Energy equations and their applications. Low Temperature Physics, Joule-Thomson effect and its equations. Thermoelectricity: Thermocouple, Seabeck's effect, Peltier's effect,

Recommended Books:

1. D. Halliday, R. Resnick and K. Krane, "Physics", John Wiley, 5th ed.2002.
2. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley, 9th ed. 2010.

3. M. W. Zemansky, "Heat and Thermodynamics", Mc Graw Hill, 7th ed.1997.
4. M. Sprackling, "Thermal Physics" McMillan 1991.
5. B. N. Roy, "Principle of Modern Thermodynamics", Institute of Physics,London 1995.

PHY-504 WAVES AND OSCILLATIONS Credit Hours: : 4(3-1)

Pre-requisites: Mechanics, Calculus II

Objective(s):

To develop a unified mathematical theory of oscillations and waves in physical systems.

Simple and Damped Simple Harmonic Oscillation: Mass-Spring System, Simple Harmonic Oscillator Equation, Complex Number Notation, LC Circuit, Simple Pendulum, Quality Factor, LCR Circuit.

Forced Damped Harmonic Oscillation: Steady-State Behavior, Driven LCR Circuit, Transient Oscillator Response, Resonance.

Coupled Oscillations: Two Spring-Coupled Masses, Two Coupled LC Circuits, Three Spring Coupled Masses, Normal Modes, Atomic and Lattice Vibrations.

Transverse Waves: Transverse Standing Waves, Normal Modes, General Time Evolution of a Uniform String, Phase velocity, Group Velocity, Pulse wave form.

Longitudinal Waves: Spring Coupled Masses, Sound Waves in an Elastic Solid, Sound Waves in an Ideal Gas.

Traveling Waves:, Traveling Waves in an Infinite Continuous Medium, Energy Conservation, Reflection and Transmission at Boundaries, Electromagnetic Waves. Standing Waves in a Finite Continuous Medium

Multi-Dimensional Waves: Plane Waves, Three-Dimensional Wave Equation, Laws of Geometric Optics, Waveguides, Cylindrical Waves.

Interference and Diffraction of Waves: Double-Slit Interference, Single-Slit Diffraction.

Recommended Books:

1. J. Pain, "The Physics of Vibrations and Waves", John Wiley, 6th ed. 2005.
2. P. French, "Vibrations and Waves", CBS Publishers (2003).
3. F. S. Crawford, Jr., "Waves and Oscillations", Berkeley Physics Course,
4. Vol. 3, McGraw-Hill, 1968.
5. A. Hirose, and K. E. Lonngren, "Introduction to Wave Phenomena",Krieger Publications, 2003.

Practical (Waves and Oscillation)

1) Oscillations of a spring pendulum, and determination of oscillation period as a function of the oscillating mass
2) The frequency of the oscillators to be determined with the electronic counter of the light barrier and the stopwatch for a particular frequency of excitation.
3) By means of a path-time measurement the phase velocity of a transverse wave is to be determined.
4) For three different frequencies the corresponding wavelengths are to be measured and it is to be shown that the product of frequency and wavelength is a constant.
5) The four lowest natural frequencies with two ends of the oscillator system fixed are to be detected.

6) Use the comb to generate two circular waves and observe the resulting interference. Increase the number of interfering circular waves up to ten by using all teeth of the comb to demonstrate Huygens' Principle.
7) Generate plane water waves and use a barrier to demonstrate diffraction at an edge. Then, form a slit and observe diffraction behind the slit. Repeat this experiment for a double-slit.
8) By using the integrated wave generator as well as the external wave generator, generate two circular waves and observe the interference. Vary the phase of the external wave generator and observe the resulting interference pattern to understand the principle of "phased array antennas".

PHY-505 MODERN PHYSICS-I Credit Hours: : 3(3-0)

Pre-requisites: Mechanics, Electricity and Magnetism

Objective(s):

To understand the non-classical aspects of Physics, the emphasis is on the applications of Quantum Physics in microscopic-scale Physics, atomic and molecular structure and processes.

Motivation for Non--Classical Physics: Blackbody radiation and ultraviolet catastrophe, Planck's quantization.

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

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

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

Recommended Books:

1. R.A. Serway, C.J. Moses and C.A. Moyer, “Modern Physics”, Brooks Cole, 3rd ed. 2004.
2. Paul A. Tipler and Ralph A. Llewellyn, “Modern Physics”, W H Freeman and Company 6th ed. 2012.
3. Arthur Beiser, “Concepts of Modern Physics”, McGraw-Hill, 6th ed. 2002.
4. R. M. Eisberg and R. Resnick, “Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles”, John Wiley, 2nd ed. 2002.

PHY-506 PROPERTIES OF MATTERS Credit Hours: 04(3-1)

Objective To study some basic properties of matter including elasticity, elastic modulus and liquid flow, viscosity of a liquid.

CONTENTS:

ELASTIC PROPERTIES OF MATTER: Physical Basis of Elasticity; Tension, Compression & shearing, Different Moduli of Elasticity; Poisson's Ratio; Relation between Elastic Moduli; Experimental Methods for determination of Elastic Moduli; Determination of Poisson's Ratio.
VISCOSITY: Streamline and Turbulent Flow; Flow of a Liquid through a Capillary Tube (Poiseuille's Formula); Experimental Determination of the Coefficient of Viscosity of a Liquid; Motion in a Viscous Medium (Stokes's Formula'); Measurement of viscosity of liquid by falling sphere method (Stokes's method).
SURFACE TENSION: Molecular Theory of Surface Tension; Angle of Contact and Curvature of Liquid Surface; Surface Energy and Surface Tension; Formation of Drops and Bubbles; Capillarity and Measurement of Surface Tension of a Liquid.

Practical:
1. Modulus of Rigidity by Static method (Barton's Apparatus).
2. Modulus of Rigidity by Dynamic method (Maxwell's needle).
3. Measurement of viscosity of liquid by Stoke's / Poiseulli's method.
4. Surface tension of water by capillary tube method.
5. To study the conservation of energy (Hook's law).

BOOKS RECOMMENDED
1. Resnick, D. Halliday and K.S. Krane 'Physics' Volume I and II 5/e .John Wiley (2002)
2. Halliday. R. Resnick and J. Walker 'Fundamentals of Physics' John Wiley Latest Edition
3. I.D. Young and R.A. Freedman 'Sears and Zamansky's University Physics' 11/e Pearson Education (2004)
4. P.A. Tipler 'Physics for Scientists and Engineers' 5/e, W.H. Freeman (2003)
5. R..A. Serway and J.W. Jewett Jr. 'Physics for Scientists and Engineers' 6/e or Latest Edition, Thomson (2004)
6. D C. Giancoli 'Physics for Scientists and Engineers with Modern Physics' 2/e or Latest edition Prentice Hall

PHY- 507 CIRCUIT THEORY Credit Hours: 4(3-1)

OBJECTIVE
To study the combinations of circuit different, related laws and rules, different techniques of circuit analysis, network theorems, charge storing devices and make the students familiar with circuit maker software.

CONTENTS

(1) Introduction:
Resistance, temperature effect on resistance, thermistors, super conductors, types of resistors, varistor, strain gauge, resistor color code, ohms law, power, and energy, efficiency, home electricity billing system.

(2) Series and parallel circuits:
series circuit, voltage sources in series, Kirchhoff's voltage law, voltage divider rule, voltage sources and ground, voltage regulation and the internal
resistance of voltage sources, protoboards (breadboards), parallel circuit, Kirchhoff's current law, current divider rule, voltage sources in parallel, open and short circuits, series and parallel combinations, potentiometer loading

(3) Method of analysis:
current sources, source conversions, current sources in parallel, current sources in series, branch-current analysis, mesh analysis (general approach), mesh analysis (format approach), nodal

analysis (general approach), nodal analysis (format approach), bridge networks, y- delta and delta –y conversions,

(4) Network theorem:

Superposition theorem, Thévenin's theorem, Norto's theorem, maximum power transfer theorem, Millman's theorem, substitution theorem, reciprocity theorem

(5) Capacitors:

Capacitance, capacitor construction, internal structure and capacitance analysis, types of capacitors, temperature effects, capacitor labeling, transients in capacitive networks (the charging phase, discharging phase), instantaneous values, capacitors in series and in parallel, energy stored by a capacitor

(6) Inductors:

Magnetic field, electromagnets and their applications, inductance, inductor construction, induced voltage, RL transients, reluctance, ohm's law for magnetic circuits, magnetizing force, Ampère's circuital law, RLC series and parallel circuits.

Practical:

1. Prove of Kirchhoff voltage law using Series circuits.
2. Prove of Kirchhoff current law using parallel circuits.
3. Determine the charging and discharging effect of capacitor.
4. Determine instantaneous values, capacitors in series and in parallel
5. Study of RL/ RLC circuits

SOFTWARE: Analysis of circuits in all chapters using multisim or circuit maker software

BOOKS RECOMMENDED

1. Robert L. Boylestad. Introductory Circuit Analysis, 12th /e,
2. Hayt & Kimberly Circuit Analysis - Electrical and Computer Engineering, McGraw-Hill Book Company 8th /e

PHY-508 OPTICS Credit Hours: 3(3-0)

Pre-Requisites: Waves and Oscillations

Objective(s): To understand the optical phenomena and their uses in physical systems

Propagation of Light & 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.

Matrix Methods in Paraxial Optics: Ray Transfer Matrices, Thick Lens, Significance of System Matrix Elements, Cardinal Points of an Optical System with examples, Optical Instruments including Simple Magnifiers, Telescopes and Microscopes, Chromatic and Monochromatic Aberrations, Spherical Aberrations, Coma, Distortion, Stops, Pupils, Windows.

Superposition & Interference: Standing Waves, Beats, Phase and Group Velocities, Two-Beam and Multiple-Beam Interference, Thin Dielectric Films, Michelson and Fabry-Perot Interferometers, Resolving Power, Free-Spectral Range.

Polarization: Jones Matrices, Production of Polarized Light, Dichroism, Brewster's Law, Birefringence, Double Refraction.

Fraunhofer Diffraction: from a Single Slit, Rectangular and Circular Apertures, Double Slit, Many Slits, Diffraction Grating, Dispersion, Resolving Power Blazed Gratings.

Fresnel Diffraction: Zone Plates, Rectangular Apertures, Cornu's Spiral

Coherence & Holography: Temporal Coherence, Spatial Coherence, Holography of a Point object and an Extended Object

Laser Basics: Stimulated Emission, Population Inversion, Resonators, Threshold and Gain, Multi-layered Dielectric Films.

Recommended Books:

1. F.Pedrotti, L.S. Pedrotti and L.M. Pedrotti,"Introduction to Optics", Pearson Prentice Hall, 3rd ed. 2007.
2. E. Hecht and A. Ganesan, "Optics", Dorling Kindersley, 4th ed. 2008.
3. M. V. Klein and T. E. Furtak, "Optics", John Wiley, 2nd ed. 1986.
4. K. K Sharam, "Optics: Principles and Applications", Academic Press, 2006.

5. C. A. Bennett, "Principles of Physical Optics", John Wiley, 2008.

PHY-509 MODERN PHYSICS-II Credit Hours: 4(3-1)

Pre-requisites: Modern Physics-I

Objective(s): To understand the non-classical aspects of Physics, the emphasis is on the applications of Quantum Physics in microscopic-scale Physics, atomic and molecular structure and processes.

Special Theory of Relativity: Inertial and non-inertial frame, Postulates of Relativity, The Lorentz Transformation, Derivation, Assumptions on which inverse transformation is derived, Consequences of Lorentz transformation, Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity, variation of mass with velocity, mass energy relation and its importance, relativistic momentum and Relativistic energy, (Lorentz invariants)

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

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

Practical:

1. Determination of ionization potential of mercury.
2. Variation of Photoelectric current with intensity of light.
3. To study the characteristic curves of a G. M. tube.
4. Determination of range of α particle.
5. Study of the parameter of wave i.e. amplitude, phase and time period of a complex signal on an oscilloscope.

Recommended Books:

1. R.A. Serway, C.J. Moses and C.A. Moyer, "Modern Physics", Brooks Cole, 3rd ed. 2004.
2. Paul A. Tipler and Ralph A. Llewellyn, "Modern Physics", W H Freeman and Company 6th ed. 2012.
3. Arthur Beiser, "Concepts of Modern Physics", McGraw-Hill, 6th ed. 2002.
4. R. M. Eisberg and R. Resnick, "Quantum Physics of Atoms, molecules, Solids, Nuclei and Particles", John Wiley, 2nd ed. 2002.