AD_Physics

MECHANICS Credit Hours: 3(3+0)

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.

Course Contents:

Basic Concepts: Units and Dimensions, Changing Units, Scalars and Vectors, Adding Vectors: Graphical as well as Component Method, Multiplying Vectors: Dot and Cross Products.

Motion: Position & Displacement, Velocity and Acceleration, Motion under Constant Acceleration, Projectile Motion, Uniform Circular Motion.

Newton's Laws: Newton's Laws of Motion and their Applications, Newton's Law of Gravitation, Gravitational Potential Energy, Escape Velocity, Kepler's Laws.

Work and Energy: Work done by Constant and Variable 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.

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.

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, Torque, Angular Momentum for a single Particle, Conservation of Angular Momentum, Static Equilibrium involving Forces and Torques.

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.

Special Theory of Relativity: Inertial and non-inertial frame, Postulates of Relativity, The Lorentz Transformation, Derivation, Consequences of Lorentz transformation, Relativity of time, Relativity of length, Relativity of mass, Transformation of velocity, mass energy relation and its importance, relativistic momentum and Relativistic energy.

Recommended Books:

1. D. Halliday, R. Resnick and J. Walker, "Fundamentals of Physics", John Wiley & Sons, 9^{th} ed. 2010.

2. R. A. Serway and J. W. Jewett, "Physics for Scientists and Engineers", Golden Sunburst Series, 8^{th} ed. 2010.

3. R. A. Freedman, H. D. Young, and A. L. Ford (Sears and Zeemansky), "University Physics with Modern Physics", Addison-Wesley-Longman, 13^{th} International ed. 2010.

4. F. J Keller, W. E. Gettys and M. J. Skove, "Physics: Classical and Modern, McGraw Hill. 2^{nd} ed. 1992.

5. D. C. Giancoli, "Physics for Scientists and Engineers, with Modern Physics", Addison-Wesley, 4^{th} ed. 2008.

WAVES AND OSCILLATIONS **Credit Hours: 3(3+0)**

Objectives:

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.

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

Traveling Waves: Standing Waves in a Finite Continuous Medium, Traveling Waves in an Infinite Continuous Medium, Energy Conservation, Transmission Lines, Reflection and Transmissionat Boundaries, lectromagnetic Waves.

Wave Pulses: Fourier Series and Fourier Transforms, Bandwidth, Heisenberg's Uncertainty Principle.

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, Vol. 3, McGraw-Hill, 1968.

4. A. Hirose, and K. E. Lonngren, "Introduction to Wave Phenomena", Krieger Publications, 2003.

ELECTRICITY & MAGNETISM   Credit Hours: 3(3+0)

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.

Course Contents:

Electrostatics: Electric Charge, Conductors and Insulators, Coulomb's Law, Electric Fields due to a Point Charge and an Electric Dipole, Electric Field due to a Charge Distribution, Electric Dipole in an Electric Field, Electric Flux, Gauss' Law and its Applications.

Electric Potential: 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 Energy.

Capacitors and Capacitance: Parallel Plate, Capacitors in Series and Parallel, Energy Stored in an Electric Field, Dielectrics and Gauss' Law.

DC Circuits: Electric Current and Current Density, Resistance and Resistivity, Ohm's Law, Power in Electric Circuits, Semiconductors and Superconductors, EMF, Resistances in Series and Parallel, Kirchhoff's Rules, RC Circuits, Charging and Discharging of a Capacitor.

Magnetic Field and Magnetic Force: Hall Effect, Magnetic Force on a Current Carrying Wire, Torque on a Current Loop, Magnetic Dipole Moment, Ampere's Law, Biot-Savart Law, Magnetic Field due to Current in Solenoids and Toroids, Faraday's Law of Induction, Lenz's Law, Self and Mutual Induction. Energy Stored in a Magnetic Field.

Alternating Fields and Currents: Alternating Currents, 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.

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 d2008.

HEAT AND THERMODYNAMICS Credit Hours: 3(3+0)

Objectives:

To understand the fundamentals of heat and thermodynamics.

Course Contents:

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

Heat and Temperature: Temperature, Kinetic theory of ideal gas, Work done on an ideal gas, Internal energy of an ideal gas: Equipartition of Energy, Intermolecular forces, 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. 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, Low Temperature Physics, Joule-Thomson effect. Thermoelectricity: Thermocouple, Seabeck’s effect, Peltier’s effect, Thomson effect.

Introduction to Statistical Mechanics: Statistical distribution and mean values, Mean free path and microscopic calculations of mean free path. Distribution of Molecular Speeds, Distribution of Energies, Maxwell distribution, Maxwell Boltzmann energy distribution, Internal energy of an ideal gas.

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.

MODERN PHYSICS **Credit Hours: 3(3+0)**

Objectives:

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.

Course Contents:

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

Wace-Particle Duality: Photoelectric effect, Compton effect, production and properties of X-rays, concept of matter waves, de Broglie relationship, 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 wave function, 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.

Quantum Mechanics in Three Dimensions: The Hydrogen atom, orbitals, angular momentum and its quantization, orbital magnetism, Zeeman effect, concept of spin, Pauli's exclusion principle, Building of the periodic table, magnetic resonance and MRI, why is iron magnetic? White dwarfs, and neutron stars.
From Atoms to Molecules and Solids: Ionic bonds, covalent bonds, hydrogen bonds, molecular orbitals, how crystals are different from amorphous solids? Why and how do metals conduct electricity? Bands in solids, semiconductors, introduction to LED's and lasers, introducing grapheme.

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

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.

Calculus-I **Credit Hours: 3+0**

Specific Objectives of the Course:

Calculus is serving as the foundation of advanced subjects in all areas of mathematics. The course, equally, emphasizes the basic concepts and skills needed for mathematical manipulation. This Calculus focus on the study of functions of a single variable.

Course Outline:

Functions, upper and lower bounds of variables and functions, inverses of exponential, circular, hyperbolic and logarithmic functions, one sided and two sided limits of functions, continuity of functions and their graphical representations, properties of continuous function on closed bounded intervals, discontinuity of function and its types. Derivatives: Definition, techniques of differentiation. Derivatives of polynomials and rational, exponential, logarithmic and trigonometric functions, Inverse functions and their derivatives. The chain rule. Implicit differentiation. Rates of change in natural and social sciences. Related rates. Linear approximations and differentials. Higher derivatives, Leibnitz's theorem. Applications of derivatives: Increasing and decreasing functions. Relative extrema and optimization. First derivative test for relative extrema. Convexity and point of inflection. The second derivative test for extrema. Indeterminate forms and L'Hopitals rule. Anti-derivatives and integrals. Riemann sums and the definite integral. Properties of Integral.

Recommended Books:

- J. Stewart, Calculus (5th edition or latest edition), 2002, Brooks/Cole
- H. Anton, I. Bevens, S. Davis, Calculus: A New Horizen (8th edition or latest), 2005, John Wiley, New York
- G. B. Thomas, A. R. Finney, Calculus (11th edition or latest edition), 2005, Addison-Wesley, Reading, Ma, USA

Calculus-II **Credit Hours: 3+0**

Specific Objectives of the Course:

Analytical geometry is serving as the foundation of advanced subjects in all areas of mathematical analysis. The sequence, equally, emphasizes the basic concepts and skills needed for mathematical manipulation. As continuation of Calculus, it focuses on the study of foundation of plane and one, two dimensional geometry.

Course Outline:

Curves and their representation in cartesian, polar and parametric forms, tangents and normal, maxima, minima and points of inflection, convexity and concavity, asymptotes and curve tracing, translation and rotation of axes in one dimension, general equation of the second degree and the classification of conic sections, conic in polar coordinates, tangents and normal, rectangular coordinate system, translation and rotation of axes in two dimension, direction cosines, ratios and angles between two lines, standard forms of equations of planes and lines, intersection of planes and lines, distance between points, lines and planes, shortest distance between lines, symmetry, intercepts and sections of a surface, spherical, polar and cylindrical coordinate systems, standard form of the equations of sphere, cylinder, cone, ellipsoid, parabolid and hyperboloid.

Recommended Books:

- J. Stewart, Calculus (5th edition or latest edition), 2002, Brooks/Cole
- H. Anton, I. Bevens, S. Davis, Calculus: A New Horizen (8th edition or latest), 2005, John Wiley, New York
- G. B. Thomas, AR Finney, Calculus (11th edition or latest), 2005, Addison-Wesley, Reading, Ma, USA

Linear Algebra **Credit Hours: 3 + 0**

Specific Objectives of the Course:

This is a course in abstract linear algebra. The majority of follow up courses in both pure and applied mathematics assume the material covered in this course.

Course Outline:

Algebra of matrices, determinants, matrix of a linear transformation, row and column operations, rank, inverse of matrices, solution of homogeneous and non-homogeneous equations, orthogonal transformation. Vector spaces, subspaces, linear dependence and independence, linear span of a subset of a vector space, bases and dimensions of a vector space, sums and direct sums of subspaces of a finite dimensional vector space, dimension theorem, linear transformation, null space, image space of linear transformation, rank and nullity of a linear transformation, relation between rank, nullity and dimension of the domain of a linear transformation, matrix of linear transformation, change of basis, inner product spaces, orthogonal and orthonormal basis, similar matrices and diagonalization of a matrix, Home (V,W), dimension and basis of Home (V,W), dual space and dual basis, annihilators, Eigen values and Eigen vectors and minimal polynomials.

Recommended Books:

- S. J. Axle, Linear Algebra Done Right, Undergraduate Texts in Mathematics, 1996, Springer, New York, Schaum's outlines series
- G. Birkhoff, S. Maclane, A Survey of Modern Algebra (4th edition), AKP
- W. L. C. Perry, Elementary Linear Algebra, 1988, McGraw-Hill, New York

Ordinary Differential Equations **Credit Hours: 3+0**

Specific Objectives of the Course:

This course will provide the foundation for all advanced subjects in Mathematics. Strong foundation and applications of Ordinary Differential Equations is the goal of the course.

Course Outline:

Basic definition of differential equations, formation of differential equations, initial and boundary value problems, differential equations of the first order and first degree, equations with separable variable, homogeneous differential equations, equations reducible to homogeneous form, exact differential equations, integrating factors, rules for determinations of integrating factors, linear equations of the first order, Non-linear equations of the first order, linear differential equations of high order, solution of homogeneous linear equations, principle of superposition and Wronksian, determination of particular integral, short methods for finding particular integral, orthogonal trajectories, Cauchy-Euler equations, 2nd order linear differential equations, reduction of order method, undetermined Coefficient method, variations of parameters method.

Recommended Books:

- D.G. Zill, M.R, Cullen, Differential Equations with Boundary-Value Problems, (latest Edition), PWS Publishing Company
- D.G. Zill, Advanced Engineering Mathematics, Jones and Bartlett Publishers, 2005
- Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons (9th edition)
- G.E. Andrews, R. Askey, and R. Roy, Special Functions, Cambridge University Press