PHY-106 Mechanics

Credit Hours: 3-1

Pre-requisite: None

Course Objectives:

This is a basic course in the first semester of 4-year BS program. The main objective of this course is to understand motion of objects in various dimensions on a macroscopic scale and to develop simple mathematical formalisms to analyse such motions.

Core Contents:

Measurements, Vectors and Scalars, Motion along a straight line, Motion in 2-D and 3-D, Force and Motion, Newtonian mechanics, Frictional, Drag and Centripetal force, Kinetic Energy and Work, Work-Kinetic Energy theorem, Potential Energy and Conservation of Potential Energy. System of Particles, Center of Mass and Linear Momentum, Rotational motion, Rolling, Torque and Angular Momentum, Equilibrium and Elasticity, Gravitation and Kepler's laws, Einstein and Gravitation.

Detailed Course Contents:

Basic/Fundamental and derived quantities, SI Units, Dimensional analysis, Vectors and Scalars, Components of vectors, adding vectors by components, Multiplying Vectors, Position and Displacement in 1-D, Displacement in 1-D. Analysis of position-time graph, Average velocity and average speed, Instantaneous velocity and speed, Average acceleration and instantaneous acceleration, velocity-time graph, acceleration-time graph, Uniform Acceleration, Basic equation for constant acceleration. Free fall acceleration, Relative motion in 1-D, Position and velocity in 2-D and 3-D, Relative motion in 2-D, Qualitative and Quantitative analysis on Projectile motion, Uniform circular motion, Force, Resultant force and principle of superposition for forces, Newton's first law of motion, Inertial frames, Extracting mass for unknown object using mass of standard object, Newton's 2nd law in 1-D and 3-D, Newton's 3rd law, Gravitational force, Weight, Normal force, Friction force, Tension, Applying Newton's law, Frictional forces, Properties of friction, The drag force and Terminal speed, Centripetal force, Work done by a constant force in 1-D along with special cases, Work done by a general variable force in 1-D and 3-D, Kinetic Energy. Work-

Kinetic Energy theorem, Work done by the Gravitational force and Spring force, Power, Work and Potential Energy, Path independence of Conservative forces, determining potential energy values, Conservation of mechanical energy, Reading a potential energy curve. Work done on a system by an external force, Conservation of Energy, The Center of Mass for system of particles and solid bodies, Newton's 2nd law for a system of particles, Linear momentum for a particle and system of particles, Collision and Impulse, Conservation of Linear momentum, Elastic and Inelastic Collision in 1-D and 2-D, System with varying mass: A Rocket, Rotational variables, Rotation with constant angular acceleration, Relating the linear and angular variables, Kinetic energy of rotation, Calculating the rotational inertia, Torque, Work and rotational kinetic energy, Rolling as Translation and rotation combined, The kinetic energy of rolling, The force of rolling, The Yo-Yo, The torque (revisited), Angular momentum, Newton's 2nd law in angular form, The angular momentum of a system of particle, The angular momentum of a rigid body rotating about a fixed axis, Conservation of angular momentum, Precession of a Gyroscope, Equilibrium, The requirements of equilibrium, The center of gravity, Sample problems involving static equilibrium, Indeterminate structures, Elasticity- Tension and Compression, Shearing and Hydraulic Stress, Newton's law of Gravitation, Gravitation and the Principle of superposition, Gravitation near earth's surface, Gravitation inside earth, Gravitational potential energy, Planets and Satellites: Kepler's laws, Satellites: Orbits and Energy, Einstein and Gravitation.

Course Outcomes:

At the end of the course, the students will be able to:

- Understand the rules about how things are measured and compared.
- Understand the motion of single as well as system of particles in various dimensions.
- Know the energies as well as momentum for conservative and non-conservative systems.
- Grasp the concept of rotational motion of rigid bodies as well as rotation with translational motion.
- Understand Planets & Satellites and the Einstein approach towards Gravitation.

Textbooks:
Fundamentals of Physics, Authors: D. Halliday, R. Resnick and J. Walker (HRW), Publisher: John Wiley Sons, 9th ed., 2011.

Reference Books:
Physics for Scientists and Engineers, Author: R. A. Serway and J. W. Jewett (SJ), Publisher: Golden Sunburst Series, 8th ed., 2010.
University Physics with Modern Physics, Author: R. A. Freedman, H. D. Young, and A. L. Ford (FYF), Publisher: Addison-Wesley-Longman, 13th International ed., 2010.

Weekly Breakdown		
Week	Section	Topics
1	HRW 1.3-1.6 HRW 3.2, 3.3	What is mechanics? basic/fundamental quantities, derived quantities, SI units, basic quantities and their units used in mechanics with definitions. prefixes of SI units, changing unites, scientific notations, dimensional analysis. Why Vectors? Illustration of vector in the context of displacement, Scalars, Adding vectors geometrically in the context the context of displacement vector. Verifying the commutative and associative laws for vector addition. Opposite vector and subtraction of two vectors
2	HRW 3.4-3.8 HRW 2.1-2.6	Unit vectors, Introduction to Rectangular coordinate system, Components of vectors, adding vectors by components, Multiplying Vectors: Multiplying a vector by a scalar, Scalar product, Vector product. Motion along a straight line: Objective of physics, Motion and restrictions on general properties of motion. Position in 1-D, Displacement in 1-D. Analysis of position-time graph. Average velocity and average speed, Average velocity from position-time graph, Instantaneous velocity and speed, Average acceleration and instantaneous acceleration. velocity-time graph: Illustration of average acceleration, uniform velocity and deceleration acceleration-time graph: Illustration of uniform acceleration, uniform velocity and uniform deceleration
3	HRW 2.7-2.9 HRW 4.5, 4.6, 4.8, 4.9	Uniform Acceleration (A special case): derivation of basic equation for constant acceleration. Free fall acceleration, Relative motion in 1-D, Position and velocity in 2-D and 3-D, Relative motion in 2-D, Qualitative discussion on Projectile motion, Quantitative analysis on Projectile motion
4	HRW 4.7 HRW 5.1-5.6	Qualitative and quantitative analysis on uniform circular motion. Acceleration of non-uniform circular motion. Force and Motion-I: Why Newtonian mechanics? What is force and how to get its unit, Resultant force and principle of superposition for forces, Newton's first law of motion, Inertial frames, what is mass exactly? Extracting mass for unknown object using mass of standard object. Newton's 2nd law in 1-D and 3-D.

5	HRW 5.7-5.9	Some particular forces: Newton's 3rd law, Gravitational force, Weight, Normal force, Friction force, Tension, Applying Newton's law.
6	HRW 6.2-6.4	Force and Motion-II: Frictional forces- Static and kinetic frictional force, Mechanism of cold-welding, Properties of friction, The drag force and Terminal speed
7	HRW 6.5 HRW 7.3, 7.4, 7.5, 7.8	Uniform circular motion and centripetal force. Kinetic Energy and Work: Work done by a constant force in 1-D along with special cases. Work done by a general variable force in 1-D and 3-D, Kinetic Energy. Work-Kinetic Energy theorem
8	HRW 7.6, 7.7 HRW 8.2, 8.3	Work done by the Gravitational force, Spring force and the Work-done by a spring force, Average and instantaneous power. Potential Energy and Conservation of Energy: Work and Potential Energy, Path independence of Conservative forces.
		Midterm Exam
9	HRW 8.4-8.8	Determining potential energy values, Conservation of mechanical energy, Reading a potential energy curve. Work done on a system by an external force, Conservation of Energy, Power
10	HRW 9.2-9.7	Center of mass and Linear Momentum: The Center of Mass for system of particles and solid bodies, Newton's 2nd law for a system of particles, Linear momentum for a particle and system of particles, Newton's 2nd law in terms of linear momentum, Collision and Impulse, Conservation of Linear momentum.
11	HRW 9.8-9.12	Momentum and Kinetic Energy in Collision, Inelastic Collision in 1-D, Elastic Collision in 1-D. Collision in 2-D, System with varying mass: A Rocket
12	HRW 10.2-10.10	Rotation: Rotational variables and their directions. Rotation with constant angular acceleration, Relating the linear and angular variables, Kinetic energy of rotation, Calculating the

		rotational inertia, Torque, Work and rotational kinetic energy
13	HRW 11.2-11.12	Rolling, Torque and Angular momentum: Rolling as Translation and rotation combined, the kinetic energy of rolling, The force of rolling, The Yo-Yo, The torque (revisited), Angular momentum, Newton's 2nd law in angular form, The angular momentum of a system of particle, The angular momentum of a rigid body rotating about a fixed axis, Conservation of angular momentum, Precession of a Gyroscope.
14	HRW 12.2-12.7	Equilibrium and Elasticity: Equilibrium, the requirements of equilibrium, The center of gravity, Sample problems involving static equilibrium, Indeterminate structures, Elasticity- Tension and Compression, Shearing and Hydraulic Stress
15	HRW 13.2-13.9	Gravitation: Newton's law of Gravitation, Gravitation and the Principle of superposition, Gravitation near earth's surface, Gravitation inside earth, Gravitational potential energy, Planets and Satellites: Kepler's laws, Satellites: Orbits and Energy, Einstein and Gravitation