PHY-115 Introductory Mechanics

Credit Hours: 2-1
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 formalism to analyze 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.

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.

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.

Textbooks:
Fundamentals of Physics, Authors: D. Halliday, R. Resnick and J. Walker (HRW), Publisher: John Wiley & Sons, 10th ed., 2013.

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 1.1-1.3	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.
2	HRW 2.1-2.5	Motion along a straight line: 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 Acceleration (A special case): derivation of basic equation for constant acceleration. Free fall acceleration.
3	HRW 3.1-3.2	Why Vectors? Illustration of vector in the context of displacement, Scalars, Adding vectors geometrically. Verifying the commutative and associative laws for vector addition. Opposite vector and subtraction of two vectors. Unit vectors, Introduction to Rectangular coordinate system, Components of vectors, adding vectors by components.

4	HRW 3.3, 4.4	Multiplying Vectors: Multiplying a vector by a scalar, Scalar product, Vector product. Qualitative discussion on Projectile motion, Quantitative analysis on Projectile motion.
5	HRW 4.5 - 4.7	Qualitative and quantitative analysis on uniform circular motion. Acceleration of non-uniform circular motion. Relative motion in 1-D, Position and velocity in 2-D and 3-D, Relative motion in 2-D.
6	HRW 5.1, 5.2	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, Free body diagrams. Some particular forces: Gravitational force, Weight, Normal force, Friction force, Tension.
7	HRW 5.3 HRW 6.1, 6.2	Applying Newton's law. Newton's 3rd law. Force and Motion-II: Frictional forces- Static and kinetic frictional force, Mechanism of cold-welding, Properties of friction, The drag force and Terminal speed
8	HRW 6.3 HRW 7.1-7.3	Uniform circular motion and centripetal force. Kinetic Energy and Work: Kinetic Energy, Work done by a constant force in 1-D along with special cases, Work-Kinetic Energy theorem for a constant force. Work done by the Gravitational force.
		Midterm Exam
9	HRW 7.4-7.6	Spring force and the Work-done by a spring force, Work done by a general variable force in 1-D and 3-D, Work-Kinetic Energy theorem for a variable force. Average and instantaneous power.
10	HRW 8.1-8.3	Potential Energy and Conservation of Energy: Work and Potential Energy, Path independence of Conservative forces. Determining potential energy values, Conservation of mechanical energy, Reading a potential energy curve.
11	HRW 8.4, 8.5	Work done on a system by an external force, Conservation of Energy. Center of mass and Linear Momentum: The Center of Mass for system of particles and solid bodies, Newton's 2nd law for a

	HRW 9.1-9.4	system of particles, Linear momentum for a particle and system of particles, Newton's 2nd law in terms of linear momentum, Collision and Impulse.
12	HRW 9.5-9.9	Conservation of Linear momentum, 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
13	HRW 10.1-10.5	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.
14	HRW 10.6-10.8 HRW 11.1-11.3	Torque, Newton's second law for rotation, Work and rotational kinetic energy. Rolling, Torque and Angular momentum: Rolling as Translation and rotation combined, the kinetic energy of rolling, The force of rolling, The Yo-Yo.
15	HRW 11.4-11.9	The torque (revisited), Angular momentum, Newton's 2nd law in angular form, The angular momentum of a system of particles, The angular momentum of a rigid body rotating about a fixed axis, Conservation of angular momentum, Precession of a Gyroscope.