PHY-203 Classical Mechanics I

Credit Hours: 3-0

Pre-requisite: Mechanics

Course Objectives: It is an advanced undergraduate core course and aims to make students understand concepts of Newton's laws and its applications to single and many particles' systems problem-solving techniques, conservation theorems and their importance nonlinear systems and their phase diagrams Calculus of variations, Euler's equations and Lagrange and Hamilton formalism of mechanics.

Core contents: Review of Newtonian mechanics, Euler's Lagrange equation, Lagrange's equation with constraints, central force problem, Dynamics of a system of particles, Hamiltonian mechanics

Detailed Course Contents: Review of scalars, vectors and matrices with relation to coordinate transformation and rotation, vector calculus with examples, Newton's laws for free particles, the concept of frame of reference, problem solving techniques, motion on inclined planes, resistive forces, projectile motion, Atwood machine, motion of a particle in electromagnetic field, work, energy, angular momentum, conservation laws, system of pulleys, gravitational force and potential, comparison of gravitation and electromagnetism, equipotential surfaces, ocean tides, the functional and Euler's equation, Brachistochrone problem, geodesic, Euler's equation with several variables, constraint and Lagrange's multiplier, Hamilton's principle, generalized coordinates and Lagrange's equation, applications to several problems, central force motion, reduced mass, conservation theorems-first integral of the motion, equation of motion, orbits in a central field, centrifugal energy, Kepler's problem, stability of circular orbits, dynamics of a system of particles, center of mass and linear momentum for system of particles, angular momentum and energy of a system, elastic collisions in the laboratory and center of mass frames, inelastic collisions, coupled oscillations and normal modes, rotating coordinate systems, planer motion, inertial tensor, axes of inertia, Eulerian angles, Euler's equations for a rigid body, symmetric top, stability of rotating rigid body, Hamiltonian mechanics, the basic variables, Hamilton's equation for one dimensional systems, Hamilton's equations in several dimensions, ignorable coordinates, Lagrange equations vs. Hamilton's equations, phase-space orbits, Liouville's theorem

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

- how to apply Newton's laws to solve various problems
- basic concepts about the phase diagrams for chaotic systems
- advantages of using Lagrangian and Hamiltonian approach for certain problems.

Textbooks:

Stephen T. Thornton and Jerry B. Marion, Classical Dynamics of Particles and Systems, 5th edition, Cengage learning, 2003 (referred as MT)

John R. Taylor, Classical Mechanics, University Science Books, 2005 (referred as JT)

Reference Books:

Herbert Goldstein, Charles Poole, John Safko, Classical Mechanics, 3rd ed. Pearson, 2001

Weekly Breakdown		
Week	Section	Topics
1	MT. 1.1-1.3, 1.8-1.17	Review of scalars, vectors and matrices with relation to coordinate transformation and rotation, vector calculus with examples
2	MT 2.1-2.4	Newton's laws for free particles, the concept of frame of reference, problem solving techniques, motion on inclined planes, resistive forces, projectile motion, Atwood machine, motion of a particle in electromagnetic field
3	MT 2.5-2.6,	Work, energy, angular momentum, conservation laws, system of pulleys
4	MT 6.2, 6.3	The functional and Euler's equation, Brachistochrone problem
5	MT 6.5-6.7, 7.2	Geodesic, Euler's equation with several variables, constraint and Lagrange's multiplier, Hamilton's principle
6	MT 7.3, 7.4	Generalized coordinates and Lagrange's equation, applications

		to several problems
7	MT 7.5-7.9	Lagrange's equations with constraints, equivalence to Newton's laws, conservation laws revisited
8	MT 8.2-8.5	Central force motion, reduced mass, conservation theorems-first integral of the motion, equation of motion, orbits in a central field
		Midterm Exam
9	MT 8.6, 8.7, 8.10	Centrifugal energy, Kepler's problem, stability of circular orbits
10	MT 9.1-9.5	Dynamics of a system of particles, center of mass and linear momentum for system of particles, angular momentum and energy of a system
11	MT 9.6-9.8	Elastic collisions in the laboratory and center of mass frames, Inelastic collisions
12	MT 10.1, 10.2, 11.1-11.8	Rotating coordinate systems, planer motion, inertial tensor, axes of inertia, Eulerian angles
13	MT 11.9-11.12	Euler's equations for a rigid body, symmetric top, stability of rotating rigid body
14	JT 13.1-13.4	Hamiltonian mechanics, the basic variables, Hamilton's equation for one dimensional systems Hamilton's equations in several dimensions, ignorable coordinates
15	JT 13.5-13.7	Lagrange equations vs. Hamilton's equations, phase-space orbits, Liouville's theorem