CLASSICAL MECHANICS: FROM NEWTONIAN TO LAGRANGIAN FORMULATION

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TYPE OF COURSE : Rerun | Elective | PG
COURSE DURATION : 12 weeks (26 July 2021 - 15 Oct 2021)
EXAM DATE : 24 Oct 2021

INTENDED AUDIENCE : UG students from various degree and engineering colleges

COURSE OUTLINE :

This course deals with fundamentals of classical mechanics. Mechanics is one of the core subjects for physics and engineering disciplines. This course starts from basics of Newtonian mechanics. Then we introduce rigid dynamics and finally Lagrangian formulation of dynamics followed by small oscillations. We also offer tutorials to develop problem solving skills. We aim to give a basic understanding of various fields of classical mechanics to our students.

ABOUT INSTRUCTOR :

I am an Assistant Professor at department of physics, IIT Kharagpur. I am taking classical mechanics for 2nd year UG students of the department for past 3 years.

COURSE PLAN :

Week 1: 1. Review of basic Newtonian mechanics, kinematics problems 2. Motion under resistance: terminal velocity 3. System with variable mass: Rocket, raindrop, etc.

Week 2: 1. Central forces: plane polar co-ordinate system 2. 2-body central force problem, general equation of the orbit 3. Kepler's laws of planetary motion

Week 3: 1.Effective potential of central force, 2. Escape velocity, eccentricity of the orbit under various initial conditions 3. Satellite, Ballistic missile and orbit transfer

Week 4: 1.Moving co-ordinate system: pseudo forces 2. Coriolis and centrifugal force, Foucault's pendulum 3. Introduction to system of particles

Week 5: 1.Dynamics in center of mass frame, introduction to rigid body 2. Degrees of freedom (DOF) and constrains 3. Rotational dynamics of rigid body, moments of inertia tensor

Week 6: 1.Principle moments of inertia, ellipsoid of inertia, parallel and perpendicular axis theorem 2. Euler's equation of rigid body rotation under external torque 3. Torque free motion of spherical, symmetric and asymmetric top

Week 7: 1.Introduction to Euler angles, pitch, precession and nutation 2. The heavy symmetric top, the energy equation 3. Special case of 'fast' and 'sleeping' top

Week 8: 1.Lagrangian dynamics: Forces of constrain, virtual displacement 2. Principle of virtual wok and D'Alembert's principle 3. Generalized co-ordinates, Lagrange's equation of 1st kind, Lagrange's undetermined multiplier

Week 9: 1.Generalized velocity and force, Lagrange's equation of 2nd kind, Lagrangian 2.Classification of constrains, Lagrange's equations for non-holonomic systems 3. Dissipation and gauge function, most general form of Lagrange's equation, review of rigid body including heavy symmetric top

Week 10: 1.Variation principle, calculus of variation 2. Principle of least action and Lagrange's equation from it 3. Application of variation principle (catenary, geodesic, etc.)

Week 11: 1.Small oscillation: Introduction to coupled systems, normal modes 2. Types of equilibrium, Kinetic and potential energy of a coupled system, expression of energy in matrix form 3. Equation of motion of a coupled system, normal frequencies , eigenvalues and eigenvectors of K.E. and P.E. matrices

Week 12: 1. Diagonalization of K.E. and P.E. matrices 2. Normal modes of oscillation, 3. Examples (linear molecules, spring mass systems etc.)