SHIV NADAR UNIVERSITY

UNDERGRADUATE COURSE PROPOSAL – MONSOON 2022

I. **COURSE TITLE: CLASSICAL MECHANICS**

II. **COURSE CODE: PHY301**

III. **COURSE CREDITS (L:T:P) : 3:1:0**

IV. **TOTAL CONTACT HOURS/ BATCH/WEEK (L:T:P) : 3:1:0**

V. **NO. OF BATCHES : 1**

VI. **COURSE TYPE (MAJOR/UWE/CCC/REAL/VELS/IC) : MAJOR/UWE**

VII. **PREREQUISITE/S (IF ANY) : PHY101** OR **PHY103** [***Needs to Pass in one of these***]. **Also Preferred :** PHY203 (Basic Mathematical Physics) & PHY102/PHY104 (Basic Electromagnetism), *or equivalent*.

VIII. **COURSE COORDINATOR/INSTRUCTOR(S) : Dr. SUBHRA SEN GUPTA (Course Instructor) & ZUBAIR NABI (Teaching Assistant)**

IX. **SCHOOL/DEPARTMENT : School of Natural Sciences/Department of Physics.**

X. **DISCIPLINES TO WHICH THE COURSE MAY BE OF INTEREST :** Physics, Engineering (some branches like Mechanical), Computer Science, Mathematics.

XI. **COURSE CONTENT:**

Overview

This Course follows up the developments in PHY103 (which deals mainly with Classical Newtonian Mechanics, based mainly on solving Newton's differential equation of Motion in various circumstances) with a more formal, unified and advanced approach to Mechanics, or what is formally known as Analytical Mechanics, which allows a smooth transition to Quantum Mechanics later. It starts with a very basic and physical introduction to the ***Principle of "Least" Action****, which is the backbone of not only Mechanics but also various other advanced branches of Physics, like Quantum Mechanics (Path Integral Formulation), Statistical Physics and Field Theory. It then formalizes this approach, via the principles of the Calculus of Variations, to the Lagrangian Formulation of Classical Mechanics that results in the Euler-Lagrange equations of Motion, that is formally equivalent to Newton's Laws. The Lagrangian for various systems is then discussed, before delving into the various Conservation laws and culminating into Noether's Theorem. Next it deals with the integration of these Equations of Motion in various situations like the Central Field problem and Kepler's Laws.*

Here, before dealing with more sophisticated applications, it introduces the alternate Hamiltonian formulation of Mechanics and the Canonical equations, and many important advanced concepts like the Routhian, the Poisson Brackets, the Hamilton-Jacobi (H-J) equation, the concept of Adiabatic Invariants etc.

In the last part of the course, it comes back to more advanced applications of the methods already learnt. First it deals with the problem of Small Oscillations and the decoupling of the motion of a complex/composite vibrating body into various basic modes in terms of which any eigen-oscillation of the system may be written, for small displacements about equilibrium, and applies it to various situations. Next it deals with the problem of rigid body dynamics, rotations etc. introducing the concept of the moment of Inertia tensor etc. and culminating in the derivation and solution of Euler's equations for the motion of a rigid body, applying it to the problem of the symmetric and asymmetric tops.

*The detailed syllabus is given below. More Advanced Topics marked with a "*****" are optional and will only be covered if time permits.*

Detailed Syllabus

1. **Starter :** ***A Beginner's Introduction to The Principle of "Least" Action.***

2. **The Equations of Motion : The Variational Principle and The Lagrangian Formulation**
   - Generalized Coordiantes
   - The Principle of "Least" Action and the Euler-Lagrange Equations
   - Galileo's Relativity Principle
   - The Lagrangian for a Free Particle
   - The Lagrangian for a System of Particles

3. **Conservation Laws**
   - Energy
   - Momentum
   - The Centre of Mass
   - Angular Momentum
   - Mechanical Similarity*
   - Symmetry and Conservation Laws : Noether's Theorem*

4. **Integration of the Equations of Motion**
   - Motion in One Dimension
   - Determination of the Potential Energy from the Period of Oscillation
   - The Reduced Mass
   - Motion in a Central Field
   - Kepler's Problem

5. **The Canonical Equations : The Hamiltonian Formulation of Mechanics**
   - Hamilton's Equations
   - The Routhian
   - Poisson Brackets
   - The Action as a Function of the Coordinates
   - Maupertuis's Principle
   - Canonical Transformations
   - Liouville's Theorem
   - The Hamilton-Jacobi Equation
   - Separation of the Variables
   - Adiabatic Invariants
   - Canonical Variables
   - Accuracy of the Conservation of the Adiabatic Invariant*
   - Conditionally Periodic Motion*

6. **Small Oscillations**
   - Free Oscillations in One-Dimension
   - Forced Oscillations
   - Oscillations of Systems with More than One Degree of Freedom : Normal Modes
   - Damped Oscillations
   - Forced Oscillations under Friction
   - Parametric Resonance*
   - Vibrations of Molecules*
   - Anharmonic Oscillations*

7. **The Motion of a Rigid Body**
   - Angular Velocity
   - The Inertia Tensor
   - Angular Momentum of a Rigid Body
   - The Equations of Motion of a Rigid Body
   - Eulerian Angles
   - Euler's Equations, The Symmetric Top & The Asymmetric Top*
   - Motion in a Non-inertial Frame of Reference*

XII. TEXT BOOK(S) & REFERENCES :

1) ***Mechanics (Course of Theoretical Physics: Vol. 1, 3rd Edition)* : L.D. Landau & E.M. Lifshitz.**
2) ***Classical Mechanics, 3rd Edition* : H. Goldstein & Charles P. Poole.**
3) ***The Feynman Lectures on Physics (Vol. 1* and Parts of *Vol. 2*) : R.P. Feynman, R.B. Leighton & M. Sands**
4) ***Classical Dynamics - A Contemporary Approach* : Jorge V. José and Eugene J. Saletan.**
5) ***Various Lecture Notes and Other Online Resources that will be mentioned from time to time.***

XIII. ASSESSMENT SCHEME :

(Passing criteria: ≥ 34% (*absolute*) or "40% of Highest Score" (*relative*), as relevant.**)**

Component	Weight
Group Presentations (1) (Spread over the Semester)	*10*
Quizzes (2) (September & November)	*2 x 15 = 30*
Mid-Term Examination (1) (October)	*30*
End-Term Examination (1) (December)	*30*

(*As per SNU guidelines,* ***85% Attendance is mandatory*** *to appear in the exams and complete the course.*)