First Hand Out, PHY401 : 2024-25 Semester I

Instructor : Tapobrata Sarkar (tapo@iitk.ac.in).

Objectives : The objective of this course is to prepare the student for professional level physics skills in Classical Mechanics. This course will involve problem based discussion on essential concepts of Classical Mechanics, leading to the understanding of its fundamental working principles and ideas. At the end, the student will have developed and understood the necessary tools that are required for the applications of Classical Mechanics methods to various real life problems. Basic familiarity with UG level mechanics will be assumed.

Syllabus : The prescribed syllabus is as follows :

Review of Newton's laws of motion, Galilean transformations, Frames of reference and pseudo-forces. Symmetries in Newton's laws, Lagrangian formulation, Configuration space. Calculus of variations, Hamilton's principle of least action, Euler-Lagrange's equations, Conserved quantities and Noether's theorem*. Small oscillations and normal modes, Anharmonic oscillators. Resonances in harmonic and anharmonic oscillators*, Parametric resonance. Secular (regular) perturbation theory*, Lindstedt-Poincare method. Rigid body dynamics. (About 19 Lectures)

Fixed points and linear stability analysis*, Limit cycles*, Flow on a torus and quasi-periodicity*, Qualitative discussion of Poincare-Bendixon theorem (no chaos in 2D autonomous flow). Legendre transformation, Hamiltonian formulation, Phase plane, Integral invariants, Symplectic area conservation, (Generalized) Liouville's theorem, Poincare recurrence theorem, Modified Hamilton's principle. Canonical transformations, Infinitesimal canonical transformations, Poisson brackets, Active view versus passive view of canonical transformations. Principle of varying action and Hamilton-Jacobi theory, Optico-mechanical analogy, Action-angle variables*. (About 18 Lectures)

Lorentz system, Chaotic attractor, Lyapunov exponents*. Qualitative discussion of non-integrability and chaos in Hamiltonian systems. (About 4 Lectures).

Topics with a * are essential for PHY402A.

Mode of instruction : As per website, class timings are Tuesday, Friday 12 noon -13:15 p.m and tutorial is Wednesday 12 noon – 12:50 p.m. Class venue is L7.

Books : Landau-Lifshitz, Goldstein, Jose-Saletan, Percival-Richards are the standard books. For parts related to non-linear dynamics, Strogatz will be followed. The discussions in class will be self-contained.

Home work : One problem sheet per one/two weeks consisting of about 8 – 10

problems will be given and some of these will be solved in the tutorial sessions. The student is expected to solve all problems of all sheets.

Attendance : You are strongly encouraged to attend all classes and tutorials. Digital attendance will be taken at 12:06 p.m.

You are **very strongly** encouraged to ask as many questions as possible in class.

Evaluation : Mid Sem 40 marks, end sem 60 marks and 2 quizzes of 10 marks each (one before mid sem and one before end sem), all with uniform weightage. Total marks : 120. Pass cut off is 30 percent, i.e. 36 marks out of 120. There is no separate marks for home works.

Unfair means : We follow a zero tolerance policy for unfair means and anyone found doing this in exams will be immediately de-registered from the course.

Important :

Please note that doors will be closed at 12:05 p.m after which entry is not allowed.

Electronic devices such as cell phones, tablets, laptops etc. are to be strictly kept in the off mode throughout the duration of all lectures/tutorials unless specifically asked by the instructor.

Please note that texting/messaging or engaging in any type of social media activity during class/tutorial/exam is considered a serious offence as a matter of course policy and will attract a penalty of 10 marks per incidence.