CLASSICAL MECHANICS (Phys 501, fall 2010, Mo We Fr 9.35 – 10.30 in P112).

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Classical mechanics has always been used to describe the motion of point particles and rigid bodies, but more recently it has also become an active field of research into nonlinear problems. This course will on the one hand give a systematic introduction to the standard subjects of classical mechanics, but in the second part of the course we also discuss more modern approaches such as geometrical aspects and nonlinear dynamics. Due to lack of time we do not discuss elasticity theory, nor special relativity (which anyhow is discussed in courses on electromagnetism) and only a bit of rigid body theory.

We BEGIN this graduate course with what might be considered the fundamental concepts of classical mechanics [1]: the Lagrangian and Hamiltonian approaches, various variational principles, Euler-Lagrange equations, canonical transformations, and Noether's theorem about the connection between conserved quantities and symmetries. For fun, and also to learn to calculate, we shall work through some time-honored simple examples: the brachistochrone of Bernouilli, Kepler orbits without and with precession, stability of orbits, motion in rotating frames, and the basics of lots of pendula (the linear, nonlinear, spherical, conical, physical, damped, driven, sliding, spring, upside-down, double, two coupled).

Next we show that the Lagrangian approach is equivalent to Newton's equations provided one assumes the principle of Bernouilli-D'Alembert and introduces Lagrange multipliers. We shall calculate the reaction forces in a few cases, but we shall not emphasize this part of the course.

After that we study the theory of small oscillations. This is not a subject of deep theoretical meaning but it is very important for applications of which we give a few. We also discuss the basics of rigid bodies.

The rest of the course focuses on more modern developments [2]. We study three models which display classical chaos: the double pendulum, the nonlinear pendulum, and the driven anharmonic oscillator.This leads to Poincare' sections, attractors, separatrices, etc. Then we study fluid mechanics (its stress tensor) and the Navier-Stokes equations, the equation of Burgers, and basics of turbulence. Finally we discuss Hamilton- Jacobi theory, symplectic geometry, and Dirac's formalism for constrained Hamiltonian systems (" Dirac brackets").

The requirements for the course are a course in classical mechanics at the undergraduate level, in particular some familiarity with Lagrangian methods [3].There is homework every week and at the end a written and an oral exam. The grade will be based on these exams, and to a lesser extent on the homeworks.

LITERATURE:

[1] H. Goldstein, Classical Mechanics, SECOND edition (this is the main book we follow)
[2] J.V.José and E.J.Saletan, Classical Dynamics, a contemporary approach (advanced)
[3] L.N. Hand and J.D.Finch, Analytical Dynamics (intermediate, to freshen up your Lagrangian methods)

A list of other books from which we sometimes borrow, will be handed out in class.