Fall 2012: PHYC54 Classical Mechanics

Course Information:

Instructor: Dr. Salam Tawfiq

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Lectures and/or Tutorials: MO (IC-328) and WE (BV-365) both at 11.00-13.00

Office Hours: MO: 12:30-13:30 PM and by appointment

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and the Access*ability* Services at UTSC as early as possible in the term. They will determine reasonable accommodations for this course.

Textbook:

One of;

"Classical Mechanics", John R. Taylor (University Science Books, 2005)

"Classical Dynamics of Particles and Systems", S. T. Thornton and J. B. Marion (Holt Rinehart & Winston)

Motivations and objectives:

Though classical mechanics has been superseded by relativistic mechanics and quantum mechanics, there is still a large class of interesting phenomena where classical mechanics provides an accurate and complete description. Furthermore, the physical and mathematical tools used in the study of classical mechanics are indispensable for study of physics in general, and especially for the non-classical mechanics that invalidated or extended the principles of classical mechanics.

In Newton's view, our universe is entirely mechanical and deterministic, like a giant clock. To describe deterministic motions, Newton invented calculus. In this class we will review the kinematics and dynamics of single particles. Even in this simple case, complications can arise due to motion in a nontrivial potential, in a non-inertial reference frame or being constrained, as we will explain. The general principle of least action, or Lagrangian and Hamiltonian dynamics, will be presented in detail. These formulations are particular powerful when deal with systems subjected to various constraints. You will appreciate the connection between symmetry and conservation laws. The complexity of motion increases significantly once the interactions between the particles are introduced. We will spend some time studying systems consisting of two particles, such as planetary motions and coupled harmonic oscillators. In a straightforward manner we can generalize our learning of two-particle systems to understand physics of many particles. Here two broad classes of systems can be specified; one concerns with rigid body motions and the other concerns with deformable bodies. These are generally called continuous media, which allow additional degrees of freedom, such as rotation and wave propagation, to exist. If time permits, we will devote some times to address this important subject or at least part of it. It should be noted, as you already know, that though Newtonian mechanics is beautiful and full of predictive power, modern physics showed that such a world of view is incomplete.

The main objective for this course is three fold; first, to provide the students with a strong background in the technics of classical mechanics at an intermediate level. Second, to introduce the mathematical and computational techniques for setting up and solving differential equations to determine the motion of particles and rigid bodies. Finally, to help students explore the interplay between Physics and Math through the beauty of physics conservative laws.

It is hard to find a single textbook that covers all the topics in a complete fashion. Therefore, we will be switching between two textbooks "Classical Dynamics of Particles and Systems," 5^{th} edition, by Marion and Thornton and "Classical Mechanics" by Taylor depending on the topic. You can get any of them, and in any case, I will provide lecture notes to cover the other. Check both and get the one you feel more comfortable with. There are a number of good reference books, such as "Classical Mechanics" by Joel A. Shapiro, Classical Mechanics by Herbert Goldstein and "Mechanics" by Landau and Lifshitz, which are available in the library. There will be homework assignments almost every week and students are required to complete the homework on time. Each day of delay, will be a 15% of reduction in the score. Altogether there will be one (or two) midterm tests and one final. Final grade for the course shall be determined by; your score in the homework (30%), the midterm (25%), and the final (40%). There is a 5% for class participation.

Topics Covered:

While all of you have already taken a mechanics class, we will cover the material at a more sophisticated level and introduce new techniques that are also widely used in quantum mechanics and other advanced physics classes. The most important skill you will get from the class is the ability to use advanced mathematics to describe physical phenomena and to interpret mathematical results in physical terms. A tentative schedule (*subject to change*) is given below:

I. Newtonian Mechanics — Review of Single Particle Dynamics

- Newton's Laws (Newton's First Law, Second Law, and Third Law)
- Conservation Theorems
- impulse and linear momentum
- torque and angular momentum
- work and kinetic energy

- conservative forces and potential energy

II. Central-Force Motion

- Velocity and Acceleration in Polar Coordinates
- Potential Energy and Angular Momentum in a Central Field
- Orbit of a Particle in a Central Field
- Kepler's Laws of Planetary Motion
- Motion in an Inverse-Square Repulsive Field

III. Lagrangian Mechanics

- Principle of stationary action
- Lagrange Equations
- Hamilton's Principle
- Coordinate transformations and rigid constraints
- Total-time derivatives and the Euler-Lagrange operator

IV. Hamiltonian Mechanics

- Hamilton's equations
- Legendre transformation
- Hamiltonian action and Poisson brackets
- Phase space reduction
- Evolution in phase space and Liouville theorem

V. Motion in a Non inertial Reference Frame

- Rotating Coordinate Systems
- Centrifugal and Coriolis Forces
- Effects of the Earth's Rotation, the Foucault Pendulum
- Inertia Tensor and Angular Momentum

Good Luck