Syllabus for Physics 1331, Mechanics for Undergraduates

(Aug. 20, 2012)

Classical mechanics is one of the earliest and the well-established fields of physics. It is inconceivable that one can study more advanced subjects, such as quantum mechanics, statistical physics, and electromagnetism, without a solid background in classical mechanics. The subject also allows students to learn and practice mathematical methods that are commonly used in physics, such as vector calculus, variational principles, Fourier methods, and stability analysis.

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 start with the study of 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. The general principle of least action, or Lagrangian and Hamiltonian dynamics, will be presented. These formulations are particular powerful when deal with systems subjected to various constraints. The complexity of motion increases significantly once the interactions between the particles are introduced. We will spend considerable time studying systems consisting of two interacting particles, such as planetary motions, particle collisions, and coupled harmonic oscillators. We will 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 motion and wave propagation, to exist. We will devote some times to address these important subjects. It should be noted that though Newtonian mechanics is beautiful and full of predictive power, modern physics showed that such a world of view is incomplete. The problem stems from the fact that many natural phenomena are tainted by noise. Such noise can be a result of quantum fluctuations via the Heisenberg uncertainty principle or thermal fluctuations, known as the $k_B T$-effect. Remarkably, due to the pioneering work of E.N. Lorenz, we now know that nonlinear interactions among the constitutive parts of a system can generate noise itself and thus spoil deterministic behavior of a classical mechanical system. This last effect, known in popular literature as chaos, greatly expands the scope of classical mechanics and forms a vibrant field of current research. We wish to touch upon this fascinating subject as well.

We will use the textbook "Classical Dynamics of Particles and Systems," 5th edition, by Marion and Thornton. The text book has fourteen chapters. Except for the last one on special theory of relativity, all other chapters in the book will be covered. There are a number of good reference books, such as "intermediate Dynamics" by Patrick Hamill and "Mechanics" by Landau and Lifshitz, and they are readily available in the library. There will be homework assignments each week and students are required to complete the homework on time. Each day of delay, without a legitimate excuse, will be a 15% of reduction in the score. Altogether there will be three exams, two midterms and one final. Your final score for the course will be determined by the homework (20%), the midterms (20%x2), and the final (40%).

There will be two office hours per week, and it is tentatively scheduled on Monday and Wednesday after the lectures, from 11:00-12:00. Here is my contact information: 408 Allen Hall, 4-0873, xlwu@pitt.edu.

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, (412) 648-78901(412) 383-7355 (TTY), as early as possible in the term. DRS will verify your disability and determine reasonable accommodations for this course.

A tentative reading schedule (*subject to change*) is given below:

Week 1 8/27-8/31	Vector Calculus 1.1-1.17	
Week 2 9/3-9/7	Newtonian Mechanics of Single Particles 2.1-2.7 (Labor day, no lecture on Mon.)	
Week 3 9/10-9/14	Dynamics of Many Particles 9.1-9.5	
Week 4 9/17-9/21	Dynamics of Many Particles 9.1-9.5	
Week 5 9/24-9/28	Oscillations 3.1-3.8	(1st mid term)
Week 6 10/1-10/5	Oscillations 3.1-3.8	
Week 7 10/8-10/12	Non-Linear Oscillations and Chaos 4.1-4.7 (Break, shift Mon. class to Tue.)	
Week 8 10/15-10/19	Non-Linear Oscillations and Chaos 4.1-4.7	
Week 9 10/22-10/26	Gravitation 5.1-5.2	(2nd mid term)
Week 10 10/29-11/2	Methods in the Calculus of Variations 6.1-6.7	

Week 11 11/5-11/9	Hamilton's Principle 7.1-7.5
Week 12 11/12-11/16	Hamilton's Principle 7.6-7.11
Week 13 11/19-11/23	Central-Force Motion 8.1-8.8
Week 14 11/26-11/30	Dynamics of a System of Particles (Scattering Problems) 9.6-9.10
Week 15 12/3-12/7	Motion in a Noninertial Frame 10.1-10.4
Week 16 12/10-12/15	Final Study Week