Physics 411T: Classical Mechanics

Fall 2010

Location: TPL 114
Time: F 1:10-2:25pm
Office Hours: by appointment

Instructor: Dr. Frederick W. Strauch
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Required Text: *Classical Mechanics* by John R. Taylor

Recommended: Computer with *Mathematica*

Suggested Reading: *Synch* by Steven Strogatz, *Variational Principles of Mechanics* by Cornelius Lanczos

Course Overview

Classical Mechanics is a tutorial study of advanced theoretical and computational approaches to Newtonian and Lagrangian mechanics. While nearly all of the methods studied in this course existed at the end of the nineteenth century, they form the bedrock of modern theoretical and experimental physics, central to the design and operation of particle accelerators and satellite observatories, our main tools to study the smallest and largest structures of the universe.

The focus of this course (and Taylor's text) is the development and application of the *Lagrangian approach*. This method is incredibly powerful, and while fully equivalent to Newton's laws of motion, it too plays a central role in particle physics and cosmology: the *action principle* underlies all of modern field theories. Furthermore, it was through Feynman's *path integral formulation* of quantum mechanics in the mid-twentieth century that the Lagrangian's importance was fully appreciated.

There are four main topics that form the outline of this course. First, we will review the Newtonian methods familiar from introductory physics, here in fully three-dimensional problems and with dissipation. Special attention will be given to nonlinear and chaotic systems. In the second part, we will introduce a powerful theoretical tool, the calculus of variations, and its application to motion, known as the Lagrangian and Hamiltonian formulations of mechanics. The third part of this course will apply the Lagrangian method to systems with central forces, rotating frames and bodies, coupled oscillators, and colllisions. Finally, we will explore advanced topics from both the text and beyond.

Course Goals

At the end of this course, you will be able to identify multiple paths to solve for the dynamics of simple and complex systems, including approximations, numerical methods, and even qualitative approaches to differential equations. As a tutorial, you will gain experience in mastering and presenting material learned independently (and in collaboration), in and outside of the textbook. Correspondingly, the scheduled lectures will not cover all topics to be discussed in tutorial sessions or studied in the problem sets. This time will usually consist of a general outline, and often followed by alternatives to the textbook material, special techniques for certain problems, and sometimes new approaches discovered in the preceding week's tutorial sessions.

Grading

Much of your final assessment will be based on performance during the tutorial sessions. Attendance at these sessions is mandatory---if you anticipate being unable to attend a session (for a good reason), please contact me well in advance. Other components of the course are written work to be turned in every week, and a final take-home exam.

Graded Work	**Grading Weight**
Tutorial Session	30 %
Homework	35 %
Final Exam	35 %

Late policy: Problem sets will be due each Friday at the lecture. In general, and due to the pace of this course, late homework will not be accepted.

Guidelines for the tutorial session: The primary goal of the session is to foster effective communication about physics. Therefore, you should feel free to bring questions you have about the topic and the problem set for that week. However, you should have attempted almost every problem (> 75%) of a given problem set before the session, and be prepared to discuss potential solutions.

Course Outline and Schedule

Week	**Dates**	**Topic / Chapter**
1	Sept. 10	Projectiles and Charged Particles (Chapters 1 and 2)
2	Sept. 17	Energy (Chapter 4) and Oscillations (Chapter 5)
3	Sept. 24	Nonlinear Mechanics (Chapters 5 and 12)
4	Oct. 1	Calculus of Variations (Chapter 6)
5	Oct. 8	Lagrange's Equations (Chapters 6 and 7)
6	Oct. 15	Hamiltonian Mechanics (Chapter 13)
7	Oct. 22	Extra lecture due to reading days / Mountain Day
8	Oct. 29	Two-Body Central-Force Problems (Chapter 8)
9	Nov. 5	Mechanics in Noninertial Frames (Chapter 9)
10	Nov. 12	Rotational Motion of Rigid Bodies (Chapters 9 and 10)
11	Nov. 19	Coupled Oscillators and Collision Theory (Chapters 11 and 14)
12	Dec. 3	Field Theory and Independent Topics
13	Dec. 10	Wrap-up
Final	Dec. **15**	Final Exam

Note that the date indicates the initial lecture; the tutorial sessions will be during the following week. However, two weeks (indicated by the *) will have no tutorial sessions: week 6 (Oct. 12-13, due to the reading days), and week 12 (Nov. 23-24). Note also that Mountain Day will occur in October (not necessarily Oct. 15); expect to be flexible for this and the surrounding lectures.

Honor Code

Every work that is done by you and your fellow students is subject to the honor code. Note that the honor code is not just about cheating: all activities in class are to be undertaken with honesty and integrity. However, this should not be pursued at the expense of learning. Your peers are a great resource, and you are greatly encouraged to discuss this class and all assignments (with the exception of the final exam) with your fellow students. However, all submitted work must be your own. Significant collaboration with others should be acknowledged. If in doubt, contact me with your question.

Final Disclaimers

All contents of this syllabus are subject to revision by the instructor. While physics is not usually a politically charged topic, passionate discussion may occasionally occur. Please do not take any perceived offense personally, and please see me if you have any concerns.