

Physics 351: Advanced Classical Mechanics

Spring 2013

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Physics 351	Room	Time
Lecture	Eaton 105	11:15-12:10 MWF

Required Text

- John R. Taylor, *Classical Mechanics* (University Science Books, 2004)

Recommended Texts

- Seymour Lipschutz, Murray R. Spiegel, and John Liu, *Mathematical Handbook of Formulas and Tables* (Addison-Wesley) in the Schaum's Outlines Series.
- Vernon D. Barger & Martin G. Olsson, *Classical mechanics: A modern perspective* (McGraw-Hill series in fundamentals of physics)
- Don S. Lemons, *Perfect Form: Variational Principles, Methods, and Applications in Elementary Physics* (Princeton University Press, 1997)
- Arnold Sommerfeld, *Mechanics: Lectures on Theoretical Physics Vol. I* (Academic Press, 1952) (Out of print)
- Herbert Goldstein, Charles Poole, and John Safko, *Classical Mechanics* (Addison-Wesley)
- L. D. Landau & E. M. Lifshitz, *Mechanics: Course of Theoretical Physics Vol. 1* (Butterworth-Heinemann, 1996)

Objectives

The objectives for this course are for students to obtain a working knowledge of the principles and concepts of classical mechanics. Students should be able to apply these principles to problems stated in plain English.

About Physics 351

Classical mechanics may seem old and dusty. It is anything but that! Classical mechanics was the “theory of everything” from the time of Newton until the advent of Maxwell’s electromagnetic theory around 1860 and is still the foundation of physics. Classical mechanics is still extremely useful: no one would use quantum mechanics—thought to be the correct fundamental mechanical theory—to design an automobile engine or compute the orbits of a planet around the sun. Quantum mechanics is far more difficult to use in such situations and its predictions will not differ much from those of classical mechanics.

Nearly all of our concepts in modern physics trace their lineage back to classical mechanics. Classical mechanics is far more than just Newton’s laws of motion; there are deep mathematical mysteries lying within Newton’s laws that connect to optics and lead directly to quantum mechanics and the most advanced theories of modern physics. We will start with Newton’s laws for linear motion and proceed on to motion in two or more dimensions. We will prove in detail many of the results that were merely argued for in introductory physics. Within a few weeks we should be looking at things only hinted at in introductory physics: variational principles, the two-body problem, motion in accelerated frames, rigid body motion, Hamiltonian mechanics, and continuum mechanics.

This class satisfies both goal 3 (quantitative reasoning) and goal 4 (scientific inquiry).

Office Hours

Initially office hours will be Wednesday 2:00 - 3:00 pm and Friday 2:00 - 3:00 pm and by appointment. If these hours are inconvenient for you, please tell me and I'll try to find some more convenient times. You may stop by any time to see if I am free, but if my door is closed, it is likely that I am busy.

Time Requirements

In addition to three lectures a week, students should expect to spend five to ten hours per week on studying and homework.

Attendance Policy

Attendance is not required but spotty attendance will result in a low participation score in the final grade.

Late Policy

Late work will not be accepted without prior approval. Approval will not be granted without a sufficient reason.

Grading

Grades in this class will be based on the following elements.

- **Participation** I expect each student to attend all classes, to do the assigned readings and problems, to bring questions and comments to class, and to participate in class discussions. Some of the lecture material will not be in the text, so it is important that students attend lecture. The grade for participation will be assigned at my discretion at the end of the semester.
- **Homework** Homework will be assigned on a regular basis and collected, roughly one assignment per week. I reserve the right not to give credit for late homework assignments, based on the belief that keeping up is an essential ingredient for success in the course. You may work together on the homework. Indeed, I encourage you to work together to understand the problems. However, you must each separately write up solutions in your own words (and equations) and may not turn in something that you do not understand. (That is, you may not simply paraphrase someone else's solution as your own.) Paraphrasing without understanding, or outright copying, will be considered plagiarism.
- **Exams** There will be two mid-term exams and a final exam. The final will be comprehensive. The period for the final exam as set by the Registrar is Sunday May 12 at 1:30 pm. In the past I have given take-home exams exclusively, and I anticipate continuing this policy.
- **Quizzes** There may be quizzes in class, mostly for your own diagnostic use. Any quizzes will be announced in advance and will count towards your participation grade.

The relative weights of each element of the grade for the course is as follows.

Element	Weight
participation	10%
homework	30%
hour exams	30%
final exam	30%

Disability Accommodations

Students with a documented disability for which they may need accommodations should self-identify and register for services with Mr. David Silver (x3351), the Coordinator of Disability Services at the CTL. Accommodations and services will generally not be provided until the registration and documentation process is complete. See the guidelines for documenting disabilities.

Academic Integrity

Students should familiarize themselves with the principle of academic integrity in the handbook of community standards.

Syllabus Revision Policy

This syllabus is subject to correction and revision. Any revised version will be distributed on my website and notice of revision will be given in class. The grading policy is only subject to revisions that cannot result in a lower letter grade for any set of scores. The latest version will always be at <http://people.hws.edu/tjallen/Physics351/Syllabus-351-2013S.pdf>.

Course Outline

This outline is fairly ambitious, but we should at least cover items *I* through *IX*.

I. NEWTON'S MECHANICS OF POINT PARTICLES

- A.* Newton's Three Laws
- B.* Frames of Reference
- C.* Other coordinate systems
- D.* Examples
 1. *1D* forces that depend on position
 2. *1D* forces that depend only on velocity
 3. *2D* & *3D* examples
 4. Conservative forces

II. CONSERVATION LAWS

- A.* Momentum
- B.* Angular momentum
- C.* Energy

III. OSCILLATIONS

- A. Simple Harmonic Oscillator
- B. Damped Oscillators
- C. Driven Damped Oscillators

IV. VARIATIONAL METHODS

- A. Calculus of Variations
- B. Lagrangian Mechanics
- C. Introduction to Hamiltonian Mechanics

V. TWO BODY CENTRAL-FORCE PROBLEM

- A. Center of Mass and Relative coordinates
- B. Reduction to a 1D problem
- C. Orbital motion
- D. Kepler's Laws

VI. NONINERTIAL FRAMES & FICTITIOUS FORCES

- A. Centrifugal Force
- B. Coriolis Force
- C. Foucault Pendulum

VII. RIGID BODY MOTION

- A. Inertia Tensor
- B. Principal Axes
- C. Euler's Equations
- D. Stability

VIII. COUPLED OSCILLATORS & NORMAL MODES

- A. Example
- B. Normal Modes
- C. Eigenfrequencies

IX. HAMILTONIAN MECHANICS

- A. Phase Space
- B. Poisson Brackets
- C. Conservation Laws
- D. Vortex Dynamics: $H \neq T + U$

X. SCATTERING

XI. CONTINUUM MECHANICS