Physics 351: Advanced Classical Mechanics *2004*

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

Text

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

Recommended Texts

- Murray R. Spiegel, *Mathematical Handbook* (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, *Classical Mechanics* (Addison-Wesley)
- L. D. Landau & E. M. Lifshitz, *Mechanics: Course of Theoretical Physics Vol. 1* (Elsevier, 1996)

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.

Office Hours

Initially office hours will be Wednesday 3:00 pm and Friday 1:30 pm and by appointment. If these hours are inconvenient for you, please tell me and I'll try to find some more convenient times. In addition, you may stop by any time to see if I am free to discuss physics, life, the universe, or anything else.

Course Structure
The course will consist of meetings three times a week. Although I expect to lecture at most meetings, I hope that you will have questions and that we can have good, spontaneous discussions on this difficult but fascinating subject. Please read the text carefully outside of class and bring to class your questions and confusions from the reading.

Course Requirements

Regular Homework Problems
2 Exams
Final Exam

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

- **Participation** I expect each student to do the assigned readings and problems and to bring questions and comments to class and to participate in class discussions. Implicit in this is the expectation that all students will attend all classes. 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. 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. 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%

Tentative Course Outline

This outline is fairly ambitious, but I hope we can cover most of it.

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
- *D.* Resonance

IV. VARIATIONAL METHODS: LEAST ACTION PRINCIPLE
- *A.* Calculus of Variations
- *B.* Generalized Coordinates
- *C.* Lagrangian Mechanics
- *D.* Hamiltonian Mechanics

V. TWO BODY CENTRAL-FORCE PROBLEM
- *A.* Center of Mass and Relative coordinates
- *B.* Reduction to a $1D$ Problem
- *C.* Orbital Motion

VI. NONINERTIAL FRAMES & FICTITIOUS FORCES
- *A.* Centrifugal Force
- *B.* Coriolis Force
- *C.* Foucault Pendulum

VII. RIGID BODY MOTION
- *A.* Fixed Axis Rotation
- *B.* Inertia Tensor
- *C.* Principal Axes
- *D.* Euler's Equations
- *E.* Stability

VIII. COUPLED OSCILLATORS & NORMAL MODES
- *A.* Example
- *B.* Normal Modes
- *C.* Eigenfrequencies

IX. SCATTERING
- *A.* Impact Parameter & Scattering Angle
- *B.* Cross Sections
- *C.* Differential Cross Section
- *D.* Rutherford Scattering

X. CONTINUUM MECHANICS
- *A.* Stress Tensor
- *B.* Strain Tensor
- *C.* Constitutive Equations
- *D.* Fluid Dynamics: Navier-Stokes Equation