PH 610/710-2A: Advanced Classical Mechanics I

Fall Semester 2007

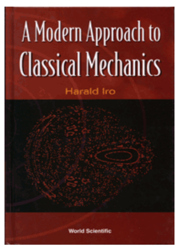
Time and location: Tuesdays & Thursdays 8:00am – 9:15am (EB 144)

Instructor and office hours:

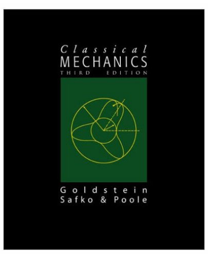
Dr. Renato Camata, camata@uab.edu
CH 306, (205) 934-8143

Tuesdays/Thursdays 9:30am – 10:30am
(Other times by appointment)

Textbooks:



A Modern Approach to Classical Mechanics
Harald Iro
World Scientific
ISBN: 981-238-213-5



Classical Mechanics
(3rd Edition)
Goldstein, Poole, and Safko
Addison-Wesley
ISBN: 0-201-65702-3

Use of textbooks:
Iro will be used as the course roadmap since it provides a superior logical framework for mechanics in light of modern developments such as the treatment of non-integrable systems and chaotic behavior. Throughout the course, content from *Goldstein, Poole, and Safko* will be used to expand *Iro's* presentation particularly for the most advanced analyses of rigid body motion, Hamilton's canonical formulation of mechanics, and the Hamilton-Jacobi Theory.

Other Books and Resources Suggested:

Nonlinear Dynamics and Chaos with Applications to Physics, Biology, Chemistry, and Engineering *S. Strogatz* *Addison Wesley* *ISBN: 0-201-54344-3*	**Classical Mechanics:** ***Transformations, Flows, Integrable and Chaotic Dynamics*** *J. L. McCauley* *Cambridge University Press* *ISBN: 0-521-57882-5*	**Introduction to Maple** (3rd Edition) *A. Heck* *Springer* *ISBN: 0-387-00230-8*

Catalog Description: Analysis of dynamics, including rigid body motion, featuring the Lagrange formulation, introduction to the Hamiltonian formulation, Poisson brackets, analyses in nonrelativistic applications.

Prerequisite: PH 562 or approval of Physics Graduate Committee.

Last Day to Withdraw with "W": December 5.

Course Activities: This course will comprise lectures integrated with classroom discussions and written problem-solving exercises assigned by the instructor (problem sets). Lectures, classroom discussions, and problem set activities will involve the use of both analytical and computational tools in the solution of mechanics problems. Students will be able to solve problems numerically using the computational tools featured in the software package **Maple 10** available in the Department of Physics. Students will be required to demonstrate an advanced level of understanding of the concepts of classical mechanics and skills in solving problems in this area of physics.

Related UAB core learning outcomes: Students successfully completing this course will be able to understand concepts at the advanced graduate level in classical mechanics and will be able to apply this knowledge.

Course learning objectives:

- Demonstrate advanced knowledge and understanding of the following specific fundamental concepts in classical mechanics:
  1. *Conservation laws and symmetries in physical systems*
  2. *Motion of particle and systems of particles in three dimensions*
  3. *Chaotic behavior of mechanical systems*
  4. *Lagrangian formulation of mechanics*
  5. *Dynamics of rigid bodies*
  6. *Hamiltonian formulation and Hamilton-Jacobi theory of mechanics*
- Demonstrate an ability to effectively apply the knowledge of the advanced knowledge above in solving problems involving motion in the following classic areas of mechanics:
  1. *Motion of bodies with variable mass, 1D-oscillators and pendulums*
  2. *Motion of 2D, 3D oscillators, central force problems, spherical pendulums, etc.*
  3. *Numerical solution of non-linear problems leading to chaotic behavior*
  4. *Use of Lagrangian method in systems with holonomic constraints*
  5. *Motion of rigid bodies such as spinning tops, wheels, and low-symmetry objects.*
  6. *Use of Hamiltonian formulation in central force problems and rigid body motion*
- Demonstrate advanced quantitative reasoning and mathematical analysis skills.
- Demonstrate ability to use computational tools in the numerical solution of problems in classical mechanics.

Measurement of learning objectives: Take-home tests, in-class exams, problem sets, and classroom participation will be used to measure the acquisition of *advanced knowledge* in classical mechanics and the development of students' *abilities to apply this knowledge* to problems. These measurement tools will also provide opportunities to evaluate the progression of students' reasoning and mathematical skills.

Course Grade: The course grade will be based on the following components:

- **Two take-home tests.** Open book tests that students will have one week to complete without collaboration with any other students.

- **Two in-class exams.** Closed book exams: A midterm exam M (during a regular class period: 75 min) and a final exam F (during final exam week: 2½ hours). The weighted average of in-class exams will be found from

$$\langle E \rangle = \frac{M + 2F}{3} \tag{1}$$

- **Problem sets completed.** Problem sets featuring a variety of activities to foster learning will be regularly assigned by instructor. Activities must be completed and turned in by the due date. Repeated failure to turn in problem sets may result in an **F** grade (please see grading scale below).

- **Classroom participation.** Throughout the semester the instructor will assign activities that must be completed prior to pre-determined classes. These activities will include studying chapters in the textbook, reproducing derivations in detail, and solving specific problems. Students must be prepared to discuss and solve these problems if called upon by instructor. Repeated failure to prepare for class participation may result in an **F** grade (please see grading scale below).

Grading Scale:

• Simple average of take-home tests ≥ 90% • Weighted average of in-class exams from Eq. (1) ≥ 80% • Percentage of problem sets completed ≥ 80% • Classroom participation ≥ 80% *(All conditions must be met)*	**A**
• Simple average of take-home tests ≥ 80% • Weighted average of in-class exams from Eq. (1) ≥ 70% • Percentage of problem sets completed ≥ 80% • Classroom participation ≥ 80% *(All conditions must be met)*	**B**
• Simple average of take-home tests ≥ 70% • Weighted average of in-class exams from Eq. (1) ≥ 60% • Percentage of problem sets completed ≥ 80% • Classroom participation ≥ 80% *(All conditions must be met)*	**C**
Otherwise	**F**

Important Test & Exam Dates:

- **Take-home Test 1:** Available, Tuesday, September 25
  Due, Tuesday, October 2; 5:00 PM
- **In-class Midterm Exam:** **Tuesday, October 16; 8:00-9:15 AM**
- **Take-home Test 2:** Available, Thursday, November 8
  Due, Thursday, November 15; 5:00 PM
- **In-class Final Exam:** **Thursday, December 13; 8:00-10:30 AM**

Student collaboration policy: Discussions and exchange of ideas among students are strongly encouraged during studying and working of problem sets. Copying and verbatim rendering of solutions from other students ***are not appropriate***. These practices constitute violation of the University honor code and may result in academic disciplinary action including dismissal from the degree program. Collaboration among students ***is not allowed*** during tests and exams.

Special accommodations:
Please contact Dr. Camata for an appointment to discuss special accommodations.

Web Page: http://www.phy.uab.edu/~rcamata/PH610-710.htm
(Class information and grades will be posted on this web page)

Topical Outline

1. **Reviews**
   a. Foundations of mechanics
   b. Lagrangian mechanics
   c. Systems of many particles

2. **Rigid Body Motion**
   a. Degrees of freedom of a rigid body
   b. The inertia tensor
   c. Euler's equations of motion
   d. Motion of a spinning top
   e. The symmetric spinning top

3. **Hamilton's Canonical Formulation of Mechanics**
   a. Hamiltonian dynamics
   b. Canonical equations
   c. Motion in a central force and homogeneous magnetic field
   d. Poisson brackets
   e. Canonical transformations
   f. Symmetry and conservation laws

4. **Hamilton-Jacobi Theory**
    a. Integrability
    b. Time-independent Hamilton-Jacobi theory
    c. Hamilton-Jacobi equation
    d. Three body systems
    e. The restricted three-body problem
    f. The problem of two centers of gravitation