Revised, January 26, 2006
*(Date of Exam 2 changed to **Tuesday, March 21**, due to students' request)*

PH 462/562 Classical Mechanics II

Spring Semester 2006

Time and location: Tuesdays & Thursdays 9:30am – 10:45am (CH 396)

Instructor and office hours:

Dr. Renato Camata, camata@uab.edu — Thursdays 11:00am – 12:00pm
CH 306, (205) 934-8143 — (Other times by appointment)

Textbook: Classical Mechanics, *John R. Taylor*, University Science Books

Other useful resources:

Mechanics *K. R. Symon* Addison-Wesley	**A Modern Approach to Classical Mechanics** *Harald Iro* World Scientific	**Classical Dynamics of Particles and Systems** *J. B. Marion* Academic Press

Catalog Description: Kinematics and dynamics, including central forces, rotating coordinate systems, and generalized coordinates. Lagrangian, Hamiltonian, and other equivalent formulations of mechanics.

Prerequisite: PH 461

Last Day to Withdraw with "W": PH 462 (March 7); PH562 (April 26)

Course Activities: This course will comprise formal lectures integrated with classroom discussions and written problem-solving exercises assigned by the instructor (problem sets). Lectures and problem sets 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. Through these activities, undergraduate students enrolled in **PH 462** are expected to acquire a solid understanding of the fundamentals of classical mechanics and a high degree of problem-solving skills in the subject. Graduate students enrolled in **PH 562** will be required to demonstrate the same proficiency of **PH 462** students and, in addition, develop an advanced level of understanding and problem-solving skills in this area by completing an Integrative Project. This Integrative Project will consist in a series of mechanics problems whose solutions require the *integration* of knowledge from multiple topical areas covered in the course. This series of problems will be made available during the third week of classes and students will be required to complete it and turn in a written report with all solutions for grading by **Tuesday, April 11.** In addition, **PH 562** students will be asked to select *one* problem from their Integrative Project which will be presented in the form of an oral presentation in class on **Tuesday, April 25.**

Related UAB core learning outcomes: Students successfully completing this course will demonstrate knowledge of fundamental concepts in Classical Mechanics and the ability to apply this knowledge in the description of the motion of massive point particles and extended rigid bodies.

Course learning objectives:

- Demonstrate knowledge and understanding of the following specific fundamental concepts in Classical Mechanics **(PH 462 & PH 562)**:
  1. *Energy and momentum conservation principles*
  2. *Particle motion under central forces*
  3. *Lagrangian formulation of mechanics*
  4. *The dynamics of systems of particles*
  5. *Rigid body motion*
  6. *Coupled oscillations and normal modes*
- Demonstrate an ability to effectively apply the knowledge of the fundamental concepts above in solving problems involving motion in the following classic areas of mechanics **(PH 462 & PH 562)**:
  1. *Motion of bodies with variable mass, Two-body problems,*
  2. *Celestial mechanics, scattering (e.g., Kepler problem, Rutherford scattering)*
  3. *Generalized coordinates, Lagrange's equations of motion*
  4. *Particle collisions*
  5. *Rotational motion of rigid bodies*
  6. *Weakly coupled oscillators, coupled pendulums*
- Demonstrate enhanced quantitative reasoning skills and mathematical analysis skills **(PH 462 & PH 562)**.
- Demonstrate the ability to communicate the solution of mechanics problems both in oral and written form **(PH 562)**.

Measurement of learning objectives: Problem sets with exercise assignments and exams will be used regularly to measure *understanding of the fundamental concepts* presented as well as students' *abilities to apply this understanding* to problems in classic areas of mechanics. Prompt grading of the problem sets by the instructor will provide feedback to students on their strengths and weaknesses, in preparation for the exams. Both, problem sets and exams also provide an opportunity to evaluate the progression of students' reasoning and mathematical skills. These two measuring tools will be used for both **PH 462** and **PH 562** students. In addition, students enrolled in **PH 562** will have an opportunity to integrate their knowledge more extensively through the completion of the Integrative Project. This higher level of learning will be measured through their turned in solutions. Measurement of **PH 562** students' *ability to communicate problem solutions both orally and in writing* will be achieved through the written report featuring the solution of the series of problems in the Integrative Project and in the oral presentation to the class.

Course Grade:

PH 462 *(Undergraduate)*	**PH 562** *(Graduate)*
50% - Problem Sets	25% - Problem Sets
50% - Exams*	50% - Exams*
-	25% - Integrative Project

* Three exams – equal weight

- **Exam 1:** Thursday, February 9; 9:30-10:45 AM
- **Exam 2:** Tuesday, March 21; 9:30-10:45 AM
- **Exam 3:** Tuesday, May 2; 8:00-10:30 AM

Letter grades will be assigned according to the following scale:
(All calculated grades will be rounded up to the nearest 0.1%.)

88.0% to 100% inclusive	**A**
76.0% to 87.9% inclusive	**B**
63.0% to 75.9% inclusive	**C**
50.0% to 62.9% inclusive	**D**
0.0% to 49.9% inclusive	**F**

Turning in all assigned work is a necessary condition for an **A** grade

Problem set policy:
Group work and discussions prior to turning in problem sets are appropriate.

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

Web Page: http://www.phy.uab.edu/~rcamata/PH462-562.htm
(Class information and grades will be posted on this web page)

Topical Outline

1. **Momentum and Angular Momentum** *(Text Chapter 3)*
   a. Conservation of Momentum
   b. Rockets
   c. The Center of Mass
   d. Angular Momentum for a Single Particle
   e. Angular Momentum for Several Particles

2. **Calculus of Variations** *(Text Chapter 6)*
   a. The Euler-Lagrange Equation
   b. Applications of the Euler-Lagrange Equation
   c. More than Two Variables

3. **Lagrange's Equations** *(Text Chapter 7)*
    a. Lagrange's Equations for Unconstrained Motion
    b. Constrained Systems
    c. Conservation Laws in Lagrangian Mechanics
    d. Lagrange's Equations for Magnetic Forces
    e. Lagrange Multipliers and Constraint Forces

4. **Two-Body Central Force Problems** *(Text Chapter 8)*
    a. Central Forces
    b. Energy of Interaction of Two Particles
    c. The Energy of Multiparticle Systems
    d. Center of Mass and Relative Coordinates; Reduced Mass
    e. The Equations of Motion
    f. The Equivalent One-Dimensional Problems
    g. The Equation of the Orbit
    h. The Kepler Orbits
    i. The Unbonded Kepler Orbits
    j. Changes of Orbits

5. **Motion of Rigid Bodies** *(Text Chapter 10)*
    a. Properties of the Center of Mass
    b. Rotation about a Fixed Axis
    c. Rotation about Any Axis; the Inertia Tensor
    d. Principal Axes of Inertia
    e. Finding the Principal Axes; Eigenvalue Equations
    f. Precession of a Top Due to a Weak Torque
    g. Euler's Equations
    h. Euler's Equations with Zero Torque
    i. Euler Angles
    j. Motion of a Spinning Top

6. **Coupled Oscillators and Normal Modes** *(Text Chapter 11)*
    a. Two Masses and Three Springs
    b. Identical Springs and Equal Masses
    c. Two Weakly Coupled Oscillators
    d. Lagrangian Approach; the Double Pendulum
    e. The General Case
    f. Three Coupled Pendulums
    g. Normal Coordinates