FALL 2011: PHYSICS 170 – GENERAL PHYSICS I

MTWF 9:30-10:20 (Section 1) WAT 420

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Office hours (tentative): MWF 12:00–12:30 WAT 421

Course description: This course is a calculus-based introduction to general physics, covering the mechanics of particles and rigid bodies, wave motion, thermodynamics and kinetic theory. The primary goals of the course are to gain a solid understanding of fundamental physical principles and their mathematical expression, as required for applications in the physical sciences and engineering, and to introduce and develop the application of mathematics as the basic language of physics. While these goals are achieved in part through the working of assigned problems, the course is not one in problem-solving techniques. Indeed, advances in the physical sciences can be realized only by properly recognizing and formulating new problems in the first place. And to perceive and tackle new problems, it is a solid understanding of fundamental physical and mathematical principles which is critical.

Prerequisites: MATH 242 or concurrent, or MATH 252A or concurrent. (MATH 216 with consent.)

Textbook (required): Young and Freedman, *University Physics, Volume 1*, 12th ed., Pearson Addison-Wesley, San Francisco, 2008.

Internet (required): This course uses the online resources *Mastering Physics*™ for homework and *smartPhysics*™ for pre-lectures.

iClickers (required): Available at the UH Bookstore.

Grade distribution:

In-class questions (iClickers):	3% BONUS
PreLectures/CheckPoints:	5%/5%
Daily/Weekly Homework:	15%/15%
Quizzes/Midterm Exams:	20%/20%
Final Examination:	20%

Grade assignment: (*approximate*)

A+	90 >	B+	76–80	C+	66–70	D	50–56
A	84–90	B	70–76	C	60–66	F	< 50
A–	80–84			C–	56–60		

COURSE OUTLINE

1. Preliminary Review (~1 day):
   - Overview of physics — *Ch 1*

2. Kinematics of Particles (~2 weeks):
   - motion in 1 dimension; displacement, velocity, and acceleration — *Ch 2*
   - introduction to vectors; vector addition — *Ch 1*
   - motion in 2 and 3 dimensions — *Ch 3*

3. Dynamics of Particles (~2 weeks):
   - Newton's laws of motion — *Ch 4*
   - applications; friction, circular motion — *Ch 5*

4. Work and Energy (~2 weeks):
   - vector algebra: the dot product — *Ch 1*
   - work, kinetic energy, and the work-energy theorem — *Ch 6*
   - potential energy and the conservation of energy — *Ch 7*

——— *(Midterm examination 1)* ———

5. Systems of Particles (~1 week): *Ch 8*
   - momentum and impulse; center of mass motion
   - conservation of momentum and energy
   - collisions; rocket propulsion

6. Rotation and Angular Momentum (~2 weeks):
   - angular kinematics and energy *Ch 9*
   - vector algebra: the cross product *Ch 1*
   - angular dynamics; torque and Newton's second law *Ch 10*
   - rigid bodies; conservation of angular momentum

7. Classical Newtonian Gravitation (~1 week): *Ch 12*
   - Newton's law of gravity
   - Kepler's laws of planetary motion; application to orbital mechanics

——— *(Midterm examination 2)* ———

8. Oscillations and Waves (~2 weeks):
   - simple harmonic motion *Ch 13*
   - damped and driven oscillations; complex analysis
   - simple wave motion; the wave equation; boundary conditions *Ch 15*
   - superposition principle; sound waves

9. Heat and Thermodynamics (~3 weeks): *Ch 17–20*
   - temperature; kinetic theory of gases; ideal gas law
   - the First Law of thermodynamics
   - internal energy and heat capacities
   - entropy and the Second Law of thermodynamics
   - heat engines

10. Review (~1 week)

——— *(Final examination)* ———

smartPhysics™ **Pre-Lectures**

This section (001) of Physics 170 will use the *smartPhysics*™ Pre-Lectures from the *smartPhysics* website. Two Pre-Lectures will be assigned each week (excluding the course section on thermodynamics) which the students will be required to complete by the start of class on the indicated days. The Pre-Lectures are about 20 minutes long and include some simple questions that the students need to complete to gauge their understanding of the material. In addition, there will be some 'quiz' questions on the assigned readings which the students will complete in class using their iClickers. The purpose of these exercises is to ensure that students think in advance about the material to be covered and come to class well prepared.

Daily Homework

Daily homework (usually consisting of 2 problems) will be assigned from the *Mastering Physics*™ website, and must be completed by the start of class each day. Often these problems will involve simple calculations or be of a conceptual nature, but may require you to read ahead in order to answer them. The purpose, again, is to give you the opportunity to think about the physics before the lecture, and come to class better prepared.

Weekly Homework

In addition to the daily homework, a written weekly problem set (usually consisting of 2 problems) will be due in class each Monday. Please make an effort to write solutions that are coherent and clear as well as correct. These problems will be graded according to the following guidelines:

- 5: a good effort with correct results *and* reasoning;
- 4: a good effort with minor errors, or a fair effort with no conceptual or math errors;
- 3: a good effort with modest conceptual errors and/or math errors, or a fair effort with minor errors;
- 2: a fair effort involving modest conceptual errors, or a good effort involving serious conceptual errors;
- 1: a poor effort;
- 0: no effort.

Up to 3 additional points to be given for presentation, **so that each problem is graded out of 8**. A good effort involves at least *some* English explanation and/or use of appropriate diagrams along with calculations, and/or some recognition of an implausible result. Be sure to write something for every part of a problem, even if only to indicate where you may be stumped.

Quizzes and Midterm Exams

There will be two midterm exams at approximately the places noted in the course outline, with dates to be announced in advance. Quizzes will be held in class approximately every two weeks on a Friday, and be administered via paper or iClicker.

Guidelines for Problem Sets

For presentation:

1. Solutions should be written in complete and proper English.
2. Proper units must accompany all final numerical results.
3. Draw diagrams whenever possible, and label them clearly.
4. Do not insert numerical values until the *final step* in a calculation.
   (Physics is learned symbolically. If you simply insert numbers at the start of a calculation and crunch away, nothing will ever make sense.)

In general:

5. Regarding significant figures: *Do not round the results of any intermediate calculations … ever!* Leave at least three significant figures when reporting numerical results.
6. Form the habit of checking the dimensions of any equations that you derive. Many times, this simple exercise will reveal whether you made an error somewhere along the line.
7. If possible, ask yourself whether an answer makes sense.

Student Learning Objectives

After completing this course, students will be expected to be familiar with the following:

- the general differential relationships between the kinematic quantities: position 'x', velocity 'v', acceleration 'a'
- the specific relationships between these quantities for the case of [a = constant]
- the graphical representations of these quantities, e.g. [a = constant] on a v-t curve

- the definition and physical significance of a SCALAR quantity
- the definition and physical significance of a VECTOR quantity
- the vectorial nature of displacement, velocity, and acceleration, and the differential relationships between them
- that all fundamental physical relationships (studied in this course) are expressed mathematically either as [SCALAR = SCALAR] or [VECTOR = VECTOR]; and the meaning of these equations

- Newton's First, Second, and Third Laws
- the definition and physical significance of an inertial reference frame
- how to determine which forces are acting on an object, and how to depict them in a free-body diagram, e.g. weight, tension, normal force, etc.
- how to resolve the components of the depicted forces in a chosen coordinate system
- how to apply and solve $\underline{F} = m\underline{a}$; e.g. how to obtain the acceleration $\underline{a}$ from the given sum of forces $\underline{F}$; or how to determine the magnitudes of unknown forces for the case in which $\underline{a}$ is known, eg. due to constraints
- how to apply Newton's Third Law when two or more objects interact with each other
- how to determine the direction and magnitude of the frictional force
- the nature and analysis of centripetal acceleration and motion in a circle

- the definition of work done by a force $\underline{F}$ on an object which moves along a path $\underline{r}$, as the integral of $\underline{F} \bullet \underline{dr}$
- the physical significance and the mathematical definition of the dot product
- the WORK-ENERGY theorem and the definition of kinetic energy K
- the significance of the potential energy function U for a conservative force

- the definition of total mechanical energy $E_{mech} = K+U$
- how to determine the total mechanical energy of a system of two or more objects, e.g. to find *all contributions* to the potential and kinetic energy
- the contributions to the total energy of a system
- the Law of Conservation of Energy

- the definition of the center of mass
- The PHYSICAL SIGNIFICANCE of the center of mass
- the definition of momentum of a particle and system of particles
- the VECTOR NATURE of momentum
- Newton's Law in terms of momentum
- the *Law of Conservation of Momentum;* application to rocket propulsion
- the fundamental relation between *Newton's Third Law* and the *Law of Conservation of Momentum*
- the distinction between an elastic and inelastic collision
- the application of the Laws of Conservation of Momentum and Energy in the analysis of collisions

- the kinematic description of rotation in terms of the *angular position* ϑ, *angular velocity* ω, and *angular acceleration* α, and the differential relations between them
- the relationship between the angular variables and the linear variables along the arc
- the definition of the MOMENT OF INERTIA I of a particle or rigid body
- the rotational kinetic energy of a rigid body about a specified axis of rotation
- the definition of the TORQUE τ of a force *with respect to a specified axis*
- Newton's Law for Rotation *with respect to a specified axis*
- the vector nature of rotation
- the definition of the CROSS PRODUCT of two vectors $\underline{A}$ and $\underline{B}$
- the algebraic properties of the cross product
- the definition of torque $\underline{\tau}$ *about a point*
- the definition of angular momentum $\underline{L}$ *about a point*
- Newton's Law for rotation of a *system of particles*
- the Law of Conservation of Angular Momentum and its application

- Kepler's laws of planetary motion
- Newton's universal law of gravitation, and its relation to Newton's laws of motion and Kepler's laws
- analysis of circular orbits, orbital energy, and escape velocity

- the importance of simple harmonic motion in physics
- the mathematical description of simple harmonic motion and oscillations
- the physical nature of waves and wave motion
- the mathematical description of waves and the wave equation
- the superposition principle
- the analysis of harmonic waves and wave energy
- sound waves and the Doppler effect

- the concept of thermal equilibrium
- the definition and measurement of temperature; the zeroth law of thermodynamics
- the kinetic theory of gases and the ideal gas law
- the concept of state variables and the use of state diagrams (eg. P-V)
- conservation of energy and the First Law of thermodynamics; heat flow
- internal energy and heat capacities of a thermodynamic system
- entropy and the Second Law of thermodynamics
- heat engines