SPRING 2012: PHYSICS 170 – GENERAL PHYSICS I

MTWF 9:30-10:20 (Section 1) WAT 420
Instructor: Eric B. Szarmes (szarmes@hawaii.edu)
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 resource *Mastering Physics*™ for homework assignments.
iClickers (required):	Available at the UH Bookstore.

Grade distribution:

In-class questions (iClickers):	3% BONUS
Daily/Weekly Homework:	20%/20%
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)* ———————

Daily and Weekly Homework

Daily homework (usually consisting of 2 problems) will be assigned from the *Mastering Physics*™ website. Often these problems will involve simple calculations or be of a conceptual nature, but may require you to read ahead. 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.

Guidelines for Weekly 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 physically.

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 $\underline{F} \cdot \underline{dr}$
- 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 $E_{\text{mech}} = K+U$
- 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

- 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
- heat engines and refrigerators; the Carnot cycles for these systems
- entropy and the Second Law of thermodynamics