2^{nd} Homework
Due: 25 October 2007

1. A box of mass 40 kg is initially at rest on the floor. The coefficient of kinetic friction between the box and the floor is $\mu_k = 0.60$. A woman pushes horizontally against the box with a force of 250 N until the box attains a speed of 2.0 m/s.

   (a) What is the change of kinetic energy of the box?

   (b) What is the work done by the friction force on the box?

   (c) What is the work done by the woman on the box?

   (H. C. Ohanian, "Physics," Q7.35, pg 181)

2. It has been reported that at Cherbourg, France, waves smashing on the coast lifted a boulder of 3200 kg over a $6 - m$ wall. What minimum energy must the waves have given to the boulder? (H. C. Ohanian, "Physics," Q7.36, pg 181)

3. A pendulum consists of a mass tied to a string of length 1.0 m. Suppose that this pendulum is initially held at an angle 30° with the vertical and then released. What is the speed with which the mass swings through its lowest point? At what angle will the mass have one half of this speed? (H. C. Ohanian, "Physics," Q7.50, pg 182)

4. A particle initially sits on top of a large smooth sphere of radius R. The particle begins to slide down the sphere, without friction. At what angular position will the particle loose contact with the surface of the sphere? where will the particle land on ground? (H. C. Ohanian, "Physics," Q7.55, pg 183) (*Hint:* What is the condition on the normal force so that the particle can be considered in contact with the sphere?).

5. A particle is subjected to a force that depends on position as follows:

$$\vec{F} = (4N)\hat{x} + (2N/m)\hat{y} \tag{1}$$

   (a) Calculate the work done by this force as the particle moves from the origin to the points $(x, y) = (1m, 1m)$ along a straight line

(b) Calculate the work down by this force if the particle moves from the point $(x, y) = (1m, 1m)$ first to the point $(x, y) = (0, 1m)$ along a straight line, and then to the origin along the y axis.

(c) Is the force conservative? If it it, what is the corresponding potential energy?

6. A package is dropped horizontally on a horizontal conveyor belt. The mass of the package is m, the speed of the conveyor belt is v, and the coefficient of kinetic friction for the package belt is μ_k. For what length of time will the package slide on belt? How far will it move in this time? How much energy is dissipated by friction? How much energy does the belt supply to the package (including the energy dissipated by friction)? (H. C. Ohanian, "Physics," Q8.16, pg204)

7. Suppose that the potential energy of a particle moving along the x axis is

$$U(x) = \frac{b}{x^2} - 2\frac{c}{x} \tag{2}$$

where b and c are positive constants.

(a) Sketch the general shape of $U(x)$. Where is the equilibrium points?

(b) Suppose the energy of the particle is $E = -\frac{1}{2}c^2/b$. Find the turning points of the motion.

(c) Suppose the energy of the particle is $E = \frac{1}{2}c^2 b$. Find the turning point.

(H.C. Ohanian, "Physics," Q8.21, pg 205)

8. Consider a projectile traveling horizontally and slowing down under the influence of air resistance. The mass of this projectile is 43.36 kg and the speed as a function of time is

$$v = (655.9\ m/s) - (61.14\ m/s^2)t + (3.26\ m/s^3)t^2 \tag{3}$$

(a) What is the position as a function of time if the projectile starts at $x = 0$?

(b) What is the acceleration of the projectile as a function of time? Calculate the force exerted by air.

(c) What is the instantaneous power removed from the projectile by the air resistance?

(d) What is the average power for the time interval from 0 to 3.0 s?

9. A binary star system consists of two stars of masses m_1 and m_2 orbiting about each other. Suppose that the orbits of the stars are circles of radii r_1 and r_2 centered on the center of mass. Show that the period of the orbital is given by:

$$T^2 = \frac{4\pi^2}{G(m_1 + m_2)}(r_1 + r_2)^3 \tag{4}$$

(H. C. Ohanian, "Physics," Q9.15, pg239)

10. The Sun is moving in a circular orbit around the center of our galaxy. The radius of this orbit is 3×10^4 light years. Calculate the period of the orbital motion and calculate the orbital speed of the Sun. The mass of our Galaxy is 4×10^{41} kg and all this mass can be regarded as concentrated at the center of the Galaxy. (H. C. Ohanian, "Physics," Q9.11, pg239)

11. Let $v(r)$ denote the speed that a mass should have in order for it to have a circular orbit of radius r around a mass M. Obtain an expression for $v(r)$.