University of Alabama
Department of Physics and Astronomy

PH 125 / LeClair Fall 2014

Problem Set 4

Instructions:

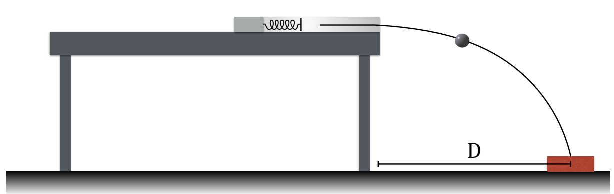
1. Answer all questions below. Show your work for full credit.
2. All problems are due by the end of the day on 22 Sept 2014.
3. You may collaborate, but everyone must turn in their own work.

1. A 100 kg block is pulled at a constant speed of 5.0 m/s across a horizontal floor by an applied force of 122 N directed 37° above the horizontal. What is the rate at which the force does work on the block?

2. A 250 g block is dropped onto a relaxed vertical spring that has a spring constant of $k = 2.5$ N/cm. The block becomes attached to the spring and compresses the spring 12 cm before momentarily stopping. While the spring is being compressed, what work is done on the block by **(a)** the gravitational force on it, and **(b)** the spring force? **(c)** What is the speed of the block just before it hits the spring? (Assume that friction is negligible.) **(d)** If the speed at impact is doubled, what is the maximum compression of the spring?

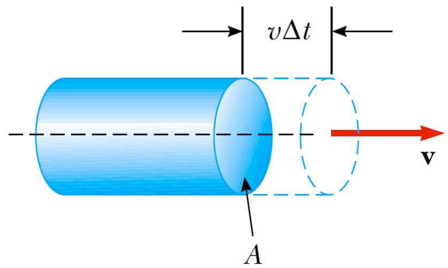
3. A chain is held on a frictionless table with one fourth of its length hanging over the edge. If the chain has length $L = 28$ cm and mass $m = 0.012$ kg, how much work is required to pull the hanging part back onto the table?

4. Two children are playing a game in which they try to hit a small target on the floor with a marble fired from a spring-loaded gun that is mounted on a table. The target box is a horizontal distance $D = 2.20$ m from the edge of the table, see the figure below. Bobby compresses the spring 1.10 cm, but the center of the marble falls 27.0 cm short of the center of the box. How far should Josephine compress the spring to score a direct hit? (Assume neither the ball nor the spring encounters friction in the gun, and ignore air resistance.)



5. As it plows a parking lot, a snowplow pushes an ever-growing pile of snow in front of it. Suppose a car moving through the air is similarly modeled as a cylinder pushing a growing plug of air in front of it. The originally stationary air is set into motion at the constant speed v of the cylinder, as shown below. In a time interval δt, a new disk of air of mass δm must be moved a distance $v\delta t$

and hence must be given a kinetic energy $\frac{1}{2}(\delta m)v^2$. Using this model, show that the resistive force due to the air is $F_{\text{drag}} = \frac{1}{2}\rho A v^2$, where ρ is the density of the air. Note that $F = dp/dt$, where p is momentum.



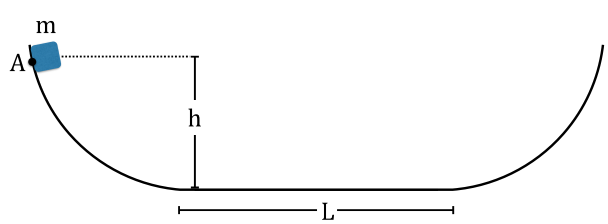
6. The potential energy of an Argon dimer may be modeled by

$$U(r) = 4\epsilon \left(\frac{\sigma^{12}}{r^{12}} - \frac{\sigma^6}{r^6} \right)$$

(a) Find the equilibrium separation of the dimer (i.e., the value of r at equilibrium).

(b) Is the equilibrium stable? Justify your answer.

7. A particle can slide along a track with elevated ends and a flat central part, as shown in the figure below. The flat part has length $L = 40\,\text{cm}$. The curved portions of the track are frictionless, but for the flat part the coefficient of kinetic friction is $\mu_k = 0.20$. The particle is released from point A, which is at height $h = L/2$. How far from the left edge of the flat part does the particle finally stop?



8. To stretch a spring a distance d from equilibrium takes an amount W_o of work. **(a)** How much work does it take to stretch the spring from d to $2d$ from equilibrium? **(b)** From Nd to $(N+1)d$ from equilibrium?