Assignment VIII, HONS 157 (Honors Physics I)
Fall 2015
Due 10/23/15 at start of class

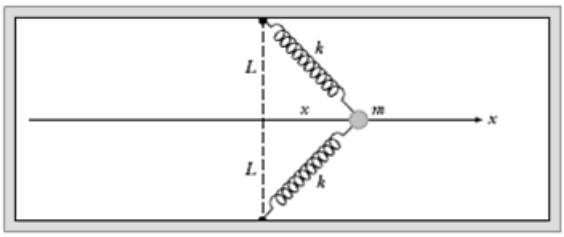
1. A particle of mass m is suspended between two identical springs on a horizontal frictionless tabletop as shown in the figure below. Both springs have spring constant k, and the springs are neither stretched nor compressed when $x = 0$.

   a) If the particle is pulled a distance x along a direction perpendicular to the initial configuration of the springs (e.g. if the particle is initially moved to the position shown in the figure), show that the system's potential energy due to the springs is:

   $$U(x) = kx^2 + 2kL\left(L - \sqrt{x^2 + L^2}\right)$$

   b) If $L = 1.35$ m, $k = 70$ N/m, $m = 0.39$ kg and the particle is pulled 0.3 m to the right and then released from rest, what is its speed when it reaches $x = 0$?

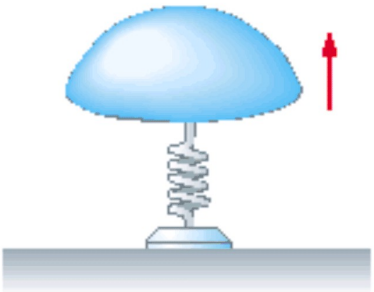
   c) Same as part (b), but find the particle's speed when it reaches $x = 0.20$ m.



Top View

Figure P8.47

2. A toy consists of a piece of plastic attached to a spring. The spring is compressed 3.00 cm and the toy is released. If the mass of the toy is 180 g and it rises to a maximum height of 85 cm, estimate the force constant of the spring.



3. During the battle of Gettysburg, the gunfire was so intense that several bullets collided in midair and fused together. Assume a 5.00 g Union musket ball moving to the right at 280 m/s and 23.0° above the horizontal collides with a 3.75 g Conferedarate ball moving to the left at 294 m/s and 14° above the horizontal. Immediately after they fuse together, what is their velocity?

4. A neutron in a reactor makes a collision with the nucleus of a carbon atom initially at rest. (Assume that the nucleus of a carbon atom is initially equal to 12 times the mass of a neutron).

   a) If the collision was inelastic (e.g. the neutron combines with the carbon nucleus), what fraction of the initial kinetic energy of the neutron is lost?

   b) If the collision was actually elastic (e.g. the neutron just "hits" the carbon nucleus; all motion stays in a line), then what fraction of the neutron's kinetic energy is transferred to the carbon nucleus?

   c) Again, if the collision was actually elastic and if the initial kinetic energy of the neutron was 1.93×10^{-13} J, what are the final kinetic energies of both the neutron and the Carbon nucleus after the collision?

5. A bullet of mass m and initial speed v passes completely through an initially stationary pendulum bob of mass M and length ℓ. The bullet emerges with a speed αv. (α is an unspecified constant somewhere between 0 and 1). The pendulum bob is suspended by a stiff rod of length ℓ and negligible mass. What is the minimum value of v such that the pendulum bob will barely swing through a complete vertical circle? (Note, the picture below assumes $\alpha = \frac{1}{2}$, but we want to keep the answer general here – don't assume the speed coming out is $v/2$).