PHY 110 Spring 2018 Quiz 7 Solution

1. In the diagram to the left, assume that the two masses are equal and that the pulleys are frictionless and have no mass. You may also assume that the string does not stretch or break. If the system starts from rest, what is the speed of block A when the blocks have a vertical separation of *d*?

a) $\sqrt{\frac{gd}{2}}$ b) $\sqrt{\frac{2gd}{3}}$ c) $\sqrt{\frac{3gd}{4}}$ **d)** $\boxed{\sqrt{\frac{8gd}{15}}}$ e) $\sqrt{\frac{11gd}{13}}$

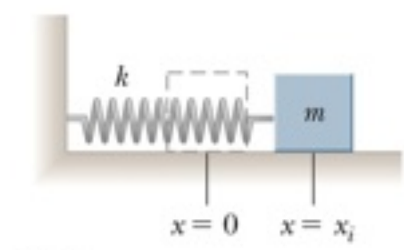
Since A has to move twice as far as B moves (every inch that B rises requires 2 inches of string, which drops A twice as far), then we know that when the two masses are separated by a distance d, B moved d/3 up and A moved 2d/3 down. This analysis also requires that the speed of A will always be twice the speed of B. Set the zero of potential energy at the final position of A. Then conservation of energy gives us

$$E_f = E_i$$

$$mgd + \frac{1}{2}mv_A^2 + \frac{1}{2}mv_B^2 = 2mg\frac{2d}{3}$$

$$mgd + \frac{1}{2}mv_A^2 + \frac{1}{2}m\left(\frac{v_A}{2}\right)^2 = 4mg\frac{d}{3}$$

$$\frac{5}{8}v_A^2 = g\frac{d}{3} \quad or \quad v_A = \sqrt{\frac{8gd}{15}}$$



2. A 2 kg block is attached to a horizontal spring (k = 500 N/m) and moves along a rough horizontal table ($\mu_k = 0.350$). If the block is moved 5 cm to the right of the spring's equilibrium position and released from rest, what maximum speed will the block achieve?

a) 0.483 m/s b) 0.520 m/s $\boxed{\text{c) } 0.573 \text{ m/s}}$ d) 0.639 m/s

The maximum speed is achieved where the friction force and the spring force are equal (no net force, therefore no acceleration, therefore max speed). $(0.350)(2)(9.81) = (500)x \quad x = 0.0137\,m$. *Then use conservation of energy in the presence of a non-conserving force (like friction)*

$$W_{nc} = E_f - E_i$$

$$-(0.350)(2)(9.81)(0.05 - 0.0137) = \frac{1}{2}(2)v_{\max}^2 + \frac{1}{2}(500)(0.0137)^2 - \frac{1}{2}(500)(0.05)^2$$

$$v_{\max} = 0.573\frac{m}{s}$$

3. A rubber ball (m = 0.010 kg) is dropped from a height of 1.00 m. It hits the floor and rebounds to a height of 0.700 m. How much work is done by non-conservative forces during this motion?

a) –18.3 mJ $\boxed{\text{b) –29.4 mJ}}$ c) –37.5 mJ d) –48.6 mJ

All the ball's initial potential energy is converted to kinetic energy, giving the ball's velocity just before the bounce. After the bounce, the ball's now reduced kinetic energy is converted back to potential energy. So the difference in the ball's potential energy tells us how much kinetic energy was lost in the bounce process. (Note that the work done by gravity during the bounce is zero – gravity does positive work as the ball is squished in the first part of the bounce, then gravity does an equal amount of negative work as the ball "unsquishes".)

$$W_{nc} = E_f - E_i = mg\left(h_f - h_i\right) = (0.010)(9.81)(0.700 - 1.00) = -0.0294\,J = -29.4\,mJ$$

4. A 1 kg ball hangs from a nail at the end of a 1 m long string. What minimum tangential velocity must you give the ball at its lowest point if you want to ensure that the ball will swing in a complete vertical circle around the nail, moving only in a circle with a radius of 1 m?

a) 4.00 m/s b) 5.00 m/s c) 6.00 m/s $\boxed{\text{d) 7.00 m/s}}$

In order to complete the circular motion, the ball must have a minimum speed at the top of the trajectory so that the radial acceleration required can be provided by gravity. $\frac{v_{top}^2}{r} = g$. *Since r = 1 m, this gives* $v_{top}^2 = g$. *Set h = 0 at the bottom of the circle, then conservation of energy gives*

$$E_f = E_i$$

$$mg(2r) + \frac{1}{2}mv_{top}^2 = \frac{1}{2}mv_{bottom}^2$$

$$2g + \frac{g}{2} = \frac{v_{bottom}^2}{2} \quad or \quad v_{bottom} = \sqrt{5g} = 7.00\frac{m}{s}$$

5. Suppose the kinetic energy of an object decreases during part of its motion. During that time, one may safely assume that (circle all that apply)

a) At least one non-conservative forces must have acted.
b) The total potential energy of the object must have increased.
c) The total potential energy of the object must have decreased.
$\boxed{\text{d) The net work done by all the forces must have been negative.}}$
e) The net work done by all the forces must have been positive.
f) The net work done by all the forces must have been zero.
g) No general statement about the net work done can be made without knowledge of the change in total potential energy.

$$K = \frac{1}{2}mv^2 \quad W_{net} = \Delta K \quad E = K + U \quad U_{spring} = \frac{1}{2}kx^2 \quad U_g = mgh \quad W_{nc} = E_f - E_i \quad W_f = -fd \quad a_{radial} = \frac{v^2}{r}$$