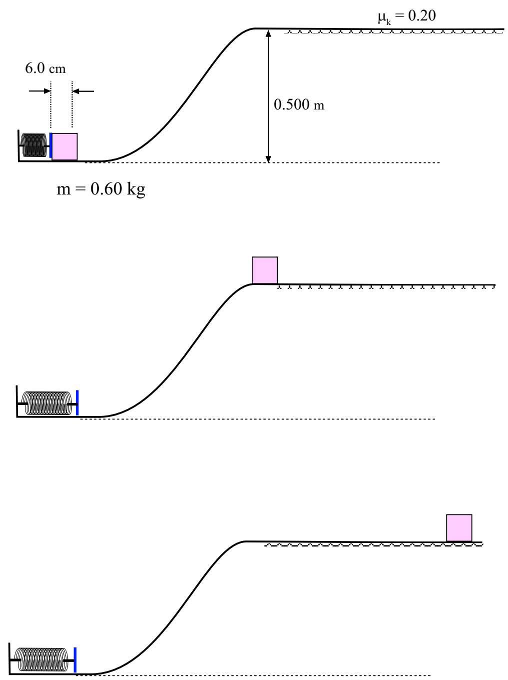
Name________________________________

Mar. 17, 2010

Quiz #3 – Spring 2010
Phys 2110 – Sec 3

1. A mass is pressed against a horizontal spring of force constant $2.00\times10^3\,\frac{\mathrm{N}}{\mathrm{m}}$, compressing it by 6.00 cm. The mass is released and it slides on a curving/flat track shown here; it goes up to a height of 0.500 m and thereafter moves on a level but a rough surface for which the coefficient of kinetic friction is 0.200. While sliding on the (flat) rough surface, the mass comes to a halt.

At all times the block stays in contact with the track, and there is only friction on the upper section of the track.



a) What is the speed of the mass just after it leaves the spring?

Conservation of energy: Energy stored in spring is all changed to the KE of the mass:

$$\tfrac{1}{2}kx^2 = \tfrac{1}{2}mv_1^2 \qquad \Longrightarrow \qquad v_1^2 = \frac{kx^2}{m}$$

Plug in: $$v_1^2 = \frac{(2000\frac{\mathrm{N}}{\mathrm{m}})(0.060\ \mathrm{m})^2}{(0.60\ \mathrm{kg})} = 12\,\frac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v_1 = 3.46\frac{\mathrm{m}}{\mathrm{s}}$$

b) What is the speed of the mass when it first gets to the upper (flat) surface?

Energy is conserved between the initial configuration (when there was just spring PE) and the time in question, when there is KE and gravity PE. Thus

$$\tfrac{1}{2}kx^2 = \tfrac{1}{2}mv_2^2 + mgy \qquad \Longrightarrow \qquad \frac{kx^2}{m} = v_2^2 + 2gy$$

Plug in numbers:

$$v_2^2 = \frac{kx^2}{m} - 2gy = \frac{(2000\frac{\mathrm{N}}{\mathrm{m}})(0.060\ \mathrm{m})^2}{(0.60\ \mathrm{kg})} - 2(9.80\tfrac{\mathrm{m}}{\mathrm{s}^2})(0.50\ \mathrm{m}) = 2.2\,\frac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v_2 = 1.48\frac{\mathrm{m}}{\mathrm{s}}$$

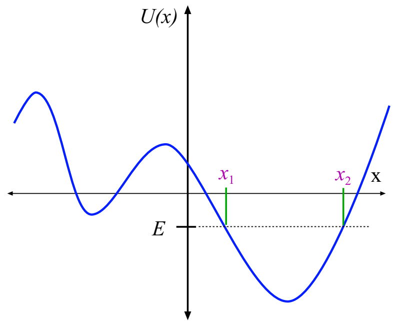
c) How far does the mass move on the rough surface?

The force of friction has magnitude $\mu_k mg$ and opposes the motion; if the mass slides a distance z then the work done by friction is $W_{\mathrm{fric}} = -\mu_k mgz$. As it comes to rest, the change in energy is $\Delta E = 0 - \frac{1}{2}mv_2^2$. Thus:

$$\Delta E = W_{\mathrm{fric}} \qquad \Longrightarrow \qquad -\tfrac{1}{2}mv_2^2 = -\mu_k mgz \qquad \Longrightarrow \qquad z = \frac{v_2^2}{2\mu_k g} = \frac{(1.48\frac{\mathrm{m}}{\mathrm{s}})^2}{2(0.20)(9.80\frac{\mathrm{m}}{\mathrm{s}^2})} = 0.56\ \mathrm{m}$$

2. A potential energy curve for a particle moving in one dimension is shown at the right; on the vertical axis is indicated the total energy of the particle, E.

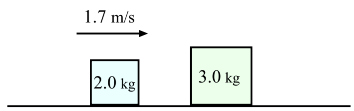
Mark the turning points of the motion for this particle. Briefly *explain* your choice.



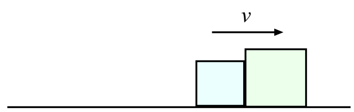
The turning points are the values of x where the potential energy U equals the total energy E so that the KE is zero, and the particle must turn around. These values of x are marked on the graph.

3. On a frictionless level track, a 2.0 kg mass approaches a stationary 3.0 kg mass at a speed of $1.70\frac{\mathrm{m}}{\mathrm{s}}$. The masses stick together in a one-dimensional collision.

What is the final speed of the masses?



The masses make up an isolated system during their interaction (so horizontal forces; vertical forces cancel out) so that their total momentum is conserved. If the final velocity of the masses is v, then this condition gives



$$(2.0\ \mathrm{kg})(1.70\tfrac{\mathrm{m}}{\mathrm{s}}) + 0 = (2.0\ \mathrm{kg} + 3.0\ \mathrm{kg})v$$

Solve for v:

$$v = \frac{(2.0\ \mathrm{kg})(1.70\frac{\mathrm{m}}{\mathrm{s}})}{(5.0\ \mathrm{kg})} = 0.68\tfrac{\mathrm{m}}{\mathrm{s}}$$

You must show all your work and include the right units with your answers!

$$\mathbf{F} = m\mathbf{a} \qquad W = mg \qquad g = 9.80\tfrac{\mathrm{m}}{\mathrm{s}^2} \qquad a_c = \frac{v^2}{r} \qquad F_{\mathrm{spr}} = -kx \qquad f_k = \mu_k n \qquad f_{\mathrm{s}}^{\mathrm{Max}} = \mu_s n$$

$$K = \tfrac{1}{2}mv^2 \qquad U_{\mathrm{grav}} = mgy \qquad U_{\mathrm{spr}} = \tfrac{1}{2}kx^2 \qquad x_{\mathrm{cm}} = \frac{1}{M}\sum_i m_i x_i \qquad \mathbf{p} = m\mathbf{v}$$