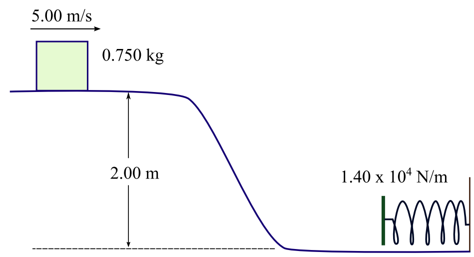
Name________________________

Mar. 16, 2012

Quiz #3 — Spring 2012

Phys 2110 – Sec 4

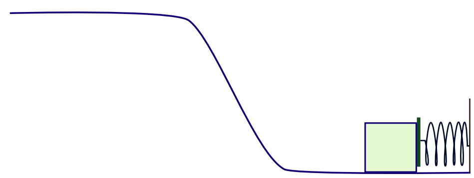
1. A 0.750−kg mass is sliding on a flat frictionless surface at a speed of $5.00\frac{\text{m}}{\text{s}}$. It slides smoothly down a frictionless slope to a flat (frictionless!) surface 2.00 m lower than the first one, where it slides into a spring of force constant $1.40 \times 10^4 \frac{\text{N}}{\text{m}}$, compressing it and momentarily coming to rest!



a) What is the kinetic energy of the mass as it moves on the top surface?

At the top we have

$$K = \tfrac{1}{2}mv^2 = \tfrac{1}{2}(0.750\ \text{kg})(5.00\tfrac{\text{m}}{\text{s}})^2 = \boxed{9.38\ \text{J}}$$



b) By how much is the spring maximally compressed?

There are no friction forces (and normal forces from the surface do now work) so mechanical energy is conserved. In the final position (zero height) we have only the potential energy of the spring, thus

$$E_{\text{top}} = E_{\text{bottom}} \qquad \Longrightarrow \qquad \tfrac{1}{2}mv^2 + mgh = \tfrac{1}{2}kx^2$$

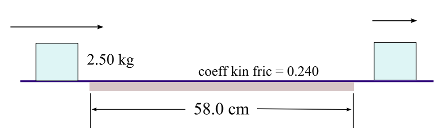
The kinetic energy was found in (a), while the initial potential energy is

$$mgh = (0.750\ \text{kg})(9.80\tfrac{\text{m}}{\text{s}^2})(2.00\ \text{m}) = 14.7\ \text{J} \qquad \Longrightarrow \qquad E = 9.38\ \text{J} + 14.7\ \text{J} = 24.1\ \text{J}$$

Then

$$E = 24.1\ \text{J} = \tfrac{1}{2}kx^2 \qquad \Longrightarrow \qquad x^2 = \frac{2(24.1\ \text{J})}{(1.40 \times 10^4\ \frac{\text{N}}{\text{m}})} \qquad \Longrightarrow \qquad x = \boxed{5.87\ \text{cm}}$$

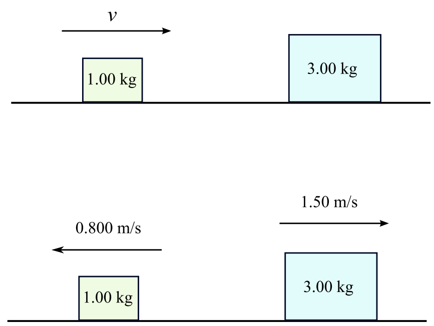
2. A 2.50−kg mass slides 58.0 cm on a flat surface with coefficient of kinetic friction 0.240.
What is the work done by friction?



Force of friction has magnitude $f_k = \mu_k n = \mu_k mg$. Friction is directed *opposite* the direction of motion, so

$$W_{\text{fric}} = Fd\cos\theta = \mu_k mgd(-1) = -(0.240)(2.50\ \text{kg})(9.80\tfrac{\text{m}}{\text{s}^2})(0.580\ \text{m}) = \boxed{-3.41\ \text{J}}$$

3. A 1.00 kg moves moves on a frictionless track to the right, toward a stationary 3.00 kg mass. It collides, and after the collision, the 1.00 kg mass is moving to the left at a speed of $0.800\frac{\text{m}}{\text{s}}$ and the 3.00−kg mass moves to the right with a speed of $1.50\frac{\text{m}}{\text{s}}$.



a) What was the initial speed of the 1.00−kg mass?

Isolated system; momentum is conserved. If the initial velocity of the 1.00−kg mass was v then

$$(1.00\ \text{kg})v = (1.00\ \text{kg})(-0.800\tfrac{\text{m}}{\text{s}}) + (3.00\ \text{kg})(1.50\tfrac{\text{m}}{\text{s}}) \qquad \Longrightarrow \qquad v = 3.70\tfrac{\text{m}}{\text{s}}$$

Initial speed was $\boxed{v = 3.70\frac{\text{m}}{\text{s}}}$.

b) What is the speed of the center of mass before the collision?

Before collision,

$$V_{cm} = \frac{1}{M}\sum m_i v_i = \frac{1}{4.00\ \text{kg}}(1.00\ \text{kg})(3.70\tfrac{\text{m}}{\text{s}}) = \boxed{0.925\tfrac{\text{m}}{\text{s}}}.$$

c) What is its speed after the collision? (Whatever you say here, *give a reason*.)

It is the same after the collision because in the absence of external forces the acceleration of the center of mass is constant, hence the cm velocity is constant. $v = \boxed{0.925\frac{\text{m}}{\text{s}}}$.

d) How much energy was lost in this collision?

Initial kinetic energy of the system was

$$K_{\text{Tot},i} = \tfrac{1}{2}(1.00\ \text{kg})(3.70\tfrac{\text{m}}{\text{s}})^2 + 0 = 6.84\ \text{J}$$

Final kinetic energy of the system was

$$K_{\text{Tot},f} = \tfrac{1}{2}(1.00\ \text{kg})(0.800\tfrac{\text{m}}{\text{s}})^2 + \tfrac{1}{2}(3.00\ \text{kg})(1.5\tfrac{\text{m}}{\text{s}})^2 = 3.70\ \text{J}$$

Then there was a *loss* of

$$-\Delta K = 6.84\ \text{J} - 3.70\ \text{J} = \boxed{3.14\ \text{J}}$$

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

$$F_c = \frac{mv^2}{r} \qquad f_k = \mu_k n \qquad W = Fs\cos\theta \qquad W = \int_{x_1}^{x_2} F_x\,dx \qquad W = \int_a^b \mathbf{F}\cdot d\mathbf{r} \qquad W_{\text{net}} = \Delta K$$

$$K = \tfrac{1}{2}mv^2 \qquad \Delta U = -W_{a\to b} \qquad U_{\text{grav}} = mgy \qquad U_{\text{spring}} = \tfrac{1}{2}kx^2 \qquad \Delta(K+U) = W_{\text{noncons}}$$

$$\mathbf{r}_{\text{cm}} = \frac{1}{M}\sum_i m_i\mathbf{r}_i \qquad \mathbf{v}_{\text{cm}} = \frac{1}{M}\sum_i m_i\mathbf{v}_i$$

$$\mathbf{p} \equiv m\mathbf{v} \qquad \mathbf{r}_{\text{cm}} = \frac{1}{M}\sum_i m_i\mathbf{r}_i \qquad \mathbf{F}_{\text{net ext}} = M\mathbf{a}_{\text{cm}} = \frac{d\mathbf{P}}{dt} \qquad \text{If } \mathbf{F}_{\text{net ext}} = 0,\ \ \mathbf{P} = \text{ constant}$$