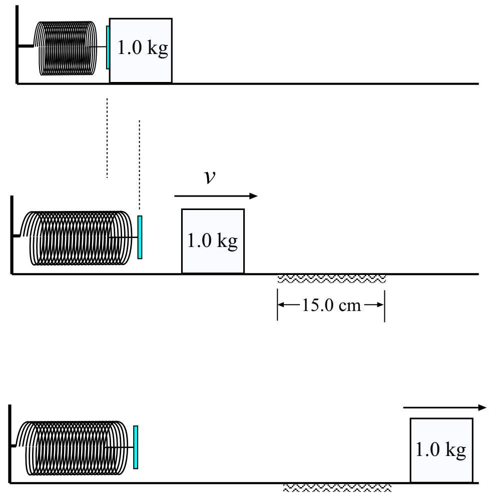
Name________________________________

Oct. 24, 2008

Quiz #3 — Fall 2008

Phys 2110 – Sec 3

1. A 1.0 kg mass moves on a horizontal surface. Initially the mass is held against a horizontal spring of force constant 1600 N/m, compressing it by 4.00 cm. The mass is released; the spring uncompresses and the mass at first slides over a smooth surface.



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

Just after the mass leaves the spring the energy of the system is conserved; the intial potential energy of the spring equals the kinetic energy of the mass, so

$$\tfrac{1}{2}kx^2 = \tfrac{1}{2}mv^2 \qquad \Longrightarrow \qquad v^2 = \frac{kx^2}{m}$$

Plug in numbers:

$$v^2 = \frac{(1600\ \mathrm{N/m})(0.040\ \mathrm{m})^2}{(1.0\ \mathrm{kg})} = 2.56\,\tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v = 1.60\tfrac{\mathrm{m}}{\mathrm{s}}$$

b) The mass then slides for 15.0 cm over a rough surface with a coefficient of kinetic friction of 0.30. What is the work done by friction on the mass?

The normal force of the surface is $n = mg$ and the force of kinetic friction is $f_k = \mu_k n = \mu_k mg$. Since the force of friction *opposes* the motion the work done is

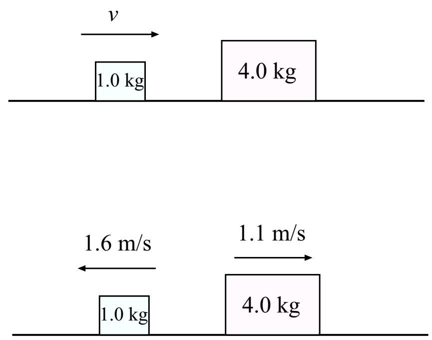
$$W_{\mathrm{fric}} = -f_k d = -\mu_k mgd = -(0.30)(1.0\ \mathrm{kg})(9.80\tfrac{\mathrm{m}}{\mathrm{s}^2})(0.15\ \mathrm{m}) = -0.441\ \mathrm{J}$$

c) What is the kinetic energy of the mass after it leaves the rough surface?

The total energy of the system is initially $E_i = U_{\mathrm{spr}} = \frac{1}{2}kx^2$, but changes (decreases) from the work the work done by friction. When the block leaves the rough surface and has kinetic energy K', the total energy of the system is $E_f = K'$. Thus:

$$K' = E_f = E_i + W_{\mathrm{fric}} = \tfrac{1}{2}kx^2 - 0.441\ \mathrm{J} = 1.28\ \mathrm{J} - 0.441\ \mathrm{J} = 0.84\ \mathrm{J}$$

2. A 1.0 kg mass and a 4.0 kg mass have a one-dimensional collision on a frictionless track. Initially the 1.0 kg mass moves to the right at speed v and the 4.0 kg mass is at rest. After the collision, the 1.0 kg mass moves to the left at speed $1.6\frac{\text{m}}{\text{s}}$ and the 4.0 kg mass moves to the right at speed $1.1\frac{\text{m}}{\text{s}}$



a) What was the speed of the 1.0 kg mass before the collision?

If the initial velocity of the 1.0 kg mass was v, then from momentum conservation,

$$(1.0\text{ kg})v = (1.0\text{ kg})(-1.6\tfrac{\text{m}}{\text{s}}) + (4.0\text{ kg})(+1.1\tfrac{\text{m}}{\text{s}})$$

Solve for v:

$$(1.0\text{ kg})v = 2.8\tfrac{\text{kg}\cdot\text{m}}{\text{s}} \qquad \Longrightarrow \qquad v = 2.8\tfrac{\text{m}}{\text{s}}$$

b) How much energy was lost in the collision?

The initial kinetic energy of the system was

$$K_i = \tfrac{1}{2}m_1v_1^2 = \tfrac{1}{2}(1.0\text{ kg})(2.8\tfrac{\text{m}}{\text{s}})^2 = 3.92\text{ J}$$

The final kinetic energy of the system was

$$K_f = \tfrac{1}{2}m_1v_1'^2 + \tfrac{1}{2}m_2v_2'^2 = \tfrac{1}{2}(1.0\text{ kg})(1.6\tfrac{\text{m}}{\text{s}})^2 + \tfrac{1}{2}(4.0\text{ kg})(1.1\tfrac{\text{m}}{\text{s}})^2 = 3.70\text{ J}$$

The difference is

$$K_f - K_i = 0.22\text{ J}$$

so in the collision, $\boxed{0.22\text{ J}}$ of energy was lost (to thermal energy).

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

$$v_x = v_{x0} + a_xt \qquad x = x_0 + v_{x0}t + \tfrac{1}{2}a_xt^2 \qquad v_x^2 = v_{x0}^2 + 2a_x(x - x_0) \qquad x - x_0 = \tfrac{1}{2}(v_{x0} + v_x)t$$

$$g = 9.80\tfrac{\text{m}}{\text{s}^2} \qquad \mathbf{F} = m\mathbf{a} \qquad v = \frac{2\pi r}{T} \qquad a_c = \frac{v^2}{r} \qquad F_{\text{spr}} = -kx \qquad f_k = \mu_k n$$

$$K = \tfrac{1}{2}mv^2 \qquad W = F\Delta r\cos\theta \qquad W = \int_{x_1}^{x_2} F_x\,dx \qquad U_{\text{grav}} = mgy \qquad U_{\text{spr}} = \tfrac{1}{2}kx^2$$

$$\Delta K + \Delta U = W_{\text{noncons}} \qquad \mathbf{p} = m\mathbf{v} \qquad \mathbf{P} = \sum_i \mathbf{p}_i \quad \text{is constant if } F_{\text{net, ext}} = 0$$