Name________________________

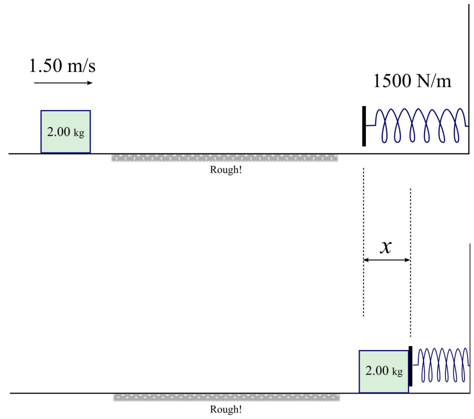
Nov. 2, 2011

Quiz #3 — Fall 2011

Phys 2110 – Sec 4

1. A 2.00−kg mass is moving at $1.50\frac{\text{m}}{\text{s}}$ on a slightly rough surface; it slides into a spring of force constant $1500\frac{\text{N}}{\text{m}}$ maximally compressing it by 5.00 cm.

What was the work done by friction (in this interval)?

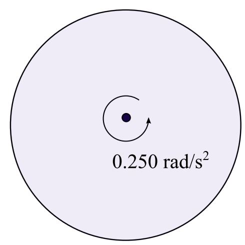


We can't calculate it directly; use $\Delta E = W_{\text{non-cons}}$:

$$\begin{aligned}\Delta E &= \tfrac{1}{2}kx^2 - \tfrac{1}{2}mv^2 \\ &= \tfrac{1}{2}(1500\tfrac{\text{N}}{\text{m}})(0.0500\ \text{m})^2 - \tfrac{1}{2}(2.00\ \text{kg})(1.50\tfrac{\text{m}}{\text{s}})^2 \\ &= -0.375\ \text{J} = W_{\text{fric}}\end{aligned}$$

So the work done by friction was $\boxed{-0.375\ \text{J}}$.

2. A rotating wheel starts from rest and undergoes a constant angular acceleration of $0.25\frac{\text{rad}}{\text{s}^2}$. After 3.00 s how many revolutions has it made?



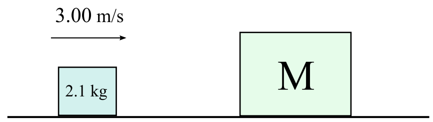
With $\omega_0 = 0$ and $\alpha = 0.25\frac{\text{rad}}{\text{s}^2}$, the angle the wheel turns through is

$$\begin{aligned}\theta - \theta_0 &= \omega_0 t + \tfrac{1}{2}\alpha t^2 \\ &= \tfrac{1}{2}(0.25\tfrac{\text{rad}}{\text{s}^2})(3.00\ \text{s})^2 = 1.12\ \text{rad}\end{aligned}$$

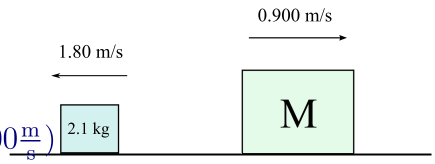
In revolutions this is

$$\Delta\theta = 1.12\ \text{rad}\left(\frac{1\ \text{rev}}{2\pi\ \text{rad}}\right) = \boxed{0.18\ \text{rev}}$$

3. On a one-dimensional frictionless track, 2.10−kg mass slides to the right at a speed of $3.00\frac{\mathrm{m}}{\mathrm{s}}$ and collides with a stationary mass M. After the collision, the 2.10−kg mass moves to the left at a speed of $1.80\frac{\mathrm{m}}{\mathrm{s}}$ and the mass M slides to the right at a speed of $0.900\frac{\mathrm{m}}{\mathrm{s}}$.



a) What is the value of M?



Total momentum is conserved in the collision. This gives

$$P_{xi} = (2.10\ \mathrm{kg})(3.00\tfrac{\mathrm{m}}{\mathrm{s}}) = P_{xf} = (2.10\ \mathrm{kg})(-1.80\tfrac{\mathrm{m}}{\mathrm{s}}) + M(0.900\tfrac{\mathrm{m}}{\mathrm{s}})$$

Solve for M:

$$M = \frac{(2.10\ \mathrm{kg})(4.80\frac{\mathrm{m}}{\mathrm{s}})}{(0.900\frac{\mathrm{m}}{\mathrm{s}})} = \boxed{11.2\ \mathrm{kg}}$$

b) What was the magnitude of the impulse received by the 2.10−kg mass?

"Impulse" is the change in momentum. For the 2.10−kg mass, this is

$$J_x = \Delta p_x = (2.10\ \mathrm{kg})(-1.80\tfrac{\mathrm{m}}{\mathrm{s}}) - (2.10\ \mathrm{kg})(3.00\tfrac{\mathrm{m}}{\mathrm{s}}) = -10.1\tfrac{\mathrm{kg\cdot m}}{\mathrm{s}}$$

The *magnitude* of J_x is

$$|J_x| = \boxed{10.1\tfrac{\mathrm{kg\cdot m}}{\mathrm{s}}}$$

c) How much energy was lost (or gained) in the collision?

Find $\Delta K = K_{\mathrm{Tot},f} - K_{\mathrm{Tot},i}$:

$$\begin{aligned}\Delta K &= \left[\tfrac{1}{2}(11.2\ \mathrm{kg})(0.900\tfrac{\mathrm{m}}{\mathrm{s}})^2 + \tfrac{1}{2}(2.1\ \mathrm{kg})(1.80\tfrac{\mathrm{m}}{\mathrm{s}})^2 - \tfrac{1}{2}(2.10\ \mathrm{kg})(3.00\tfrac{\mathrm{m}}{\mathrm{s}})^2\right] \\ &= -1.512\ \mathrm{J}\end{aligned}$$

So $\boxed{1.51\ \mathrm{J}}$ of energy was $\boxed{\text{lost}}$ in the collision.

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

$$f_k = \mu_k n \qquad W = Fs\cos\theta \qquad W = \int_a^b F_x\,dx \qquad K = \tfrac{1}{2}mv^2 \qquad U_{\mathrm{gr}} = mgy \qquad U_{\mathrm{spr}} = \tfrac{1}{2}kx^2$$

$$\Delta E = \Delta U + \Delta K = W_{\mathrm{non-cons}} \qquad \mathbf{p} = m\mathbf{v} \qquad \mathbf{J} = \Delta\mathbf{p} \qquad \mathbf{F}_{\mathrm{ext}} = M\mathbf{a}_{\mathrm{cm}} \qquad \mathbf{r}_{\mathrm{cm}} = \frac{1}{M}\sum_i m_i\mathbf{r}_i$$

$$\sum \mathbf{F}_{\mathrm{ext}} = 0 \implies \mathbf{P}_i = \mathbf{P}_f \qquad \omega = \omega_0 + \alpha t \qquad \theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2$$