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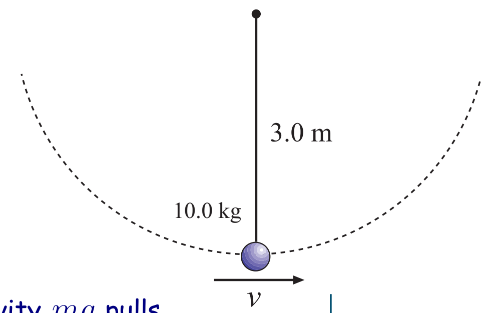
Mar. 21, 2007

**Quiz #3 — Spring 2007**

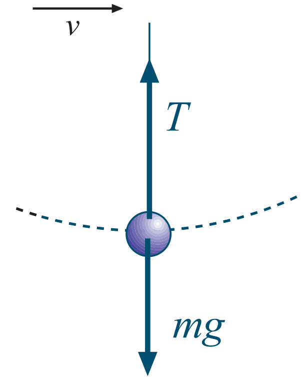
**Phys 2110 – Sec 2**

**1.** A 10.0–kg mass swings in a vertical circle at the end of a cable of length 3.0 m. If the cable cannot withstand a tension greater than 130 N, what is the greatest speed which the mass can have at the bottom of the swing?

I would like to see a free–body diagram (i.e. a force diagram) in your answer!




Here's the force diagram. String tension $T$ pulls up, gravity $mg$ pulls down. The mass is accelerating toward the center of the circular path; the net force is the centripetal force. Then Newton's 2nd law sez:




$$F_{\rm net} = T - mg = \frac{mv^2}{r}$$

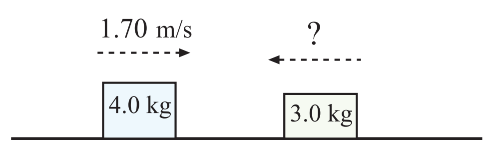
To find the greatest possible $v$, use the greatest possible $T$, namely $T = 130\ \mathrm{N}$. Solve for $v$:

$$\frac{mv^2}{r} = T - mg = 130\ \mathrm{N} - (10.0\ \mathrm{kg})(9.8\tfrac{\mathrm{m}}{\mathrm{s}^2}) = 32\ \mathrm{N}$$

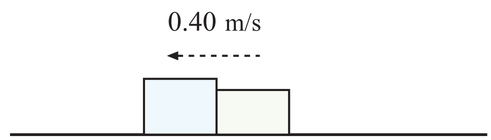
$$v^2 = \frac{(3.0\ \mathrm{m})(32\ \mathrm{N})}{(10.0\ \mathrm{kg})} = 96\ \tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad v = 3.10\tfrac{\mathrm{m}}{\mathrm{s}}$$

**2.** On a one-dimesional track, two low-friction carts are moving: a 4.0 kg cart moves to the right with speed $1.7\frac{\mathrm{m}}{\mathrm{s}}$ and a 3.0 kg cart moves to the left with some unknown speed. The carts collide and stick together; the combined mass moves to the left with speed $0.40\frac{\mathrm{m}}{\mathrm{s}}$.

What was the initial speed of the 3.0 kg cart?




Using momentum conservation,



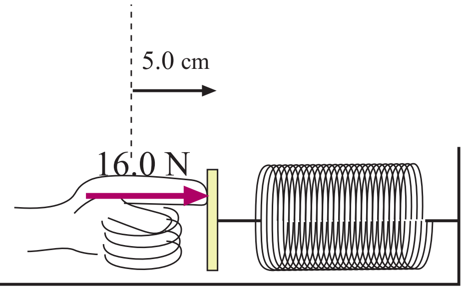

$$(4.0\ \mathrm{kg})(1.7\tfrac{\mathrm{m}}{\mathrm{s}}) + (3.0\ \mathrm{kg})v_x = (7.0\ \mathrm{kg})(-0.40\tfrac{\mathrm{m}}{\mathrm{s}})$$

Solve for $v_x$, get:

$$v_x = -3.2\tfrac{\mathrm{m}}{\mathrm{s}} \qquad \Longrightarrow \qquad |v_x| = 3.2\tfrac{\mathrm{m}}{\mathrm{s}}$$

**3.** When we exert a force on a horizontal ideal spring (as shown) we find that it takes 16.0 N of force to squish the spring by 5.0 cm from its unstressed length.

When the same spring is squished by 8.0 cm, how much energy is stored in the spring?




We are given that the magnitude of the spring force is 16.0 N when the magnitude of its compression is $|x| = 0.050\ \mathrm{m}$. Then the force constant of the spring is

$$k = \frac{|F_x|}{|x|} = \frac{(16.0\ \mathrm{N})}{(0.050\ \mathrm{m})} = 320\ \tfrac{\mathrm{N}}{\mathrm{m}}$$

Then when $|x| = 0.080\ \mathrm{m}$, the energy stored in the spring is

$$U_{\mathrm{spring}} = \tfrac{1}{2}kx^2 = \tfrac{1}{2}(320\ \tfrac{\mathrm{N}}{\mathrm{m}})(0.080\ \mathrm{m})^2 = 1.02\ \mathrm{J}$$

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

$$v_x = v_{ix} + a_x t \qquad x = x_i + v_{ix}\Delta t + \tfrac{1}{2}a_x(\Delta t)^2 \qquad v_x^2 = v_{ix}^2 + 2a_x\Delta x \qquad x - x_i = \tfrac{1}{2}(v_{ix} + v_x)\Delta t$$

$$g = 9.80\tfrac{\mathrm{m}}{\mathrm{s}^2} \qquad a = g\sin\theta \qquad \mathbf{F}_{\mathrm{net}} = m\mathbf{a} \qquad f_{\mathrm{s}}^{\mathrm{max}} = \mu_{\mathrm{s}} n \qquad f_{\mathrm{k}} = \mu_{\mathrm{k}} n$$

$$\mathbf{p} = m\mathbf{v} \qquad \mathbf{J} = \Delta\mathbf{p} \qquad \mathbf{F}_{\mathrm{av}} = \frac{\Delta\mathbf{p}}{\Delta t} \qquad \text{Isolated system: } \mathbf{P} \text{ is conserved}$$

$$F_x = -kx \qquad K = \tfrac{1}{2}mv^2 \qquad U_{\mathrm{grav}} = mgy \qquad U_{\mathrm{spr}} = \tfrac{1}{2}kx^2$$

$$W = \int_{\mathbf{r}_1}^{\mathbf{r}_2} \mathbf{F}\cdot d\mathbf{r} \qquad F_x = -\frac{\partial U}{\partial x} \qquad \Delta E = \Delta K + \Delta U = W_{\mathrm{nc}}$$