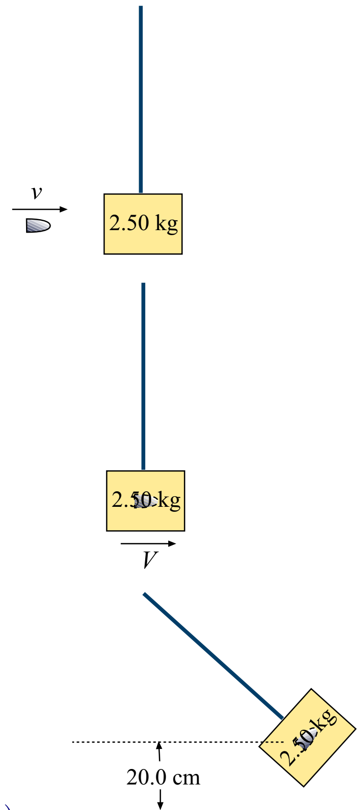
Name________________________________

Oct. 31, 2008

Quiz #4 — Fall 2008

Phys 2110 – Sec 3

1. A bullet of mass 10.0 g is fired horizontally into a suspended block of wood of mass 2.50 kg. After a very rapid collision, the bullet gets stuck in the wood and the block then swings upward to a maximum height of 20.0 cm. (We referred to such a system as a "ballistic pendulum".



a) What was the speed of the bullet/block combination just after the collision?

Conservation of energy after the rapid collision gives (with m and M the bullet and block masses),

$$\tfrac{1}{2}(M+m)V^2 = (M+m)gh \qquad \Longrightarrow \qquad V^2 = 2gh$$

Plug in numbers:

$$V^2 = 2(9.80\,\tfrac{\mathrm{m}}{\mathrm{s}^2})(0.20\ \mathrm{m}) = 3.92\,\tfrac{\mathrm{m}^2}{\mathrm{s}^2} \qquad \Longrightarrow \qquad V = 1.98\,\tfrac{\mathrm{m}}{\mathrm{s}}$$

b) What was the original speed of the bullet?

Conservation of momentum in the collision gives

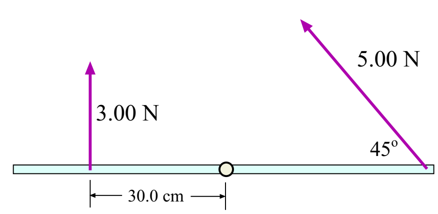
$$mv = (M+m)V \qquad \Longrightarrow \qquad v = \frac{(M+m)}{m}V$$

Plug in numbers:

$$v = \frac{(2.50\ \mathrm{kg} + 0.010\ \mathrm{kg})}{0.010\ \mathrm{kg}}(1.98\,\tfrac{\mathrm{m}}{\mathrm{s}}) = 497\,\tfrac{\mathrm{m}}{\mathrm{s}}$$

2. A 1.00 m–long rod is pivoted about its center so that it rotates in a horizontal plane. Two forces are applied as shown: One force 30.0 cm from the center and the other at the right end of the rod.

Find the magnitude of the total torque on the rod.



With cc-wise the direction for positive torques, add up the torques including the proper signs:

$$\tau_{\mathrm{net}} = -(0.30\ \mathrm{m})(3.00\ \mathrm{N}) + (0.50\ \mathrm{m})(5.00\ \mathrm{N})\sin 45^\circ = +0.868\,\mathrm{N}\cdot\mathrm{m}$$

3. A flywheel turns at an (initial) rate of 800 rpm. It slows down uniformly and comes to rest in 90.0 s.

a) What is the magnitude of its angular acceleration? (Express the answer in $\frac{\text{rad}}{\text{s}^2}$.)

Initial angular velocity is

$$\omega_0 = (800\,\tfrac{\text{rev}}{\text{min}})\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right)\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = 83.8\,\tfrac{\text{rad}}{\text{s}}$$

Angular acceleration is

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{(0 - 83.8)\,\frac{\text{rad}}{\text{s}}}{90.0\ \text{s}} = -0.931\,\tfrac{\text{rad}}{\text{s}^2}$$

Magnitude of the angular acceleration is $\boxed{0.931\,\frac{\text{rad}}{\text{s}^2}}$.

b) How many revolutions did the wheel make as it slowed to a halt?

Here it may be simplest to use

$$\theta - \theta_0 = \tfrac{1}{2}(\omega_0 + \omega)t$$

Plug in numbers:

$$\theta = \tfrac{1}{2}(83.8\,\tfrac{\text{rad}}{\text{s}} + 0)(90.0\ \text{s}) = 3771\ \text{rad}$$

Change to revolutions:

$$(3771\ \text{rad})\left(\frac{1\ \text{rev}}{2\pi\ \text{rad}}\right) = 600\ \text{rev}$$

The wheel makes $\boxed{600}$ revolutions as it slows.

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

$$K = \tfrac{1}{2}mv^2 \qquad W = F\Delta r\cos\theta \qquad W = \int_{x_1}^{x_2} F_x\,dx \qquad U_{\text{grav}} = mgy \quad g = 9.80\,\tfrac{\text{m}}{\text{s}^2} \quad U_{\text{spr}} = \tfrac{1}{2}kx^2$$

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

$$\omega = \omega_0 + \alpha t \qquad \theta = \theta_0 + \omega_0 t + \tfrac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0) \qquad \theta - \theta_0 = \tfrac{1}{2}(\omega_0 + \omega)t$$

$$\tau = rF\sin\theta \qquad \tau = I\alpha \qquad I_{\text{cyl}} = \tfrac{1}{2}MR^2 \qquad I_{\text{sph}} = \tfrac{2}{5}MR^2 \qquad 2\pi\ \text{rad} = 360\ \text{deg}$$