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Phys 221 (Section 8)

Quiz #4

1. In a one-dimensional ("head-on") collision, a 1.0 kg mass with a velocity of 0.7 $\frac{m}{s}$ collides with a 2.0 kg mass with a velocity of $-0.8\,\frac{m}{s}$. After the collision, the 1.0 kg mass has a velocity of $-0.5\,\frac{m}{s}$.

Speeds of the masses are given.

a) What is the final velocity of the 2.0 kg mass?

Total (x-) momentum is conserved:

$(1.0\,kg)(0.7\,\frac{m}{s}) + (2.0\,kg)(-.8\,\frac{m}{s}) = (1.0\,kg)(-.5\,\frac{m}{s}) + (2.0\,kg)\,V_{2f}$

Solve for V_{2f}:

$-.9\,\frac{kg\,m}{s} = -.5\,\frac{kg\,m}{s} + (2.0\,kg)V_{2f}$ $\boxed{V_{2f} = -0.2\,\frac{m}{s}}$

(Mass 2 also moves to the left after the collision.

b) Find the velocity of the center of mass.

The velocity of the CM is the same before and after the collision. Using velocity values before the collision,

$$V_c = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2} = \frac{(1.0\,kg)(0.7\,\frac{m}{s}) + (2.0\,kg)(-.8\,\frac{m}{s})}{3\,kg} = \boxed{-0.30\,\frac{m}{s}}$$

c) How much kinetic energy was lost in the collision?

Initial KE:

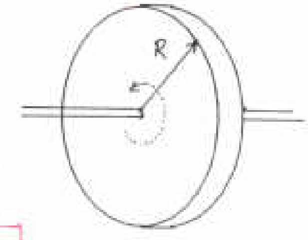
$E_i = \frac{1}{2}(1.0\,kg)(.7\,\frac{m}{s})^2 + \frac{1}{2}(2.0\,kg)(.8\,\frac{m}{s})^2 = 0.885\,J$

Final KE:

$E_f = \frac{1}{2}(1.0\,kg)(.5\,\frac{m}{s})^2 + \frac{1}{2}(2.0\,kg)(.2\,\frac{m}{s})^2 = 0.165\,J$

So $0.885\,J - 0.165\,J$ $\boxed{= 0.72\,J}$ of kinetic energy was lost.

2. A solid cylinder with a mass of 2.0 kg and a radius of 0.2 m rotates about its symmetry axis. It starts from rest and undergoes an angular acceleration of 2.0 $\frac{rad}{s^2}$.



$M = 2.0\,kg$

$R = 0.2\,m$

$\alpha = 2.0\,\frac{rad}{s^2}$

a) How long does it take for it to make 50 revolutions?

$50\,rev = (50\,rev)\left(\frac{2\pi\,rad}{rev}\right) = 314.2\,rad$, angular displacement

Since $\theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 = \frac{1}{2}\alpha t^2$, solve for t: $t = \sqrt{\frac{2\theta}{\alpha}} = \sqrt{\frac{2(314.2)}{2.0\,\frac{rad}{s^2}}} = \boxed{17.7\,s}$

b) How long does it take for it to acquire 10 J of kinetic energy?

When the wheel has 10 J of kinetic energy then

$\frac{1}{2}I\omega^2 = 10\,J$. Since $I = \frac{1}{2}MR^2 = \frac{1}{2}(2.0\,kg)(0.2\,m)^2 = 0.04\,kg\,m^2$, then

$\omega = \sqrt{\frac{2(10\,J)}{0.04\,kg\,m^2}} = 22.4\,\frac{rad}{s}$

Since $\omega = \omega_0 + \alpha t = \alpha t$ then $t = \frac{\omega}{\alpha} = \frac{22.4\,\frac{rad}{s}}{2.0\,\frac{rad}{s^2}} = \boxed{11.2\,s}$

$$\mathbf{p} = m\mathbf{v} \qquad \mathbf{P} = M\mathbf{v}_{cm} \qquad \mathbf{F}_{ext} = \frac{d\mathbf{P}}{dt}$$

For a solid, uniform disk, $I_{cm} = \frac{1}{2}MR^2$