

Your Name: \_\_\_\_\_

**PHY203  
Exam #3  
Chapters 6-8  
Fri., 11/21/14**

# **Solutions**

1. a. Two cars (masses 1250 kg and 1400 kg) travel at each other from opposite directions and come to a complete stop after crashing into each other.  
a. If the 1250 kg car was traveling with a speed of 15.0 m/s before the collision, find the speed of the 1400 kg car.

$$\vec{p}_i = \vec{p}_f = 0$$

$$0 = (m_1 v_1 + m_2 v_2)$$

**10**

$$v_2 = \frac{(1250\text{kg})(15.0\text{m/s})}{1400\text{kg}} = 13.4\text{m/s}$$

- b. Is this collision elastic or inelastic? Explain how you can tell *in this case* without doing a calculation (be brief).

The collision must be inelastic because the kinetic energy changed.

It was greater than 0 before the collision but equal to 0 after the collision. **10**

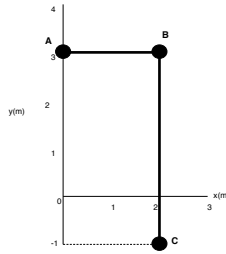
- c. Find the total change in kinetic energy before vs. after the collision.

$$K_f = 0$$

$$\Delta K = K_i = \frac{1}{2} m v_1^2 + \frac{1}{2} m v_2^2 =$$

**10**

$$\frac{1}{2}(1250)(15.0)^2 + \frac{1}{2}(1400)(13.4)^2 = 2.66 \times 10^5 \text{ J}$$



2. Three disks are connected by rods as shown above. The masses of the disks are as follows:  $M_A=1.50\text{ kg}$ ;  $M_B=2.50\text{ kg}$  and  $M_C=3.00\text{ kg}$ . The mass of the short rod is  $2.00\text{ kg}$ ; the mass of the long rod is  $4.00\text{ kg}$ .

a. Find the center of mass of the system and write it in vector notation.

$$x_{CM} = \frac{(1.50)(0) + (2.50)(2.00) + (3.00)(2.00) + (2.00)(1.00) + (4.00)(2.00)}{1.50\text{kg} + 2.50\text{kg} + 3.00\text{kg} + 2.00\text{kg} + 4.00\text{kg}}$$

$$= 1.62\text{m}$$

$$x_{CM} = \frac{(1.50\text{kg})(0) + (2.50\text{kg})(2.00\text{m}) + (3.00\text{kg})(2.00\text{m}) + (2.00\text{kg})(1.00\text{m}) + (4.00\text{kg})(2.00\text{m})}{1.50\text{kg} + 2.50\text{kg} + 3.00\text{kg} + 2.00\text{kg} + 4.00\text{kg}}$$

**15**

$$= 1.62\text{m}$$

$$y_{CM} = \frac{(1.50)(3.00) + (2.00)(3.00) + (2.50)(3.00) + (3.00)(-1.00) + (4.00)(1.00)}{13\text{kg}}$$

$$= 1.46\text{m}$$

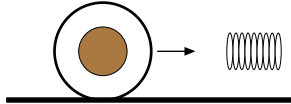
$$\vec{r}_{CM} = 1.62\hat{m}_i + 1.46\hat{m}_j$$

b. Find the moment of inertia of the system about the y-axis. (Hint: the long rod, not the short rod, can be treated as a point particle at its center of mass).

$$I = (1.50\text{kg})(0) + (2.50\text{kg})(2.00\text{m})^2 + (3.00\text{kg})(2.00\text{m})^2 + (4.00\text{kg})(2.00\text{m})^2 + \frac{1}{3}(2.00\text{kg})(2.00\text{m})^2$$

$$= 40.7\text{kgm}^2$$

**15**



3. A concentric cylinder is rolling along the ground with a linear speed of 3.50 m/s. The inner cylinder is solid with a mass of 4.00 kg and a radius of 0.500 m. The outer thin cylinder is hollow with a mass of 2.50 kg and a radius of 0.750 m.
- a. Find the moment of inertia of the object about its center of mass.

$$I = \frac{1}{2}M_i R_i^2 + M_o R_o^2 = \frac{1}{2}(4.00)(0.500)^2 + (2.50)(0.750)^2 = 1.91 \text{ kgm}^2 \quad \mathbf{10}$$

- b. Find the angular speed of the object.

$$\omega = \frac{v}{r} = \frac{3.50}{0.750} = 4.67 \text{ rad/s} \quad \mathbf{10}$$

- c. Find the kinetic energy of the object.

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}(6.50)(3.50)^2 + \frac{1}{2}(1.91)(4.67)^2 = 60.6 \text{ J} \quad \mathbf{10}$$

- d. The object runs into a spring with a spring constant of 500 N/m. Find the maximum compression of the spring.

$$K = 60.7 = \frac{1}{2}kx^2 = \frac{1}{2}(500)x^2 \quad \mathbf{10}$$

$$x = 0.492 \text{ m}$$

### Alternate Version

1. a. Two cars (masses 1350 kg and 1500 kg) travel at each other from opposite directions and come to a complete stop after crashing into each other.

a. If the 1350 kg car was traveling with a speed of 14.0 m/s before the collision, find the speed of the 1500 kg car.

$$\vec{p}_i = \vec{p}_f = 0$$

$$0 = (m_1 v_1 + m_2 v_2)$$

**10**

$$v_2 = \frac{(1350\text{kg})(14.0\text{m/s})}{1500\text{kg}} = 12.6\text{m/s}$$

b. Is this collision elastic or inelastic? Explain how you can tell *in this case* without doing a calculation (be brief).

The collision must be inelastic because the kinetic energy changed.

It was greater than 0 before the collision but equal to 0 after the collision. **10**

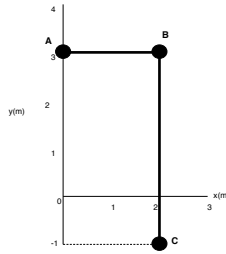
c. Find the total change in kinetic energy before vs. after the collision.

$$K_f = 0$$

$$\Delta K = K_i = \frac{1}{2} m v_1^2 + \frac{1}{2} m v_2^2 =$$

**10**

$$\frac{1}{2}(1350)(14.0)^2 + \frac{1}{2}(1500)(12.6)^2 = 2.51 \times 10^5 \text{ J}$$



2. Three disks are connected by rods as shown above. The masses of the disks are as follows:  $M_A=1.50\text{ kg}$ ;  $M_B=3.50\text{ kg}$  and  $M_C=4.00\text{ kg}$ . The mass of the short rod is  $3.00\text{ kg}$ ; the mass of the long rod is  $5.00\text{ kg}$ .

a. Find the center of mass of the system and write it in vector notation.

$$x_{CM} = \frac{(1.5)(0) + (3.50)(2.00) + (4.00)(2.00) + (3.00)(1.00) + (5.00)(2.00)}{1.50\text{kg} + 3.50\text{kg} + 4.00\text{kg} + 3.00\text{kg} + 5.00\text{kg}}$$

$$= 1.65\text{m}$$

$$x_{CM} = \frac{(1.50\text{kg})(0) + (2.50\text{kg})(2.00\text{m}) + (3.00\text{kg})(2.00\text{m}) + (2.00\text{kg})(1.00\text{m}) + (4.00\text{kg})(2.00\text{m})}{1.50\text{kg} + 2.50\text{kg} + 3.00\text{kg} + 2.00\text{kg} + 4.00\text{kg}}$$

**15**

$$= 1.62\text{m}$$

$$y_{CM} = \frac{(1.50)(3.00) + (3.00)(3.00) + (3.50)(3.00) + (4.00)(-1.00) + (5.00)(1.00)}{17\text{kg}}$$

$$= 1.47\text{m}$$

$$\vec{r}_{CM} = 1.65\hat{m}_i + 1.47\hat{m}_j$$

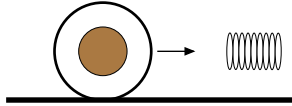
b. Find the moment of inertia of the system about the y-axis. (Hint: the long rod, not the short rod, can be treated as a point particle at its center of mass).

$$I = (1.50\text{kg})(0) + (3.50\text{kg})(2.00\text{m})^2 + (4.00\text{kg})(2.00\text{m})^2$$

$$+ (5.00\text{kg})(2.00\text{m})^2 + \frac{1}{3}(3.00\text{kg})(2.00\text{m})^2$$

**15**

$$= 54.0\text{kgm}^2$$



3. A concentric cylinder is rolling along the ground with a linear speed of 4.50 m/s. The inner cylinder is solid with a mass of 5.00 kg and a radius of 0.500 m. The outer thin cylinder is hollow with a mass of 3.50 kg and a radius of 0.750 m.
- a. Find the moment of inertia of the object about its center of mass.

$$I = \frac{1}{2}M_i R_i^2 + M_o R_o^2 = \frac{1}{2}(5.00)(0.500)^2 + (3.50)(0.750)^2 = 2.59 \text{ kgm}^2 \quad \mathbf{10}$$

- b. Find the angular speed of the object.

$$\omega = \frac{v}{r} = \frac{4.50}{0.750} = 6.00 \text{ rad/s} \quad \mathbf{10}$$

- c. Find the kinetic energy of the object.

$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}(8.50)(4.50)^2 + \frac{1}{2}(2.59)(6.00)^2 = 133 \text{ J} \quad \mathbf{10}$$

- d. The object runs into a spring with a spring constant of 500 N/m. Find the maximum compression of the spring.

$$K = 133 = \frac{1}{2}kx^2 = \frac{1}{2}(500)x^2 \quad \mathbf{10}$$

$$x = 0.729 \text{ m}$$

