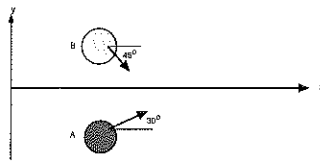


Your Name: _____

**PHY203
Exam #3
Chapters 8-10
Mon., 12/11/17**

Solutions

Exam3F17



1. Two disks traveling on an horizontal, frictionless surface, collide and stick together. The masses and speeds before the collision of disk A are 2.50 kg and 3.00 m/s and of disk B are 3.50 kg and 4.00 m/s.

a. Is this collision elastic or inelastic?

5

b. Which of the following are conserved in the collision? (Circle all that apply.)

momentum

kinetic energy

total energy

5

c. Find the momenta of the two disks, p_A and p_B , before the collision in vector notation.

$$\begin{aligned} \vec{p}_A &= (2.50) (3.00 \cos 30^\circ \hat{i} + 3.00 \sin 30^\circ \hat{j}) \\ &= (6.50 \hat{i} + 3.75 \hat{j}) \text{ kg m/s} \end{aligned}$$

5

$$\begin{aligned} \vec{p}_B &= (3.50) (4.00 \cos 45^\circ \hat{i} - 4.00 \sin 45^\circ \hat{j}) \\ &= (9.90 \hat{i} - 9.90 \hat{j}) \text{ kg m/s} \end{aligned}$$

5

d. Find the velocity in vector notation of the 2-disk system after the collision.

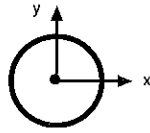
$$\begin{aligned} \vec{p}_{tot_c} &= \vec{p}_A + \vec{p}_B = (16.4 \hat{i} - 6.15 \hat{j}) \text{ kg m/s} \\ &= \vec{p}_f = (6.00) \vec{v}_f \end{aligned}$$

10

$$x: 16.4 = 6.00 v_{fx}, \quad v_{fx} = 2.73 \text{ m/s}$$

$$y: -6.15 = 6.00 v_{fy}, \quad v_{fy} = -1.02 \text{ m/s}$$

$$\vec{v}_f = (2.73 \hat{i} - 1.02 \hat{j}) \text{ m/s}$$



2. A thin spherical shell has a mass of 4.50 kg and a radius of 0.750 m. It is rotating about an axis through its center with angular speed of 5.50 rad/s in a clockwise direction.

a. Find the moment of inertia of the shell.

$$I = \frac{2}{3} (4.50) (0.750)^2 = 1.69 \text{ kg m}^2 \quad 5$$

b. Find the angular momentum of the shell in vector notation. Assume out of the page is the +z-direction..

$$\begin{aligned} \vec{L} &= I \vec{\omega} = (1.69) (5.50) (-\hat{k}) \\ &= -9.30 \hat{k} \text{ kg m}^2/\text{s} \end{aligned} \quad \begin{array}{l} \triangle \\ \text{right hand} \\ \text{rule} \end{array} \quad 5$$

c. Find the kinetic energy of the shell.

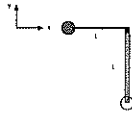
$$\begin{aligned} K &= \frac{1}{2} I \omega^2 = \frac{1}{2} (1.69) (5.50)^2 \\ &= 25.6 \text{ J} \end{aligned} \quad 5$$

d. Find how long it takes the shell to rotate through 900°.

$$\begin{aligned} 900^\circ \cdot \frac{2\pi}{360} &= 15.7 \text{ rad} \\ 15.7 &= \omega t = (5.50)t \\ t &= 2.86 \text{ s} \end{aligned} \quad 10$$

e. If an energy of 75.0 J was added to the shell, find the new angular speed of the shell.

$$\begin{aligned} K_f &= 25.6 + 75.0 = 100.6 = \frac{1}{2} I \omega_f^2 \\ 100.6 &= \frac{1}{2} (1.69) \omega_f^2 \\ \omega_f &= 10.9 \text{ rad/s} \end{aligned} \quad 10$$



3. A ball of mass 3.00 kg is attached to a string of length $L=0.750$ m. Initially it is at rest at $y=0$ as shown above. It is released and swings down, eventually hitting and sticking to the 2.00 kg rod of length 0.750 m at the bottom of the swing.

a. Find the speed of the ball at the bottom of its swing, just before it hits the rod.

$$mgh = \frac{1}{2}mv^2 \quad (\text{cons. of En.})$$

$$v = \sqrt{2g \cdot 0.75} = 3.84 \text{ m/s}$$

5

b. Find the angular momentum of the ball about the pivot point (at the top of the string) just before it hits the rod and write it in vector notation. Assume that the z -axis is positive "out of the paper".

$$L = mvr = (3.00)(3.84)(0.75)$$

$$= 8.64$$

10

$\vec{L} = 8.64 \hat{k} \text{ kg m}^2/\text{s}$

c. Find the angular momentum of ball/rod combination just after the collision and write it in vector notation.

same as b.

5

d. Find the moment of inertia of the rod with the ball stuck to it.

$$I = mr^2 + \frac{1}{3}ML^2$$

$$= (3.00)(0.75)^2 + \frac{1}{3}(2.00)(0.75)^2$$

$$= 2.06 \text{ kg m}^2$$

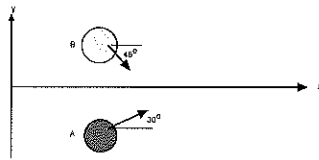
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e. Find the angular speed of the rod/ball combination just as it starts to swing up.

$$\omega_f = \frac{L}{I} = \frac{8.64}{2.06} = 4.19 \frac{\text{rad}}{\text{s}}$$

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Exam3F17alt



1. Two disks traveling on an horizontal, frictionless surface, collide and stick together. The masses and speeds before the collision of disk A are 3.50 kg and 1.50 m/s and of disk B are 2.50 kg and 3.00 m/s.

a. Is this collision elastic or inelastic?

5

b. Which of the following are conserved in the collision? (Circle all that apply.)

momentum

kinetic energy

total energy

5

c. Find the momenta of the two disks, p_A and p_B , before the collision in vector notation.

$$\begin{aligned} \vec{p}_A &= (3.50)(1.50 \cos 30^\circ \hat{i} + 1.50 \sin 30^\circ \hat{j}) \\ &= (4.155 \hat{i} + 2.42 \hat{j}) \text{ kg m/s} \end{aligned}$$

$$\begin{aligned} \vec{p}_B &= (2.50)(3.00 \cos 45^\circ \hat{i} - 3.00 \sin 45^\circ \hat{j}) \\ &= (5.30 \hat{i} - 5.30 \hat{j}) \text{ kg m/s} \end{aligned}$$

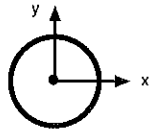
d. Find the velocity in vector notation of the 2-disk system after the collision.

$$\begin{aligned} \vec{p}_{tot} &= \vec{p}_A + \vec{p}_B = (9.85 \hat{i} - 2.68 \hat{j}) \text{ kg m/s} \\ &= p_f = (6.00) \vec{v}_f \end{aligned}$$

$$x: 9.85 = 6.00 v_{fx} \quad v_{fx} = 1.64 \text{ m/s}$$

$$y: -2.68 = 6.00 v_{fy} \quad v_{fy} = -0.447 \text{ m/s}$$

$$\vec{v}_f = (1.64 \hat{i} - 0.447 \hat{j}) \text{ m/s}$$



2. A thin spherical shell has a mass of 5.50 kg and a radius of 0.750 m. It is rotating about an axis through its center with angular speed of 6.50 rad/s in a clockwise direction.

a. Find the moment of inertia of the shell.

$$I = \frac{2}{3} MR^2 = \frac{2}{3} (5.50)(0.75)^2 = 2.06 \text{ kg m}^2 \quad 5$$

b. Find the angular momentum of the shell in vector notation. Assume out of the page is the +z-direction..

$$\begin{aligned} \vec{L} &= I\omega = (2.06)(6.50)(-\hat{k}) \\ &= -13.4 \hat{k} \text{ kg m}^2/\text{s} \end{aligned} \quad \begin{array}{l} \uparrow \text{ r.t. hand} \\ \text{rule} \end{array} \quad 5$$

c. Find the kinetic energy of the shell.

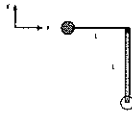
$$\begin{aligned} K &= \frac{1}{2} I \omega^2 = \frac{1}{2} (2.06)(6.50)^2 \\ &= 43.5 \text{ J} \end{aligned} \quad 5$$

d. Find how long it takes the shell to rotate through 800° .

$$\begin{aligned} 800^\circ \cdot \frac{2\pi}{360} &= 14.0 \text{ rad} \\ 14.0 &= \omega t = (6.50)t \\ t &= 2.15 \text{ s} \end{aligned} \quad 10$$

e. If an energy of 65.0 J was added to the shell, find the new angular speed of the shell.

$$\begin{aligned} K_f &= 43.5 + 65.0 = 108.5 \\ &= \frac{1}{2} I \omega_f^2 \\ 108.5 &= \frac{1}{2} (2.06) \omega_f^2 \\ \omega_f &= 10.3 \text{ rad/s} \end{aligned} \quad 10$$



3. A ball of mass 4.00 kg is attached to a string of length $L=0.850$ m. Initially it is at rest at $y=0$ as shown above. It is released and swings down, eventually hitting and sticking to the 3.00 kg rod of length 0.850 m at the bottom of the swing.

a. Find the speed of the ball at the bottom of its swing, just before it hits the rod.

$$\frac{1}{2} m v^2 = m g h \quad (\text{cons. of En.})$$

$$v = \sqrt{2gh} = \sqrt{2 \cdot 9.8 \cdot 0.85} = 4.08 \text{ m/s}$$

5

b. Find the angular momentum of the ball about the pivot point (at the top of the string) just before it hits the rod and write it in vector notation. Assume that the z -axis is positive "out of the paper".

$$L = m v r = (4.00)(4.08)(0.850) = 13.9$$

$$\vec{L} = 13.9 \hat{k} \text{ kg m}^2/\text{s}$$

right hand rule

10

c. Find the angular momentum of ball/rod combination just after the collision and write it in vector notation.

same as b.

5

d. Find the moment of inertia of the rod with the ball stuck to it.

$$I = m r^2 + \frac{1}{3} M L^2$$

$$= (4)(0.85)^2 + \frac{1}{3} (3.00)(0.850)^2$$

$$= 3.61 \text{ kg m}^2$$

10

e. Find the angular speed of the rod/ball combination just as it starts to swing up.

$$\omega_f = \frac{L}{I} = \frac{13.9}{3.61} = 3.85 \frac{\text{rad}}{\text{s}}$$

5