

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

**PHY203**  
**Exam #3**  
**Chapters 9-11,15**  
**12/13/21**

Solutions

Exam3F21

1. Bored, a boy shoots his pellet gun at a piece of cheese that sits, keeping cool for dinner guests, on a massive block of ice. On one particular shot, his 1.50 g pellet gets stuck in the cheese, causing it to slide 20.0 cm before coming to a stop. The muzzle velocity of the gun is 59.0 m/s and the cheese has a mass of 120 g. Assume all motion is in the +x direction.

a. Find the linear momentum of the pellet before the collision in vector notation. (10)

$$\begin{aligned}\vec{p}_i &= (1.50 \times 10^{-3} \text{ kg})(59.0 \text{ m/s}) \hat{i} \\ &= 8.85 \times 10^{-2} \text{ kg m/s } \hat{i}\end{aligned}$$

b. Find the linear momentum of the pellet/cheese combination just after the collision. (5)

$$\text{Same} = 8.85 \times 10^{-2} \text{ kg m/s } \hat{i}$$

c. Find the speed of the pellet/cheese combination just after the collision. (10)

$$\begin{aligned}8.85 \times 10^{-2} &= (0.120 \text{ kg} + 1.50 \times 10^{-3} \text{ kg}) v_f \\ &= (0.1215 \text{ kg}) v_f\end{aligned}$$

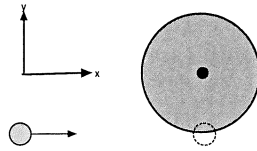
$$v_f = 0.728 \text{ m/s}$$

d. Using Conservation of Energy, find the coefficient of kinetic friction of the cheese sliding on ice. (10)

$$\frac{1}{2} m v^2 = \mu_k F_n \Delta s = \mu_k m g \Delta s$$

$$\mu_k = \frac{v^2}{2 g \Delta s} = \frac{(0.728)^2}{2 g (0.200 \text{ m})}$$

$$= 0.135$$



2. A ball with mass 4.50 kg and negligible size is traveling at a speed of 8.50 m/s in the positive x-direction. It strikes and sticks to the edge of a solid sphere which has a mass of 6.00 kg and a radius of 1.25 m. The sphere, which was initially at rest, is pinned so that it rotates around the center. (Take the z-direction as positive out of the paper.)

a. Find the moment of inertia of the sphere about its pivot point. (5)

$$I = \frac{2}{5} MR^2 = \frac{2}{5} (6.00)(1.25)^2 = 3.75 \text{ kg m}^2$$

b. Find the angular momentum of the ball just before the collision with respect to the pivot point of the sphere and write it in vector notation. (15)

$$\vec{L} = \vec{r} \times \vec{p}, \quad L = (1.25)(4.50)(8.50) = 47.8$$

$$\vec{L} = 47.8 \hat{k} \text{ kg m}^2/\text{s}$$

c. Find the angular momentum of the ball-sphere combination just after the collision. (5)

$$\text{same} = 47.8 \hat{k} \text{ kg m}^2/\text{s}$$

d. Find the magnitude of the angular velocity of the ball-sphere combination immediately after the collision. (15)

$$\begin{aligned} 47.8 &= (I_{\text{sp}} + I_{\text{ball}}) \omega_f \\ &= (3.75 + 4.50 \cdot \underbrace{1.25^2}_{7.03}) \omega_f \\ &= (10.8) \omega_f \\ \omega_f &= 4.43 \frac{\text{rad}}{\text{s}} \end{aligned}$$

3. A block of mass  $m$  on a frictionless table is attached to a spring with spring constant  $k$ , stretched by a distance  $D$  and released at  $t=0$ .

a. Assume that the maximum extension of the spring is  $0.500$  m and that the position of the block is  $-0.300$  m at a time of  $0.750$  s. Find the angular frequency of the block. (15)

$$x = D \cos \omega t$$

$$-0.300 = (0.500) \cos \omega t$$

$$\cos \omega t = -0.600$$

$$\omega t = 2.21 = \omega (0.750)$$

$$\omega = 2.95 \frac{\text{rad}}{\text{s}}$$

b. Assume the mass of the block is  $1.50$  kg. Find the energy of the block/spring. (10)

$$\omega = \sqrt{\frac{k}{m}}, \quad k = m \omega^2 = (1.50)(2.95)^2$$
$$= 13.1$$

$$E = \frac{1}{2} k A^2 = \frac{1}{2} (13.1)(0.500)^2$$
$$= 1.63 \text{ J}$$

Exam3F21alt

1. Bored, a boy shoots his pellet gun at a piece of cheese that sits, keeping cool for dinner guests, on a massive block of ice. On one particular shot, his 2.50 g pellet gets stuck in the cheese, causing it to slide 30.0 cm before coming to a stop. The muzzle velocity of the gun is 61.0 m/s and the cheese has a mass of 110 g. Assume all motion is in the +x direction.

a. Find the linear momentum of the pellet before the collision in vector notation. (10)

$$\begin{aligned}\vec{p}_i &= (2.50 \times 10^{-3})(61.0) \hat{x} \\ &= 0.152 \hat{x} \text{ kg m/s}\end{aligned}$$

b. Find the linear momentum of the pellet/cheese combination just after the collision. (5)

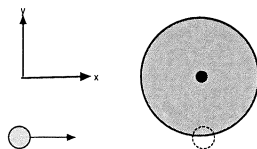
$$\text{same} = 0.152 \hat{x} \text{ kg m/s}$$

c. Find the speed of the pellet/cheese combination just after the collision. (10)

$$\begin{aligned}0.152 &= (2.50 \times 10^{-3} + 110) v_f \\ &= (0.1125) v_f \\ v_f &= 1.35 \text{ m/s}\end{aligned}$$

d. Using Conservation of Energy, find the coefficient of kinetic friction of the cheese sliding on ice. (10)

$$\begin{aligned}\frac{1}{2} m v^2 &= \mu_k F_n \Delta s = \mu_k m g \Delta s \\ \mu_k &= \frac{v^2}{2g \Delta s} = \frac{(1.35)^2}{2g(0.300)} \\ &= 0.310\end{aligned}$$



2. A ball with mass 3.50 kg and negligible size is traveling at a speed of 7.50 m/s in the positive x-direction. It strikes and sticks to the edge of a solid sphere which has a mass of 5.00 kg and a radius of 1.45 m. The sphere, which was initially at rest, is pinned so that it rotates around the center. (Take the z-direction as positive out of the paper.)

a. Find the moment of inertia of the sphere about its pivot point. (5)

$$I = \frac{2}{5} M R^2 = \frac{2}{5} (5.00) (1.45)^2 = 4.20 \text{ kg m}^2$$

b. Find the angular momentum of the ball just before the collision with respect to the pivot point of the sphere and write it in vector notation. (15)

$$\vec{L} = \vec{r} \times \vec{p}$$

$$L = (1.45) (3.50) (7.50) = 38.1$$

$$\vec{L} = 38.1 \hat{k} \text{ kg m}^2/\text{s}$$

c. Find the angular momentum of the ball-sphere combination just after the collision. (5)

$$\text{Same} = 38.1 \hat{k} \text{ kg m}^2/\text{s}$$

d. Find the magnitude of the angular velocity of the ball-sphere combination immediately after the collision. (15)

$$38.1 = (I_{\text{sphere}} + I_{\text{ball}}) \omega_f$$

$$= (4.20 + \underbrace{3.50 \cdot 1.45^2}_{7.36}) \omega_f$$

$$= 11.6 \omega_f$$

$$\omega_f = 3.30 \frac{\text{rad}}{\text{s}}$$

3. A block of mass  $m$  on a frictionless table is attached to a spring with spring constant  $k$ , stretched by a distance  $D$ , and released at  $t=0$ .

a. Assume that the maximum extension of the spring is  $0.600$  m and that the position of the block is  $-0.400$  m at a time of  $0.650$  s. Find the angular frequency of the block. (15)

$$x = D \cos \omega t$$

$$-0.400 = 0.600 \cos \omega (0.650)$$

$$\cos \omega (0.650) = -0.667$$

$$\omega (0.650) = \cos^{-1}(-0.667)$$

$$= 2.30$$

$$\omega = \frac{2.30}{0.650} = 3.53 \frac{\text{rad}}{\text{s}}$$

b. Assume the mass of the block is  $2.50$  kg. Find the energy of the block/spring. (10)

$$E = \frac{1}{2} k A^2$$

$$k = m \omega^2 = (2.50)(3.53)^2$$
$$= 31.2 \text{ N/m}$$

$$E = \frac{1}{2} (31.2)(0.600)^2$$

$$= 5.61 \text{ J}$$