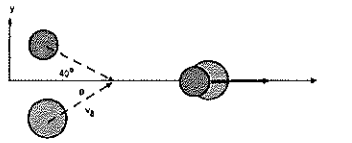


Your Name: _____

PHY203
Exam #3
Chapters 9-11,15
Mon., May 2, 2022

Solutions

Exam3S22



1. A disk (A) of mass 3.25 kg is traveling with a constant speed of 5.50 m/s on a frictionless table. A disk (B) of mass 4.75 kg is traveling with a constant speed, v_B . The trajectories of the disks before they collide are shown above. The disks collide and stick together, traveling in the +x-direction with a speed of 6.50 m/s after the collision.

a. Find the momentum of disk A in vector notation before the collision using the coordinate system above. 15

$$\begin{aligned}\vec{p}_A &= (3.25)(5.50) [\cos 40^\circ \hat{i} - \sin 40^\circ \hat{j}] \\ &= 17.8 [\cos 40^\circ \hat{i} - \sin 40^\circ \hat{j}] \\ &= (13.6\hat{i} - 11.4\hat{j}) \text{ kg m/s}\end{aligned}$$

b. Find the momentum of the two-disk combination in vector notation after the collision using the coordinate system above. 5

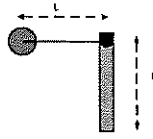
$$\vec{p} = (8.00)(6.50) \hat{i} = 52.0 \hat{i} \text{ kg m/s}$$

c. Find the velocity of disk B in vector notation before the collision using the coordinate system above. 20

$$\begin{aligned}x: \quad 52.0 &= 13.6 + (4.75) v_x \\ v_x &= 8.08 \text{ m/s}\end{aligned}$$

$$\begin{aligned}y: \quad 0 &= -11.4 + (4.75) v_y \\ v_y &= 2.40 \text{ m/s}\end{aligned}$$

$$\vec{v}_B = (8.08\hat{i} + 2.40\hat{j}) \text{ m/s}$$



2. A very small ball of mass 4.50 kg is attached to a very light string of length 1.50 m and held in a horizontal position initially as shown above. It then swings down and hits and sticks to the end of a rod. The rod has a length of 1.50 m, mass of 3.50 kg, and is allowed to pivot about its upper end. The ball-rod combination swings up about this pivot point.

a. Find the moment of inertia of the rod about its pivot point. 5

$$I = \frac{1}{3} (3.50) (1.50)^2 = 2.62 \text{ kg m}^2$$

b. Use Conservation of Energy to find the speed of the ball just as it hits the end of the rod. 5

$$mgh = \frac{1}{2} mv^2$$

$$v = \sqrt{2gh} = \sqrt{2 \cdot 9.8 \cdot 1.5} = 5.42 \text{ m/s}$$

c. Find the angular momentum of the ball in vector notation about the rod's pivot point just before the ball hits the rod. Assume the +z-direction is out of the paper. 10

$$L = (4.50) (5.42) (1.5) = 36.6$$

$$\vec{L} = 36.6 \hat{k} \text{ kg} \frac{\text{m}^2}{\text{s}}$$

d. Find the angular speed of the ball-rod combination just after the collision (before the ball-rod starts swinging up). 15

$$36.6 = (2.62 + I_{\text{ball}}) \omega$$

$$I_{\text{ball}} = mr^2 = 4.50 (1.50)^2 = 10.1$$

$$36.6 = (2.62 + 10.1) \omega$$

$$\omega = 2.87 \frac{\text{rad}}{\text{s}}$$

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. Assuming the energy of the block is 25.0 J, the mass is 2.50 kg, and the spring constant is 750 N/m, find the maximum extension of the spring. 5

$$E = \frac{1}{2} k A^2 \quad 25.0 = \frac{1}{2} (750) A^2$$

$$A = 0.258 \text{ m}$$

b. Find the maximum velocity and maximum acceleration of the block. 20

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{750}{2.50}} = 17.3 \frac{\text{rad}}{\text{s}}$$

$$x = (0.258) \cos(17.3 t)$$

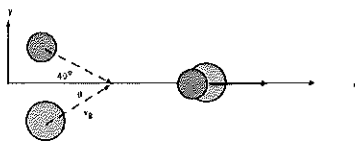
$$v = -(17.3)(0.258) \sin(17.3 t)$$

$$v_{\text{max}} = (17.3)(0.258) = 4.46 \text{ m/s}$$

$$a = -(17.3)^2 (0.258) \cos(17.3 t)$$

$$a_{\text{max}} = (17.3)^2 (0.258) = 77.2 \text{ m/s}^2$$

Exam3S22alt



1. A disk (A) of mass 3.75 kg is traveling with a constant speed of 6.50 m/s on a frictionless table. A disk (B) of mass 5.25 kg is traveling with a constant speed, v_B . The trajectories of the disks before they collide are shown above. The disks collide and stick together, traveling in the +x-direction with a speed of 8.50 m/s after the collision.

a. Find the momentum of disk A in vector notation before the collision using the coordinate system above. 15

$$\begin{aligned}\vec{p}_A &= (3.75)(6.50) [\cos 40^\circ \hat{i} - \sin 40^\circ \hat{j}] \\ &= 24.4 [\cos 40^\circ \hat{i} - \sin 40^\circ \hat{j}] \\ &= (18.7\hat{i} - 15.7\hat{j}) \text{ kg} \cdot \frac{\text{m}}{\text{s}}\end{aligned}$$

b. Find the momentum of the two-disk combination in vector notation after the collision using the coordinate system above. 5

$$\vec{p} = (9.00)(8.50) \hat{i} = 76.5 \hat{i} \text{ kg} \cdot \frac{\text{m}}{\text{s}}$$

c. Find the velocity of disk B in vector notation before the collision using the coordinate system above. 20

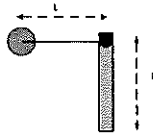
$$x: 76.5 = 18.7 + (5.25)v_x$$

$$v_x = 11.0 \text{ m/s}$$

$$y: 0 = -15.7 + (5.25)v_y$$

$$v_y = 2.99 \text{ m/s}$$

$$\vec{v}_B = (11.0\hat{i} + 2.99\hat{j}) \text{ m/s}$$



2. A very small ball of mass 3.50 kg is attached to a very light string of length 1.50 m and held in a horizontal position initially as shown above. It then swings down and hits and sticks to the end of a rod. The rod has a length of 1.50 m, mass of 4.50 kg, and is allowed to pivot about its upper end. The ball-rod combination swings up about this pivot point.

a. Find the moment of inertia of the rod about its pivot point. 5

$$I = \frac{1}{3} (4.50) (1.50)^2 = 3.38 \text{ kg m}^2$$

b. Use Conservation of Energy to find the speed of the ball just as it hits the end of the rod. 5

$$mgh = \frac{1}{2} m v^2$$

$$v = \sqrt{2gh} = \sqrt{2 \cdot 9.8 \cdot 1.5} = 5.42 \text{ m/s}$$

c. Find the angular momentum of the ball in vector notation about the rod's pivot point just before the ball hits the rod. Assume the +z-direction is out of the paper. 10

$$L = (3.50) (5.42) (1.50) = 28.5$$

$$\vec{L} = 28.5 \hat{k} \text{ kg m}^2/\text{s}$$

d. Find the angular speed of the ball-rod combination just after the collision (before the ball-rod starts swinging up). 15

$$28.5 = (3.38 + I_{\text{ball}}) \omega$$

$$I_{\text{ball}} = m r^2 = (3.50) (1.50)^2 = 7.88$$

$$28.5 = (3.38 + 7.88) \omega$$

$$\omega = 2.53 \frac{\text{rad}}{\text{s}}$$

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. Assuming the energy of the block is 35.0 J, the mass is 2.50 kg, and the spring constant is 850 N/m, find the maximum extension of the spring. 5

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

$$35.0 = \frac{1}{2} (850) A^2$$

$$A = 0.287 \text{ m}$$

b. Find the maximum velocity and maximum acceleration of the block. 20

$$\omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{850}{2.50}} = 18.4 \frac{\text{rad}}{\text{s}}$$

$$x = (0.287) \cos(18.4 t)$$

$$v = -(18.4)(0.287) \sin(18.4 t)$$

$$v_{\text{max}} = (18.4)(0.287) = 5.28 \text{ m/s}$$

$$a = -(18.4)^2 (0.287) \cos(18.4 t)$$

$$a_{\text{max}} = (18.4)^2 (0.287) = 97.2 \text{ m/s}^2$$