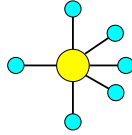


Your Name: _____

PHY203
Exam #4
Chapters 5,9,10,14
Mon., 4/28/14

Solutions



1. 6 balls are attached to a solid disk using thin rods, as shown. The mass of the disk is 5.00 kg; the radius is 0.350 m. The balls are placed a distance of 0.600 m from the center of the disk. The mass of each ball is 0.550 kg. Ignore the radii of the balls.

a. Find the moment of inertia of the system about an axis through the center of the disk and perpendicular to the page.

$$I = \frac{1}{2}M_i R_i^2 + 6M_o R_o^2 = \frac{1}{2}(5.00)(0.350)^2 + 6(0.550)(0.600)^2 \quad \mathbf{10}$$

$$= 1.49 \text{ kgm}^2$$

b. The disk is rotating clockwise as viewed from above through an axis through the center with an angular speed of 3.50 rad/s. Take out of the paper as the positive z-direction. Write the angular velocity in vector notation.

$$\omega = -3.50 \text{ rad} / \text{s} \hat{k} \quad \mathbf{5}$$

c. A torque of +5.00 Nm is applied to the system. Write the angular acceleration of the system in vector notation.

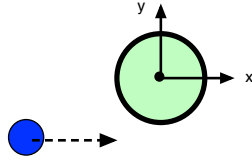
$$\vec{\alpha} = \frac{\vec{\tau}}{I} = \frac{5.00 \hat{k}}{1.49} = 3.36 \text{ rad} / \text{s}^2 \hat{k} \quad \mathbf{5}$$

d. Find the angular speed and angular displacement after the torque has been applied for 3.00 s.

$$\omega = \omega_o + \alpha t = -3.50 + (3.36)(3.00) = 6.58 \text{ rad} / \text{s}$$

15

$$\theta = 0 + (-3.50)(3.00) + \frac{1}{2}(3.36)(3.00)^2 = 4.62 \text{ rad}$$



2. A ball of mass 0.750 kg is traveling in the positive x-direction with a speed of 5.50 m/s. It hits a hollow spherical shell of mass 1.25 kg and radius 0.650 m. The ball sticks to the edge of the sphere which has an axis through its center about which it can rotate (the sphere can not translate). Take the positive z-direction as out of the page. Ignore the radius of the ball.

a. Find the angular momentum of the ball before the collision and write it in vector notation.

$$L = rp \sin \theta = rmv = (0.650)(0.750)(5.50)$$

$$= 2.68 \text{ kgm} / \text{s} \quad \mathbf{10}$$

$$\vec{L} = 2.68 \text{ kgm} / \text{s} \hat{k}$$

b. Find the moment of inertia of the spherical shell about its axis.

$$I = \frac{2}{3} MR^2 = \frac{2}{3}(1.25)(0.650)^2 = 0.352 \text{ kgm}^2 \quad \mathbf{5}$$

c. Find the moment of inertia of the stuck-together ball/spherical shell combination about axis of the shell.

$$I = 0.352 + MR^2 = 0.352 + (0.750)(0.650)^2 = 0.669 \text{ kgm}^2 \quad \mathbf{5}$$

d. Find the angular speed of the ball/shell combination just after the collision.

$$2.68 = (0.669) \omega_f \quad \mathbf{10}$$

$$\omega_f = 4.01 \text{ rad/s}$$

3. A block of mass 0.750 kg is attached to a spring. The block is stretched and released. The equation of motion of the block is as follows (with x in meters):

$$x(t) = (1.25)\cos(4.50\pi t)$$

a. Find the amplitude of the system.

$$A = 1.25 \text{ m} \qquad \qquad \qquad \mathbf{5}$$

b. Find the spring constant of the spring.

$$\omega = \sqrt{\frac{k}{m}} \qquad \qquad \qquad \mathbf{5}$$
$$k = \omega^2 m = (4.50\pi)^2 (0.75) = 150 \text{ N / m}$$

c. Find the maximum acceleration of the block.

$$a_{\text{max}} = \omega^2 A = (4.50\pi)^2 (1.25) = 250 \text{ m / s}^2 \qquad \qquad \qquad \mathbf{10}$$

d. Find the velocity the first time the block is at a position of x = -0.500 m.

$$-0.500 = A \cos(\omega t) = 1.25 \cos(4.50\pi t)$$
$$4.50\pi t = \cos^{-1}(-0.500 / 1.25) = 1.98; t = 0.140 \text{ s}$$
$$v = \frac{dx}{dt} = -\omega A \sin(\omega t) = -(4.50\pi)(1.25)\sin(1.98) \qquad \qquad \qquad \mathbf{15}$$
$$= -16.2 \text{ m / s}$$