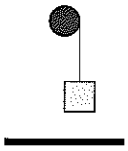
Your Name: _____

PHY203
Exam #3
Chapters 8-10,14
Mon., 4/27/20

Solutions

Exam3S20

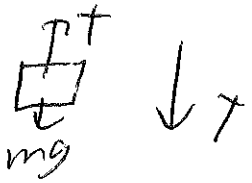


1. A block with mass 4.00 kg is suspended from a light string that is wrapped around a pulley. The pulley is a solid disk of mass 5.50 kg and radius 0.850 m. Initially the block is held at a height of 2.50 m above the floor, then released.

a. Find the moment of inertia of the pulley about its axis. (**5**)

$$I = \frac{1}{2} M r^2 = \frac{1}{2}(5.50)(0.850)^2 = 1.99 \text{ kg m}^2$$

b. Sketch a free body diagram of the block as it is falling. (**5**)



c. Write out Newton's 2nd Law for the block and the torque equation on the pulley. (**10**) Down is + y direction.

$$mg - T = ma$$

$$Tr = I\alpha = I\frac{a}{r}$$

d. Find the linear acceleration of the block while the block is falling. (**10**)

$$Tr = \frac{1}{2} M r^2 \frac{a}{r}$$

$$mg - T = ma$$

$$mg = a\left(m + \frac{M}{2}\right)$$

$$a = \frac{4.00g}{\left(4.00 + \frac{5.50}{2}\right)} = 5.81 \text{ m/s}^2$$

2. A solid sphere is rolling without slipping on a horizontal surface with a linear speed of 5.50 m/s. It rolls up a ramp which makes an angle of 35.0° with respect to the horizontal. The sphere has a mass 2.50 kg and a radius of 1.50 m.

a. Find the moment of inertia of the sphere through its axis. (**5**)

$$I = \frac{2}{5} m r^2 = \frac{2}{5} (2.50)(1.50)^2 = 2.25 \text{ kg m}^2$$

b. Find the kinetic energy of the sphere as it is rolling on the horizontal surface. (**15**)

$$K = \frac{1}{2} m v^2 + \frac{1}{2} I \omega^2$$

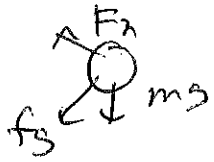
$$= \frac{1}{2} m v^2 + \frac{1}{2} \left(\frac{2}{5} m r^2\right) \frac{v^2}{r^2}$$

$$= \frac{1}{2} m v^2 (1 + .4)$$

$$= \frac{1}{2} (2.50)(5.50)^2 (1.4)$$

$$= 52.9 \text{ J}$$

c. Sketch a free body diagram of the sphere as it rolls without slipping up the ramp. (**5**)



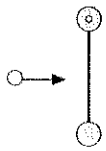
d. Use Conservation of Energy to find the distance (measured along the surface of the ramp) the sphere rolls on the ramp before coming to rest (momentarily). (**15**)

$$52.9 = mgh$$

$$h = \frac{52.9}{2.50\, g} = 2.16 \text{ m}$$

$$\sin 35^\circ = \frac{h}{L}$$

$$L = \frac{h}{\sin 35^\circ} = 3.76 \text{ m}$$



3. A barbell consists of a rod of length 1.50 m and mass 0.500 kg and two balls of mass 0.750 kg at the ends of the rod. The barbell is pinned through one ball and is hanging as shown above. A ball of mass 0.250 kg hits the barbell in the middle and sticks to it. Assume the barbell/ball combination swings up to a maximum angle of 15° and starts swinging down again in periodic motion starting at t=0. (Treat all the balls as point masses.)

a. Find the moment of inertia of the barbell/ball system about the pivot point after the ball sticks to the rod. (**10**)

$$I = \frac{1}{3} M L^2 + (0.75) L^2 + (0.250)\left(\frac{L}{2}\right)^2$$

$$= (1.50)^2 \left(\frac{1.500}{3} + 0.750 + \frac{0.250}{4} \right)$$

$$= 2.20 \text{ kg m}^2$$

b. Find the period of motion of the barbell/ball system. (**10**)

$$T = 2\pi \sqrt{\frac{I}{MgD}} \qquad M = .5 + 2(.75) + .25 = 2.25$$

$$= 2\pi \sqrt{\frac{2.20}{2.25\, g\, (1.50/2)}}$$

$$= 2.29 \text{ s}$$

c. Write an equation of motion of the barbell/ball system (θ vs. t). (**10**)

$$\omega = \frac{2\pi}{T} = 2.74 \text{ rad/s}$$

$$\theta = (15.0^\circ) \cos(2.74t)$$