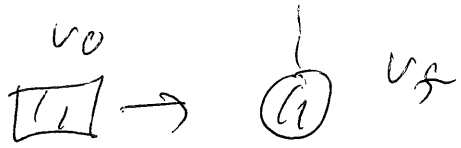
Your Name: _____

PHY203
Exam #3
Chapters 8-10,14
Mon., 4/26/21

Solutions

Exam3S21

1. A 15.0 g bullet is fired into the bob of a ballistic pendulum of mass 1.85 kg. When the bob is at its maximum height, the strings make an angle of 60° with the vertical. The length of the pendulum is 2.50 m. Find the speed of the bullet. (**30**)



$$(0.015)\,v_0 = 1.865\,v_f$$

$$v_0 = 124\,v_f$$

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

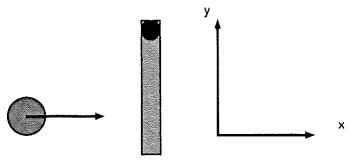
$$v_f = \sqrt{2gh}$$

$$h = L(1-\cos\theta) = 2.50(1-\cos 60^\circ) = 1.25\text{ m}$$

$$v_f = \sqrt{2gh} = 4.95\text{ m/s}$$

$$v_0 = 124(4.95)$$

$$= 615\text{ m/s}$$



2. A 2.50 kg ball is traveling in the +x-direction with a speed of 7.50 m/s when it hits and sticks to a rod that had been hanging down at rest and is free to swing about one end. The rod has a length of 1.50 m and a mass of 4.50 kg. The ball hits the rod at a distance of 1.25 m from the pivot point.

a. Find the linear momentum of the ball in vector notation before it hits the rod. (**10**)

$$\vec{p} = (2.50)(7.50)\,\hat{i}$$
$$= 18.8\ \text{kg}\frac{\text{m}}{\text{s}}\,\hat{i}$$

b. Find the angular momentum of the ball in vector notation just before it hits the rod. Assume the +z-direction is out of the paper. (**10**)

$$\vec{L} = \vec{r} \times \vec{p} = r m v \sin\theta\,\hat{k}$$
$$= (1.25)(18.8)\sin 90^\circ\,\hat{k}$$
$$= 23.5\ \text{kg}\frac{\text{m}^2}{\text{s}}\,\hat{k}$$

c. Find the angular speed of the ball-rod combination just after the collision (before the ball-rod starts swinging up). (**20**)

$$L_i = L_f = 23.5$$
$$L_f = I_f \omega_f$$
$$I_f = \frac{1}{3}ML^2 + mr^2$$
$$= \frac{1}{3}(4.50)(1.50)^2 + (2.50)(1.25)^2$$
$$= 3.375 + 3.906 = 7.28$$
$$\omega_f = \frac{23.5}{7.28} = 3.23\ \frac{\text{rad}}{\text{s}}$$

3. A block of mass m is attached to a spring with spring constant k, stretched by a distance D, and released at t=0. The maximum energy of the block is 25.0 J, the mass is 2.50 kg, and the spring constant is 750 N/m,

a. Find the angular frequency. (**5**)

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

b. Find the find the maximum extension of the spring. (**10**)

$$E = \frac{1}{2} k A^2 = 25.0$$

$$A^2 = \frac{2 \cdot 25.0}{750}$$

$$A = 0.258 \ m$$

d. Write the equation of motion of the block. (x vs. t). (**5**)

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

e. Find the maximum acceleration of the block. (**10**)

$$a = \frac{d^2 x}{dt^2}$$

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

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