CAPA 07: Solutions

Dr. Venkat Kaushik
kaushik@mailbox.sc.edu

October 31, 2015

Solution Let the speed at the lowest point be v_1 and at the highest point be v_2. The total energy is constant.

$$r + d = L \;\Rightarrow\; 2r = 2(L-d)$$
$$mgL = \frac{1}{2}mv_1^2 = \frac{1}{2}mv_2^2 + 2mg(L-d)$$
$$v_1 = \sqrt{2gL} = \sqrt{2\cdot 9.8\cdot 1.2} = 4.85\ m/s$$
$$v_2 = \sqrt{g(4d-2L)} = \sqrt{9.8((4(0.75)-2(1.2))} = 2.42\ m/s$$

••23 ILW The string in Fig. 8-38 is L = 120 cm long, has a ball attached to one end, and is fixed at its other end. The distance d from the fixed end to a fixed peg at point P is 75.0 cm. When the initially stationary ball is released with the string horizontal as shown, it will swing along the dashed arc. What is its speed when it reaches (a) its lowest point and (b) its highest point after the string catches on the peg?

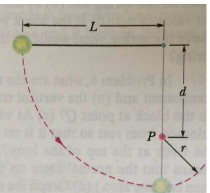
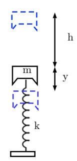


Figure 8-38 Problems 23 and 70.

••24 A block of mass m = 2.0 kg is dropped from height h = 40 cm onto a spring of spring constant k = 1960 N/m (Fig. 8-39). Find the maximum distance the spring is compressed.



Solution Apply conservation of energy. Pick one of the solutions of the quadratic equation that physically makes sense; the other does not.

$$mg(h+y) = \frac{1}{2}ky^2 \;\Rightarrow\; ky^2 - 2y - 2mgh = 0$$
$$y = \frac{1 \pm \sqrt{1+2mghk}}{k} = 0.08995\ m \simeq 9\ cm$$

Solution There are no external forces, so center of mass does NOT move when the dog walks relative to the flatboat.

$$x_{com} = \frac{m_d\cdot x_d + m_b\cdot x_b}{(m_d+m_b)} \;\Rightarrow\; \Delta x_{com} = m_d\Delta x_d + m_b\Delta x_b = 0$$
$$\Rightarrow \Delta x_b = -\frac{m_d}{m_b}\Delta x_d \quad \Delta x_b + d = \Delta x_d$$
$$\Delta x_d = \frac{d}{1+\dfrac{m_d}{m_b}} = \frac{2.4}{1+\dfrac{4.5}{18}} = 1.92\ m$$

The dog moved closer to the shore, so it is (6.1 - 1.92) = 4.18 m from the shore.

•••17 GO In Fig. 9-45a, a 4.5 kg dog stands on an 18 kg flatboat at distance D = 6.1 m from the shore. It walks 2.4 m along the boat toward shore and then stops. Assuming no friction between the boat and the water, find how far the dog is then from the shore. (*Hint:* See Fig. 9-45b.)

Solution At the instant the boy is at an angle θ from the vertical, free body diagram is shown. Applying conservation of energy at the top of the hemisphere and at this instant we get eq (1) and applying Newton's

•••34 GO A boy is initially seated on the top of a hemispherical ice mound of radius R = 13.8 m. He begins to slide down the ice, with a negligible initial speed (Fig. 8-47). Approximate the ice as being frictionless. At what height does the boy lose contact with the ice?

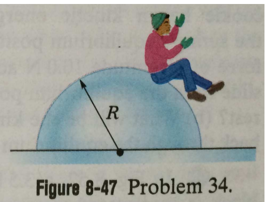
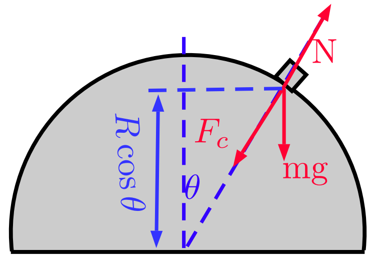


Figure 8-47 Problem 34.



second law along the normal to the hemisphere we get eq (2).

$$mgR = mgR\cos\theta + \frac{1}{2}mv^2 \quad \Rightarrow \frac{mv^2}{R} = F_c = 2mg(1-\cos\theta) \tag{1}$$

$$\frac{mv^2}{R} = F_c = mg\cos\theta - N \tag{2}$$

When the boy loses contact with the hemisphere, normal force tends to zero. Let's call the angle at which this happens as the critical angle θ_c. We can combine eq (1) and (2) and set N=0 and $\theta = \theta_c$ to obtain the height (h) at which he leaves the hemisphere

$$2mg(1-\cos\theta_c) = mg\cos\theta_c \quad \Rightarrow \cos\theta_c = 2/3 \tag{3}$$

$$h = R\cos\theta_c \quad \Rightarrow \boxed{h = 2R/3}$$

Solution The vine does not break. Use conservation of energy to solve it.

$$T - mg = \frac{mv^2}{r}$$

$$mgh = \frac{1}{2}mv^2 \quad \Rightarrow mv^2 = 2gh$$

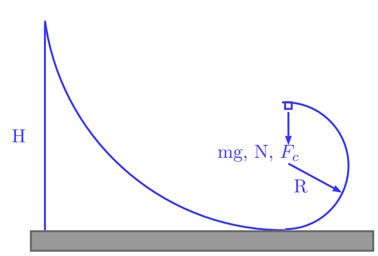
$$T = mg\left(1 + \frac{2h}{r}\right)$$

$$= 688\left(1 + \frac{2\times 3.2}{18}\right) = 932.62\ N \ \ (< 950\ N)$$

••27 Tarzan, who weighs 688 N, swings from a cliff at the end of a vine 18 m long (Fig. 8-40). From the top of the cliff to the bottom of the swing, he descends by 3.2 m. The vine will break if the force on it exceeds 950 N. (a) Does the vine break? (b) If no, what is the greatest force on it during the swing? If yes, at what angle with the vertical does it break?

Solution Am object slides from rest at the top of frictionless track of height H. What minimum value of H will prevent the object from losing contact at the top of the semicircular track of radius R?

Let the bottom of the circular track to be at zero potential energy. Apply conservation of energy. If the object is NOT supposed to lose contact at the top, we must require N > 0.



$$mgH = mg(2R) + \frac{1}{2}mv^2 \quad \frac{mv^2}{R} = F_c = mg + N$$

$$\frac{mv^2}{R} > mg \quad (N > 0) \quad \Rightarrow mv^2 > mgR$$

$$\Rightarrow \ (2mgH - 4mgR) > mgR \ H > 2.5R$$