Chapter 8

8.2

8.3 In Fig 8-30, a 2.00g ice flake is released from the edge of a hemispherical bowl whose radius is 22 cm. The flake=bowl contact is frictionless. (a) how much work is done on the flake by the gravitation force during the flake's descent to the bottom of the bowl? (b) What is the change in the potential energy of the flake Earth system during the descent? (c) If that potential energy is taken to be zero at the bottom of the bowl, what is its value when the flake is released? (d) If instead, the potential energy is taken to be zero at the release point, what is its value when the flake reaches the bottom of the bowl (e) If the mass of the flake were doubled, would the magnitudes of the answers to (a) through (d) increase, decrease, or remain the same?

a) The work done is

$$\begin{aligned} W &= -\Delta U \\ &= -(U_f - U_i) \\ &= -(0 - mgy) \\ &= 2\times10^{-3}\cdot 9.8m/s^2 \cdot 0.22m \\ &= 4.312\times10^{-3}J \end{aligned}$$

For this part of the problem, assume the bottom of the bowl is zero height

$$\begin{aligned} U_f &= 0 \\ U_i &= mgR \\ W &= -(U_f - U_i) \\ &= mgR \end{aligned}$$

b) See part (a). $\Delta U = -4.312\times10^{-3}J$

c) See part (a) $U_i = 4.312\times10^{-3}J$

d) Assume that the top of the bowl is 0 height. The bottom would be -R

$$\begin{aligned} U_i &= 0 \\ U_f &= mg(-R) = -4.312\times10^{-3}J \end{aligned}$$

e) All of these answers are linear in m. If you double the mass, the results double.

8.5 What is the spring constant of a spring that stores 25J of elastic potential energy when compressed by 7.5 cm from its relaxed length?

$$U = \frac{1}{2} k x^2$$
$$k = \frac{2U}{x^2} = \frac{2 \cdot 25 J}{(0.075)^2}$$
$$= 8888.9\ N/m$$

8.8 In the figure, a small block of mass $m = 0.032 kg$ can slide along the frictionless loop-the-loop with a loop radius of R=12 cm. The block is released from rest at a point P, at height 5.0F above the bottom of the loop. A block slides on a track from a height 5R.

a) How much work does the weight do on the block as it travels from P to Q? Assume that the potential energy at the bottom is 0.

$$\begin{aligned} W &= -\Delta U \\ &= -(mgy_f - mgy_i) \\ &= -(mgR - mg \cdot 5R) \\ &= 4mgR \\ &= 4 \cdot 0.032kg \cdot 9.8 m/s^2 \cdot 0.12m \\ &= 0.151J \end{aligned}$$

b) How much work does the weight do on the block as it travels from P to the top of the loop? Assume that the potential energy at the bottom is 0.

$$\begin{aligned} W &= -\Delta U \\ &= -(mgy_f - mgy_i) \\ &= -(mg \cdot 2R - mg \cdot 5R) \\ &= 3mgR \\ &= 3 \cdot 0.032kg \cdot 9.8 m/s^2 \cdot 0.12m \\ &= 0.113J \end{aligned}$$

c-e) Calculate the potential energies. Assume that the potential energy at the bottom is 0.

At point P $\quad U = mg(5R) = 0.188J$

At point Q $\quad U = mg(R) = 0.0376J$

At top of loop $U = mg(2R) = 0.0753J$

f) The potential energies and work done are unaffected by the initial velocity that the particle might have.

8.11

8.18

8.21 The string in Fig 8-35 is L=120 cm long, has a ball attached to one end, and is fixed at its other end. The distance d to the fixed peg at point P is 75.0cm. When the initially stationary ball is released wit 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.

We begin by computing the total energy.

$$E_i = \frac{1}{2}mv_i^2 + mgh_i$$
$$= 0 + mgL$$
$$E_i = mgL$$

The total energy remains constant throughout this problem. We now consider the lowest point.

$$E_{Low} = \frac{1}{2}mv_{Low}^2 + mgh_{Low}$$
$$h_{Low} = 0$$
$$E_{Low} = \frac{1}{2}mv_{Low}^2 + 0$$
$$E_{Low} = E_i$$
$$\frac{1}{2}mv_{Low}^2 = mgL$$
$$v_{Low} = \sqrt{2gL} = 4.85m/s$$

b) We now consider the high point after catching

8.31 In the figure a 12 kg block is released from rest on a 30 degree frictionless incline. Below the block is a spring that can be compressed 2.0 cm by a force of 270N. The block momentarily stops when it compresses the spring by 5.5 cm. (a) How far does the block move down the incline from its rest position to this stopping point. (b) What is the speed of the block just as it touches the spring.

(a) All of the potential energy of the spring comes from change in gravitational potential energy.

$$k = \frac{270N}{0.02m} = 1.35 \times 10^4 N/m$$

$$U_s = \frac{1}{2} k x^2$$

$$= \frac{1}{2} \cdot 1.35 \times 10^4 N/m \cdot (0.055)^2$$

$$= 20.42J$$

$$U_s = \Delta U_g = mg\Delta y$$

$$\Delta y = \frac{U_s}{mg} = \frac{20.42J}{12kg \cdot 9.8} = 0.1736m$$

$$d = \frac{\Delta y}{\sin\theta} = \frac{0.1736m}{\sin 30} = 0.3472m$$

(b) To compute the kinetic energy at impact, we need to find the vertical distance that the block moved. The distance down the incline before compressing the spring can be computed.

$$d' = d - 0.055m$$

$$= 0.3472m - 0.055m$$

$$= 0.2922m$$

Since we know the distance down the incline, we can find the vertical drop, change in potential energy and finally the kinetic energy and velocity.

$$\Delta y' = -d' \sin\theta$$

$$= -0.2922 \cdot \sin 30$$

$$= -0.1461m$$

$$K_f - K_i = W = -\Delta U$$

$$\frac{1}{2} m v_f^2 - \frac{1}{2} m v_i^2 = -mg\Delta y$$

$$\frac{1}{2} m v_f^2 - 0 = -mg\Delta y$$

$$v_f = \sqrt{-2g\Delta y}$$

$$= \sqrt{-2 \cdot 9.8m/s^2 \cdot -0.1461m}$$

$$= 1.692m/s$$

$$E_{High} = \frac{1}{2}mv_{High}^{\ 2} + mgh_{High}$$
$$h_{High} = 2 \cdot (L-d)$$
$$E_{High} = \frac{1}{2}mv_{High}^{\ 2} + 2mg(L-d)$$
$$E_{High} = E_i$$
$$\frac{1}{2}mv_{High}^{\ 2} + 2mg(L-d) = mgL$$
$$\frac{1}{2}mv_{High}^{\ 2} = 2mgd - mgL$$
$$v_{High}^{\ 2} = g(4d-2L)$$
$$v_{High} = \sqrt{g(4d-2L)}$$
$$= 2.42 m/s$$

8.38

8.46 A 60 kg skier leaves the end of a ski jump ramp with a velocity of 24 m/s directedc 25 degrees above the horizontal. Suppose that as a result of air drad the skier returns to the ground with a speed of 22 m/s, landing 14m vertically below the end of the ramp. From the launc to the return to the ground , by how much is the miichanical energy of the skier-Earth system reduced because of drag.

This problem requires us to compute the total energy at the jump and at the landing.

$$E_i = \frac{1}{2}mv_i^2 + mgh_i = \frac{1}{2}\cdot 60kg \cdot (24m/s)^2 + 60kg \cdot 9.8m/s^2 \cdot 14m$$
$$= 25{,}512J$$
$$E_f = \frac{1}{2}mv_f^2 + mgh_f = \frac{1}{2}\cdot 60kg \cdot (22m/s)^2 + 60kg \cdot 9.8m/s^2 \cdot 0m$$
$$= 14{,}520J$$
$$\Delta E = E_f - E_i = -10{,}992J$$

8.52 You push a 2.0 kg block against a horizontal spring, compressing the spring by 15.0 cm. Then you release the block and the spring send it sliding across a table top. It stops 75 cm from where you released it. The spring constant is 200 N/m. What is the block-table coefficient of kinetic friction?

All of the stored energy in the spring goes into work done by the frictional force.

$$|W| = U$$

$$F_f d = \frac{1}{2} k x^2$$

$$\mu N d = \frac{1}{2} k x^2$$

$$\mu = \frac{k x^2}{2Nd} = \frac{k x^2}{2mgd} = \frac{(200N/m)(0.15m)^2}{2 \cdot 2kg \cdot (9.8m/s^2) \cdot 0.75}$$

$$= 0.153$$

8.65