Chapter 7

7-10 A floating block of ice is pushed through a displacement of \( \mathbf{d} = (15 \text{ m}) \mathbf{x} - (12 \text{ m}) \mathbf{y} \) along a straight embankment by rushing water, which exerts a force \( \mathbf{F} = (210 \text{ N}) \mathbf{z} - (150 \text{ N}) \mathbf{y} \) on the block. How much work does the force do on the block during the displacement?

\[
W = \mathbf{F} \cdot \mathbf{d} = \left[ (210 \text{ N}) \mathbf{z} - (150 \text{ N}) \mathbf{y} \right] \cdot \left[ (15 \text{ m}) \mathbf{x} - (12 \text{ m}) \mathbf{y} \right] \\
= (210 \text{ N})(15 \text{ m}) + (-150 \text{ N})(-12 \text{ m}) \\
= 5,010 \text{ J}
\]

7-23 A block of ice slides down a frictionless ramp at angle \( \theta = 50^\circ \) while a worker pulls on the block (via a rope) with a force \( \mathbf{F}_r \) that has a magnitude of \( 50 \text{ N} \) and is directed up the ramp. As the block slides through distance \( d = 0.50 \text{ m} \) along the ramp, its kinetic energy increases by \( 80 \text{ J} \). How much greater would its kinetic energy have been if the rope had not been attached to the block?

\[
\Delta K = K_f - K_i = W_A + W_g
\]

\[
\Rightarrow W_A = F \cdot d = -(50 \text{ N})(0.50 \text{ m}) \\
= -25 \text{ J}
\]

So, if the rope had not been attached, the K.E. would have been \( 25 \text{ J } \) greater.
Chapter 7

7-35. The force on a particle is directed along an x-axis and given by \( F = F_0 \left( \frac{x}{x_0} - 1 \right) \). Find the work done by the force in moving the particle from \( x = 0 \) to \( x = 2x_0 \) by (a) plotting \( F(x) \) and measuring the work from the graph and (b) integrating \( F(x) \).

\[ a) \quad F_0 \]

\[ \text{Graph of } F(t) \text{ assuming } x_0 \text{ is positive} \]

Area of a triangle is \( A = \frac{1}{2}bh \)

Work done from \( x = 0 \) to \( x = x_0 \)

\[ - (x_0)(F_0)/2 = W_1 \]

Work done from \( x = x_0 \) to \( x = 2x_0 \)

\[ (2x_0 - x_0)(F_0)/2 = x_0F_0/2 = W_2 \]

\[ W_{\text{total}} = W_1 + W_2 = -\frac{x_0F_0}{2} + \frac{x_0F_0}{2} = 0 \]

\[ W_{\text{total}} = 0 \]

\[ b) \text{Integrating: } W = \int F_0 \left( \frac{x}{x_0} - 1 \right) dx = F_0 \left( \frac{x^2}{2x_0} - x \right) \]

\[ = \frac{(2x_0)^2}{2x_0} - 2x_0 = 2x_0 - 2x_0 = 0 \]

\[ W_{\text{total}} = 0 \]
Chapter 7

7-43 A 100 kg block is pulled at a constant speed of 5.0 m/s across a horizontal floor by an applied force of 122 N directed 37° above the horizontal. What is the rate at which the force does work on the block?

\[ P = F \cdot v \]

\[ P = Fv \cos \theta = (122 \text{ N})(5.0 \text{ m/s}) \cos 37° \]

\[ P = 4.9 \times 10^2 \text{ W} \]

7-54 A block is dropped onto a relaxed vertical spring that has a spring constant of \( k = 2.5 \text{ N/cm} \). The block becomes attached to the spring and compresses the spring 12 cm before momentarily stopping. While the spring is compressed, what work is done on the block by (a) the gravitational force on it and (b) the spring force?

Compression of spring \( d = 0.12 \text{ m} \)

a) Work done by force of gravity is:

\[ W_1 = mgd = (0.25 \text{ kg})(9.8 \text{ m/s}^2)(0.12 \text{ m}) \]

\[ W_1 = 0.294 \text{ J} \]

b) Work done by spring is:

\[ W_2 = -\frac{1}{2}kd^2 = -\frac{1}{2}(250 \text{ N/m})(0.12 \text{ m})^2 \]

\[ W_2 = -1.8 \text{ J} \]
Chapter 7

7-54 (continued)

(c) What is the speed of the block just before it hits the spring? (Assume that friction is negligible)

Using Work-Kinetic Energy Theorem,

\[ \Delta K = K_f - K_i = W_1 + W_2 \]
\[ = 0 - \frac{1}{2}mv_i^2 \]

\[ v_i = \left( \frac{(2)(W_1 + W_2)}{m} \right)^{1/2} = \left( \frac{(2)(0.295 + 18)}{0.25} \right)^{1/2} \]

\[ v_i = 3.5 \text{ m/s} \]

(d) If the speed at impact is doubled, what is the maximum compression of the spring?

\[ 2v_i = 2(3.5 \text{ m/s}) = 7 \text{ m/s} = v_i' \]

Reverse steps in part (c) and solve for the new distance \( d' \)

\[ 0 - \frac{1}{2}mv_i'^2 = W_1' + W_2' = mgd' - \frac{1}{2}kd'^2 \]

Quadratic equation yields

Choosing positive root,

\[ d' = \frac{mg + \sqrt{mg^2 + 4mkv_i'^2}}{k} \]

\[ d' = 0.23 \text{ m} \]