Chapter 6

16. (a) We apply Newton's second law to the "downhill" direction:

$$mg\sin\theta - f = ma,$$

where, using Eq. 6-11,

$$f = f_k = \mu_k F_N = \mu_k mg\cos\theta.$$

Thus, with $\mu_k = 0.600$, we have

$$a = g\sin\theta - \mu_k\cos\theta = -3.72 \text{ m/s}^2$$

which means, since we have chosen the positive direction in the direction of motion (down the slope) then the acceleration vector points "uphill"; it is decelerating. With $v_0 = 18.0$ m/s and $\Delta x = d = 24.0$ m, Eq. 2-16 leads to

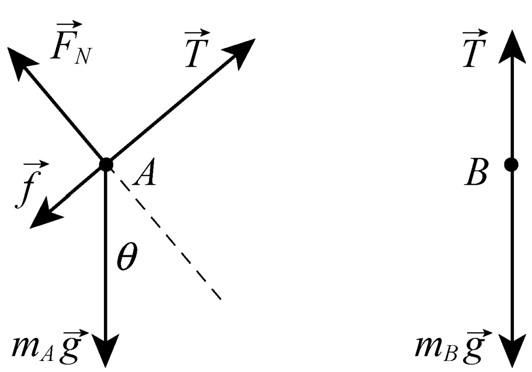
$$v = \sqrt{v_0^2 + 2ad} = 12.1 \text{ m/s}.$$

18. We find the acceleration from the slope of the graph (recall Eq. 2-11): $a = 4.5$ m/s^2. Thus, Newton's second law leads to

$$F - \mu_k mg = ma,$$

where $F = 40.0$ N is the constant horizontal force applied. With $m = 4.1$ kg, we arrive at $\mu_k = 0.54$.

30. The free-body diagrams are shown below. T is the magnitude of the tension force of the string, f is the magnitude of the force of friction on block A, F_N is the magnitude of the normal force of the plane on block A, $m_A\vec{g}$ is the force of gravity on body A (where $m_A = 10$ kg), and $m_B\vec{g}$ is the force of gravity on block B. $\theta = 30°$ is the angle of incline. For A we take the $+x$ to be uphill and $+y$ to be in the direction of the normal force; the positive direction is chosen *downward* for block B.



Since A is moving down the incline, the force of friction is uphill with magnitude $f_k = \mu_k F_N$ (where $\mu_k = 0.20$). Newton's second law leads to

$$\begin{aligned} T - f_k + m_A g \sin\theta &= m_A a = 0 \\ F_N - m_A g \cos\theta &= 0 \\ m_B g - T &= m_B a = 0 \end{aligned}$$

for the two bodies (where $a = 0$ is a consequence of the velocity being constant). We solve these for the mass of block B.

$$m_B = m_A\left(\sin\theta - \mu_k \cos\theta\right) = 3.3 \text{ kg}.$$

36. Using Eq. 6-16, we solve for the area

$$A \frac{2m\, g}{C\rho\, v_t^2}$$

which illustrates the inverse proportionality between the area and the speed-squared. Thus, when we set up a ratio of areas – of the slower case to the faster case – we obtain

$$\frac{A_{\text{slow}}}{A_{\text{fast}}} = \left(\frac{310 \text{ km/h}}{160 \text{ km/h}}\right)^2 = 3.75.$$

Chapter 7

1. (a) The change in kinetic energy for the meteorite would be

$$\Delta K = K_f - K_i = -K_i = -\frac{1}{2} m_i v_i^2 = -\frac{1}{2}\left(4\times10^6 \text{ kg}\right)\left(15\times10^3 \text{ m/s}\right)^2 = -5\times10^{14} \text{ J},$$

or $|\Delta K| = 5\times10^{14}$ J. The negative sign indicates that kinetic energy is lost.

(b) The energy loss in units of megatons of TNT would be

$$-\Delta K = \left(5\times10^{14} \text{ J}\right)\left(\frac{1 \text{ megaton TNT}}{4.2\times10^{15} \text{ J}}\right) = 0.1 \text{megaton TNT}.$$

(c) The number of bombs N that the meteorite impact would correspond to is found by noting that megaton = 1000 kilotons and setting up the ratio:

$$N = \frac{0.1 \times 1000 \,\text{kiloton TNT}}{13 \,\text{kiloton TNT}} = 8.$$

3. (a) From Table 2-1, we have $v^2 = v_0^2 + 2a\Delta x$. Thus,

$$v = \sqrt{v_0^2 + 2a\Delta x} = \sqrt{\left(2.4\times10^7 \text{ m/s}\right)^2 + 2\ \left(3.6\times10^{15} \text{ m/s}^2\right)\left(0.035 \text{ m}\right)} = 2.9\times10^7 \text{ m/s}.$$

(b) The initial kinetic energy is

$$K_i = \frac{1}{2}mv_0^2 = \frac{1}{2}\ \left(1.67\times10^{-27} \text{ kg}\right)\left(2.4\times10^7 \text{ m/s}\right)^2 = 4.8\times10^{-13} \text{ J}.$$

The final kinetic energy is

$$K_f = \frac{1}{2}mv^2 = \frac{1}{2}\ \left(1.67\times10^{-27} \text{ kg}\right)\left(2.9\times10^7 \text{ m/s}\right)^2 = 6.9\times10^{-13} \text{ J}.$$

The change in kinetic energy is $\Delta K = 6.9 \times 10^{-13}$ J – 4.8×10^{-13} J = 2.1×10^{-13} J.

14. (a) From Eq. 7-6, $F = W/x$ = 3.00 N (this is the slope of the graph).

(b) Eq. 7-10 yields $K = K_i + W$ = 3.00 J + 6.00 J = 9.00 J.

16. The forces are all constant, so the total work done by them is given by $W = F_{\text{net}}\Delta x$, where F_{net} is the magnitude of the net force and Δx is the magnitude of the displacement. We add the three vectors, finding the x and y components of the net force:

$$\begin{aligned} F_{\text{net}\,x} &= -F_1 - F_2 \sin 50.0° + F_3 \cos 35.0° = -3.00 \text{ N} - (4.00 \text{ N}) \sin 35.0° + (10.0 \text{ N}) \cos 35.0° \\ &= 2.13 \text{ N} \end{aligned}$$

$$\begin{aligned} F_{\text{net}\,y} &= -F_2 \cos 50.0° + F_3 \sin 35.0° = -(4.00 \text{ N})\ \cos 50.0° + (10.0 \text{ N}) \sin 35.0° \\ &= 3.17 \text{ N}. \end{aligned}$$

The magnitude of the net force is

$$F_{\text{net}} = \sqrt{F_{\text{net}\,x}^2 + F_{\text{net}\,y}^2} = \sqrt{(2.13 \text{ N})^2 + (3.17 \text{ N})^2} = 3.82 \text{ N}.$$

The work done by the net force is

$$W = F_{\text{net}} d = (3.82 \text{ N})(4.00 \text{ m}) = 15.3 \text{ J}$$

where we have used the fact that $\vec{d} \,||\, \vec{F}_{\text{net}}$ (which follows from the fact that the canister started from rest and moved horizontally under the action of horizontal forces — the resultant effect of which is expressed by $\vec{F}_{\text{net}}$).