Chapter 8

1. The potential energy stored by the spring is given by $U = \frac{1}{2}kx^2$, where k is the spring constant and x is the displacement of the end of the spring from its position when the spring is in equilibrium. Thus

$$k = \frac{2U}{x^2} = \frac{2(25\,\text{J})}{(0.075\,\text{m})^2} = 8.9\times10^3\ \text{N/m}.$$

3. (a) Noting that the vertical displacement is 10.0 m – 1.50 m = 8.50 m downward (same direction as $\vec{F}_g$), Eq. 7-12 yields

$$W_g = mgd\cos\phi = (2.00\ \text{kg})(9.80\ \text{m/s}^2)(8.50\ \text{m})\cos 0° = 167\ \text{J}.$$

(b) One approach (which is fairly trivial) is to use Eq. 8-1, but we feel it is instructive to instead calculate this as ΔU where $U = mgy$ (with upward understood to be the $+y$ direction). The result is

$$\Delta U = mg(y_f - y_i) = (2.00\ \text{kg})(9.80\ \text{m/s}^2)(1.50\ \text{m} - 10.0\ \text{m}) = -167\ \text{J}.$$

(c) In part (b) we used the fact that $U_i = mgy_i = 196$ J.

(d) In part (b), we also used the fact $U_f = mgy_f = 29$ J.

(e) The computation of W_g does not use the new information (that U = 100 J at the ground), so we again obtain W_g = 167 J.

(f) As a result of Eq. 8-1, we must again find $\Delta U = -W_g = -167$ J.

(g) With this new information (that U_0 = 100 J where y = 0) we have

$$U_i = mgy_i + U_0 = 296\ \text{J}.$$

(h) With this new information (that U_0 = 100 J where y = 0) we have

$$U_f = mgy_f + U_0 = 129\ \text{J}.$$

We can check part (f) by subtracting the new U_i from this result.

15. We neglect any work done by friction. We work with SI units, so the speed is converted: $v = 130(1000/3600) = 36.1$ m/s.

(a) We use Eq. 8-17: $K_f + U_f = K_i + U_i$ with $U_i = 0$, $U_f = mgh$ and $K_f = 0$. Since $K_i = \frac{1}{2}mv^2$, where v is the initial speed of the truck, we obtain

$$\frac{1}{2}mv^2 = mgh \quad \Rightarrow \quad h = \frac{v^2}{2g} = \frac{(36.1\ \text{m/s})^2}{2(9.8\ \text{m/s}^2)} = 66.5\ \text{m}.$$

If L is the length of the ramp, then $L \sin 15° = 66.5$ m so that $L = (66.5\ \text{m})/\sin 15° = 257$ m. Therefore, the ramp must be about 2.6×10^2 m long if friction is negligible.

(b) The answers do not depend on the mass of the truck. They remain the same if the mass is reduced.

(c) If the speed is decreased, h and L both decrease (note that h is proportional to the square of the speed and that L is proportional to h).

56. Energy conservation, as expressed by Eq. 8-33 (with $W = 0$) leads to

$$\Delta E_{\text{th}} = K_i - K_f + U_i - U_f \Rightarrow f_k d = 0 - 0 + \frac{1}{2}kx^2 - 0$$

$$\Rightarrow \mu_k mgd = \frac{1}{2}(200\ \text{N/m})(0.15\ \text{m})^2 \Rightarrow \mu_k(2.0\ \text{kg})(9.8\ \text{m/s}^2)(0.75\ \text{m}) = 2.25\ \text{J}$$

which yields $\mu_k = 0.15$ as the coefficient of kinetic friction.

60. We look for the distance along the incline d, which is related to the height ascended by $\Delta h = d \sin\theta$. By a force analysis of the style done in Chapter 6, we find the normal force has magnitude $F_N = mg\cos\theta$, which means $f_k = \mu_k mg\cos\theta$. Thus, Eq. 8-33 (with $W = 0$) leads to

$$\begin{aligned} 0 &= K_f - K_i + \Delta U + \Delta E_{\text{th}} \\ &= 0 - K_i + mgd\sin\theta + \mu_k mgd\cos\theta \end{aligned}$$

which leads to

$$d = \frac{K_i}{mg(\sin\theta + \mu_k\cos\theta)} = \frac{128}{(4.0)(9.8)(\sin 30° + 0.30\cos 30°)} = 4.3\,\text{m}.$$