Chapter 7

1. (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 $\Delta K = 6.9\times10^{-13}$ J $- 4.8\times10^{-13}$ J $= 2.1\times10^{-13}$ J.

5. We denote the mass of the father as m and his initial speed v_i. The initial kinetic energy of the father is

$$K_i = \frac{1}{2}K_{\text{son}}$$

and his final kinetic energy (when his speed is $v_f = v_i + 1.0$ m/s) is $K_f = K_{\text{son}}$. We use these relations along with Eq. 7-1 in our solution.

(a) We see from the above that $K_i = \frac{1}{2}K_f$, which (with SI units understood) leads to

$$\frac{1}{2}mv_i^2 = \frac{1}{2}\left[\frac{1}{2}m\left(v_i + 1.0 \text{ m/s}\right)^2\right].$$

The mass cancels and we find a second-degree equation for v_i:

$$\frac{1}{2}v_i^2 - v_i - \frac{1}{2} = 0.$$

The positive root (from the quadratic formula) yields $v_i = 2.4$ m/s.

(b) From the first relation above $\left(K_i = \frac{1}{2}K_{\text{son}}\right)$, we have

$$\frac{1}{2}mv_i^2 = \frac{1}{2}\left(\frac{1}{2}(m/2)\,v_{\text{son}}^2\right)$$

and (after canceling m and one factor of 1/2) are led to $v_{\text{son}} = 2v_i = 4.8$ m/s.

9. By the work-kinetic energy theorem,

$$W = \Delta K = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2 = \frac{1}{2}(2.0\,\text{kg})\left((6.0\,\text{m/s})^2 - (4.0\,\text{m/s})^2\right) = 20\text{ J.}$$

We note that the *directions* of $\vec{v}_f$ and $\vec{v}_i$ play no role in the calculation.

18. In both cases, there is no acceleration, so the lifting force is equal to the weight of the object.

(a) Equation 7-8 leads to $W = \vec{F}\cdot\vec{d} = (360\,\text{kN})(0.10\,\text{m}) = 36\text{ kJ}$.

(b) In this case, we find $W = (4000\text{ N})(0.050\text{ m}) = 2.0\times10^2\text{ J}$.

31. (a) As the body moves along the x axis from $x_i = 3.0$ m to $x_f = 4.0$ m the work done by the force is

$$W = \int_{x_i}^{x_f} F_x\,dx = \int_{x_i}^{x_f} -6x\,dx = -3(x_f^2 - x_i^2) = -3\,(4.0^2 - 3.0^2) = -21\text{ J.}$$

According to the work-kinetic energy theorem, this gives the change in the kinetic energy:

$$W = \Delta K = \frac{1}{2}m\left(v_f^2 - v_i^2\right)$$

where v_i is the initial velocity (at x_i) and v_f is the final velocity (at x_f). The theorem yields

$$v_f = \sqrt{\frac{2W}{m} + v_i^2} = \sqrt{\frac{2(-21\text{ J})}{2.0\text{ kg}} + (8.0\text{ m/s})^2} = 6.6\text{ m/s.}$$

(b) The velocity of the particle is $v_f = 5.0$ m/s when it is at $x = x_f$. The work-kinetic energy theorem is used to solve for x_f. The net work done on the particle is $W = -3\left(x_f^2 - x_i^2\right)$, so the theorem leads to

$$-3\left(x_f^2 - x_i^2\right) = \frac{1}{2}m\,\left(v_f^2 - v_i^2\right).$$

Thus,

$$x_f = \sqrt{-\frac{m}{6}\left(v_f^2 - v_i^2\right) + x_i^2} = \sqrt{-\frac{2.0\text{ kg}}{6\text{ N/m}}\left((5.0\text{ m/s})^2 - (8.0\text{ m/s})^2\right) + (3.0\text{ m})^2} = 4.7\text{ m.}$$

66. After converting the speed: $v = 120\ \text{km/h} = 33.33\ \text{m/s}$, we find

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(1200\ \text{kg})(33.33\ \text{m/s})^2 = 6.67 \times 10^5\ \text{J}.$$