Halliday ♦ Resnick ♦Walker

FUNDAMENTALS OF PHYSICS
SIXTH EDITION

Selected Solutions

Chapter 7

7.17
7.35

17. (a) We use $\vec{F}$ to denote the upward force exerted by the cable on the astronaut. The force of the cable is upward and the force of gravity is mg downward. Furthermore, the acceleration of the astronaut is $g/10$ upward. According to Newton's second law, $F - mg = mg/10$, so $F = 11mg/10$. Since the force $\vec{F}$ and the displacement $\vec{d}$ are in the same direction, the work done by $\vec{F}$ is

$$W_F = Fd = \frac{11mgd}{10} = \frac{11(72\,\text{kg})\left(9.8\,\text{m/s}^2\right)(15\,\text{m})}{10} = 1.164 \times 10^4\ \text{J}$$

which (with respect to significant figures) should be quoted as 1.2×10^4 J.

(b) The force of gravity has magnitude mg and is opposite in direction to the displacement. Thus, using Eq. 7-7, the work done by gravity is

$$W_g = -mgd = -(72\,\text{kg})\left(9.8\,\text{m/s}^2\right)(15\,\text{m}) = -1.058 \times 10^4\ \text{J}$$

which should be quoted as -1.1×10^4 J.

(c) The total work done is $W = 1.164 \times 10^4\ \text{J} - 1.058 \times 10^4\ \text{J} = 1.06 \times 10^3$ J. Since the astronaut started from rest, the work-kinetic energy theorem tells us that this (which we round to 1.1×10^3 J) is her final kinetic energy.

(d) Since $K = \frac{1}{2}mv^2$, her final speed is

$$v = \sqrt{\frac{2K}{m}} = \sqrt{\frac{2(1.06 \times 10^3\ \text{J})}{72\,\text{kg}}} = 5.4\ \text{m/s}\ .$$

35. The total work is the sum of the work done by gravity on the elevator, the work done by gravity on the counterweight, and the work done by the motor on the system: $W_T = W_e + W_c + W_s$. Since the elevator moves at constant velocity, its kinetic energy does not change and according to the work-kinetic energy theorem the total work done is zero. This means $W_e + W_c + W_s = 0$. The elevator moves upward through 54 m, so the work done by gravity on it is

$$W_e = -m_e g d = -(1200\,\text{kg})(9.8\,\text{m/s}^2)(54\,\text{m}) = -6.35 \times 10^5\,\text{J}\,.$$

The counterweight moves downward the same distance, so the work done by gravity on it is

$$W_c = m_c g d = (950\,\text{kg})\left(9.8\,\text{m/s}^2\right)(54\,\text{m}) = 5.03 \times 10^5\ \text{J}\,.$$

Since $W_T = 0$, the work done by the motor on the system is

$$W_s = -W_e - W_c = 6.35 \times 10^5\,\text{J} - 5.03 \times 10^5\,\text{J} = 1.32 \times 10^5\ \text{J}\,.$$

This work is done in a time interval of $\Delta t = 3.0\,\text{min} = 180\,\text{s}$, so the power supplied by the motor to lift the elevator is

$$P = \frac{W_s}{\Delta t} = \frac{1.32 \times 10^5\,\text{J}}{180\,\text{s}} = 7.4 \times 10^2\ \text{W}\,.$$