**Solutions to the Extra Practice Problems for Chapter 8**

1. You have done 61.6 J of work. Since you are pulling straight up, the force is parallel to the displacement. Thus, we can use Equation (8.1). However, we have to figure out the force. Since the object moves at constant velocity, the sum of the forces is zero. Thus, you must be lifting with a force that is equal to its weight (m·g) so as to cancel the gravitational force.

$$\mathrm{W} = \mathrm{F}_{\parallel} \cdot \Delta \mathrm{x} = \mathrm{m} \cdot \mathrm{g} \cdot \Delta \mathrm{x} = (3.14\ \mathrm{kg}) \cdot \left(9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}\right) \cdot (2.00\ \mathrm{m}) = 61.6 \frac{\mathrm{kg} \cdot \mathrm{m}^2}{\mathrm{s}^2} = 61.6\ \mathrm{J}$$

2. The height is 2.83 m. Potential energy is given by Equation (8.2). However, the mass must be in kg to match the Joules unit, so m = 0.422 kg.

$$\mathrm{PE} = \mathrm{m} \cdot \mathrm{g} \cdot \mathrm{h}$$

$$11.7\ \mathrm{J} = (0.422\ \mathrm{kg}) \cdot \left(9.81\ \frac{\mathrm{meters}}{\mathrm{s}^2}\right) \cdot (\mathrm{h})$$

$$\mathrm{h} = \frac{11.7\ \mathrm{J}}{(0.422\ \mathrm{kg}) \cdot \left(9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}\right)} = \frac{11.7\ \frac{\cancel{\mathrm{kg}} \cdot \cancel{\mathrm{m}^2}}{\cancel{\mathrm{s}^2}}}{(0.422\ \cancel{\mathrm{kg}}) \cdot \left(9.81\ \frac{\cancel{\mathrm{m}}}{\cancel{\mathrm{s}^2}}\right)} = 2.83\ \mathrm{m}$$

3. The speed is 19.7 m/s. Kinetic energy is given by Equation (8.3). However, the mass must be in kg to match the Joules unit, so m = 0.734 kg.

$$\mathrm{KE} = \frac{1}{2} \mathrm{m} \cdot \mathrm{v}^2$$

$$142\ \mathrm{J} = \frac{1}{2} (0.734\ \mathrm{kg}) \cdot \mathrm{v}^2$$

$$\mathrm{v}^2 = \frac{2 \cdot 142\ \mathrm{J}}{0.734\ \mathrm{kg}}$$

$$\mathrm{v} = \sqrt{\frac{2 \cdot 142\ \mathrm{J}}{0.734\ \mathrm{kg}}} = \sqrt{\frac{2 \cdot 142 \frac{\cancel{\mathrm{kg}} \cdot \mathrm{m}^2}{\mathrm{s}^2}}{0.734\ \cancel{\mathrm{kg}}}} = 19.7\ \frac{\mathrm{m}}{\mathrm{s}}$$

4. The speed is 4.3 m/s. When it is at rest, it has no kinetic energy. However, it does have potential energy. Of course, the potential energy depends on the height, which we have to convert to meters since we will have to use the acceleration due to gravity, so h = 0.95 m. We are ignoring friction, so:

$$\mathrm{TE} = \mathrm{KE} + \mathrm{PE} = 0 + \mathrm{m} \cdot \mathrm{g} \cdot \mathrm{h} = \mathrm{m} \cdot \left(9.81\ \frac{\mathrm{meters}}{\mathrm{s}^2}\right) \cdot (0.95\ \mathrm{meters})$$

At the bottom of the ramp, there is no potential energy, but there is lots of kinetic energy, so:

$$\mathrm{TE} = \mathrm{KE} + \mathrm{PE} = \frac{1}{2} \mathrm{m} \cdot \mathrm{v}^2 + 0$$

The First Law of Thermodynamics says those expressions must be the same, so:

$$\cancel{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (0.95\ \text{meters}) = \frac{1}{2} \cancel{m} \cdot \text{v}^2$$

$$\left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (0.95\ \text{meters}) = \frac{1}{2} \cdot \text{v}^2$$

$$\text{v} = \sqrt{2 \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (0.95\ \text{meters})} = 4.3\ \frac{\text{m}}{\text{s}}$$

5. <u>The speed is 15 m/s</u>. When it is at rest, it has no kinetic energy. However, it does have potential energy. We are ignoring friction, so:

$$\text{TE} = \text{KE} + \text{PE} = 0 + \text{m} \cdot \text{g} \cdot \text{h} = \text{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (22\ \text{meters})$$

After it has been on the track for a while, it still has a height, so it has potential energy, but it also has kinetic energy, so:

$$\text{TE} = \text{KE} + \text{PE} = \frac{1}{2}\text{m} \cdot \text{v}^2 + \text{m} \cdot \text{g} \cdot \text{h} = \frac{1}{2}\text{m} \cdot \text{v}^2 + \text{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (11\ \text{meters})$$

The First Law of Thermodynamics says those expressions must be the same, so:

$$\cancel{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (22\ \text{meters}) = \frac{1}{2} \cancel{m} \cdot \text{v}^2 + \cancel{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (11\ \text{meters})$$

$$\left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (22\ \text{meters}) = \frac{1}{2} \cdot \text{v}^2 + \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (11\ \text{meters})$$

$$\frac{1}{2} \cdot \text{v}^2 = \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (22\ \text{meters}) - \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (11\ \text{meters}) = 220\frac{\text{meters}^2}{\text{s}^2} - 110\frac{\text{meters}^2}{\text{s}^2}$$

$$\text{v} = \sqrt{2 \cdot \left[220\frac{\text{meters}^2}{\text{s}^2} - 110\frac{\text{meters}^2}{\text{s}^2}\right]} = 15\ \frac{\text{meters}}{\text{s}}$$

6. <u>His speed at the bottom is 9.46 m/s</u>. At the top of the hill, he has both kinetic and potential energy. However, we are ignoring friction, so:

$$\text{TE} = \text{KE} + \text{PE} = \frac{1}{2}\text{m} \cdot \text{v}^2 + \text{m} \cdot \text{g} \cdot \text{h} = \frac{1}{2}\text{m} \cdot (2.55\ \frac{\text{meters}}{\text{s}})^2 + \text{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (4.22\ \text{meters})$$

At the bottom of the hill, he has no potential energy, but he does have kinetic energy.

$$\text{TE} = \text{KE} + \text{PE} = \frac{1}{2}\text{m} \cdot \text{v}^2 + 0 = \frac{1}{2}\text{m} \cdot \text{v}^2$$

The First Law of Thermodynamics says those expressions must be the same, so:

$$\frac{1}{2}\cancel{m} \cdot \left(2.55\ \frac{\text{meters}}{\text{s}}\right)^2 + \cancel{m} \cdot \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (4.22\ \text{meters}) = \frac{1}{2}\cancel{m} \cdot \text{v}^2$$

$$\frac{1}{2} \cdot (2.55\ \frac{\text{meters}}{\text{s}})^2 + \left(9.81\ \frac{\text{meters}}{\text{s}^2}\right) \cdot (4.22\ \text{meters}) = \frac{1}{2} \cdot \text{v}^2$$

$$\frac{1}{2}\cdot v^2 = 3.25\ \frac{\text{meters}^2}{s^2} + 41.4\ \frac{\text{meters}^2}{s^2} = 44.7\ \frac{\text{meters}^2}{s^2}$$

$$v = \sqrt{2\cdot 44.7\ \frac{\text{meters}^2}{s^2}} = 9.46\ \frac{\text{meters}}{s}$$

Notice that I rounded to three significant figures before I added, since adding changes the rules. 20.7 was the least precise number, which limited the answer to the tenths place. That gave three significant figures for the answer.

7. Friction did 20,000 J of work. At the top of the hill, the rollercoaster has no kinetic energy, but it has potential energy. We can't ignore friction, but it hasn't had a displacement over which it could work yet, so:

$$TE = KE + PE + W_f = 0 + m\cdot g\cdot h + 0 = (557\ \text{kg})\cdot\left(9.81\ \frac{m}{s^2}\right)\cdot(22\ \text{m})$$

At the bottom of the hill, there is no potential energy, but there is kinetic energy, and friction has been able to do work.

$$TE = KE + PE + W_f = \frac{1}{2}m\cdot v^2 + 0 + W_f = \frac{1}{2}(557\ \text{kg})\cdot(18.6\ \frac{m}{s})^2 + W_f$$

The First Law of Thermodynamics says those expressions must be the same, so:

$$(557\ \text{kg})\cdot\left(9.81\ \frac{m}{s^2}\right)\cdot(22\ \text{m}) = \frac{1}{2}(557\ \text{kg})\cdot(18.6\ \frac{m}{s})^2 + W_f$$

$$W_f = (557\ \text{kg})\cdot\left(9.81\ \frac{m}{s^2}\right)\cdot(22\ \text{m}) - \frac{1}{2}(557\ \text{kg})\cdot\left(18.6\ \frac{m}{s}\right)^2 = 120{,}000\ \frac{kg\cdot m^2}{s^2} - 96{,}300\frac{kg\cdot m^2}{s^2}$$

$$W_f = 20{,}000\frac{kg\cdot m^2}{s^2} = 20{,}000\ \text{J}$$

The first term could have only two significant figures because of 22 m, so it had to be rounded to 120,000 J. The second term could have three, so it was 96,300 J. When subtracting, you keep the least precise decimal place, which is the "2" in 120,000. Thus, the answer must have its last significant figure in the ten thousands place.

8. The coefficient of friction is 0.26. The work adds energy to the block. The floor is horizonal, so there is no potential energy. Thus, the work added kinetic energy. That means the block starts out with a kinetic energy of 134 J. Friction hasn't had any displacement over which to work, so:

$$TE = KE + PE + W_f = 134\ \text{J} + 0 + 0 = 134\ \text{J}$$

At the end, there is no kinetic or potential energy, but friction has done work:

$$TE = KE + PE + W_f = 0 + 0 + W_f = W_f$$

The First Law of Thermodynamics says those expressions must be the same, so:

$$W_f = 134\ \text{J}$$

Friction always directly opposes motion, so it is parallel to the displacement, thus, we can use Equation (8.1), using the frictional force (μ·m·g) for $F_{\parallel}$.

$$W_f = \mu \cdot m \cdot g \cdot \Delta x$$

$$134\ J = \mu \cdot (17.0\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (3.1\ m)$$

$$\mu = \frac{134\ J}{(17.0\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (3.1\ m)} = \frac{134\ \frac{\cancel{kg} \cdot \cancel{m}^2}{\cancel{s^2}}}{(17.0\ \cancel{kg}) \cdot \left(9.81\ \frac{\cancel{m}}{\cancel{s^2}}\right) \cdot (3.1\ \cancel{m})} = 0.26$$

9. <u>Friction used 9.31 Watts of power</u>. Initially, it has no kinetic energy, and friction hasn't done any work. Before we can use the equation, though, we must convert height to 0.750 m.

$$TE = KE + PE + W_f = 0 + \ m \cdot g \cdot h + 0 = (2.22\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (0.750\ m)$$

At the end, there is no kinetic energy, the floor is level so there is no potential energy, but friction has done work:

$$TE = KE + PE + W_f = 0 + \ 0 + \ W_f$$

Those two expressions equal one another, so:

$$W_f = (2.22\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (0.750\ m) = 16.3\ \frac{kg \cdot m^2}{s^2} = 16.3\ J$$

Equation (8.6) allows us to determine power:

$$P = \frac{\Delta W}{\Delta t} = \frac{16.3\ J}{1.75\ s} = 9.31\ \frac{J}{s} = 9.31\ Watts$$

10. <u>It lifted the load 8.59 m</u>. Since the crane pulled straight up, the force is parallel to the displacement. Thus, we can use Equation (8.1) to calculate the work. However, we have to figure out the force. Since the load moves at constant velocity, the sum of the forces is zero. Thus, it must have lifted with a force that is equal to the load's weight (m·g) so as to cancel the gravitational force.

$$W = F_{\parallel} \cdot \Delta x = m \cdot g \cdot \Delta x = (5{,}671\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (\Delta x)$$

We don't know Δx, but there is another way we can calculate work – Equation (8.6). However, the time must be in seconds to be consistent with Watts, which are J/s. Thus, the time is $1.90 \times 10^2$ s.

$$P = \frac{\Delta W}{\Delta t}$$

$$2{,}518\ Watts = \frac{\Delta W}{1.90 \times 10^2\ s}$$

$$\Delta W = 2{,}518\ \frac{J}{\cancel{s}} \times 1.90 \times 10^2\ \cancel{s} = 478{,}000\ J$$

That's the work done, so we can now use that to get the distance:

$$W = (5{,}671\ kg) \cdot \left(9.81\ \frac{m}{s^2}\right) \cdot (\Delta x)$$

$$478{,}000\ \mathrm{J} = (5{,}671\ \mathrm{kg}) \cdot \left(9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}\right) \cdot (\Delta \mathrm{x})$$

$$\Delta \mathrm{x} = \frac{478{,}000\ \mathrm{J}}{(5{,}671\ \mathrm{kg}) \cdot \left(9.81\ \frac{\mathrm{m}}{\mathrm{s}^2}\right)} = \frac{478{,}000\ \frac{\cancel{\mathrm{kg}} \cdot \mathrm{m}^{\cancel{2}}}{\cancel{\mathrm{s}^2}}}{(5{,}671\ \cancel{\mathrm{kg}}) \cdot \left(9.81\ \frac{\cancel{\mathrm{m}}}{\cancel{\mathrm{s}^2}}\right)} = 8.59\ \mathrm{m}$$