Chapter 5 Review, pages 262–267

Knowledge

1. (d)
2. (c)
3. (a)
4. (b)
5. (c)
6. False. Mechanical work is calculated by multiplying the magnitude of a force times the displacement of the object to which it is applied.
7. True
8. False. Gravitational energy is a form of potential energy.
9. False. Energy, work, and time are scalar quantities, which means that power can also be described as a scalar quantity.
10. (a) (iii)
    (b) (iv)
    (c) (ii)
    (d) (i)
12. No work was done on the tree because there was no displacement.
13. Thermal energy is a measure of the kinetic energy of atoms and molecules.
14. Given: \( m = 60.0 \, \text{kg}; \, v = 40.0 \, \text{m/s} \)
    Required: \( E_k \)
    Analysis: \( E_k = \frac{mv^2}{2} \)
    Solution:
    \[
    E_k = \frac{mv^2}{2} = \frac{(60.0 \, \text{kg})(40.0 \, \text{m/s})^2}{2} = \frac{48 \times 10^3 \, \text{kg} \cdot \text{m}^2}{\text{s}^2} = 48 \, \text{kJ}
    \]
    Statement: The skydiver’s kinetic energy is 48 kJ.
15. The term \( m \) is mass in kilograms, \( g \) is the acceleration due to gravity (9.8 m/s\(^2\)), and \( h \) is height in metres.
16. The potential energy of the apple as it hangs from the tree is transformed into kinetic energy as it falls to the ground.
17. The two types of electrical energy are static electricity and current electricity.
18. Architects may take advantage of the Sun’s position in the sky to design buildings to best use the Sun’s energy to heat a building. They may place windows on the south-facing side of the building, or orient the building so that one wall faces the Sun. These considerations are called passive solar design.
19. Answers may vary. Sample answer: Efficiency is a ratio comparing the energy output to the energy input. It is expressed as a percentage.
20. Nuclear power plants take advantage of nuclear fission.
21. Fossil fuels are called fossil fuels because they are the decayed and compressed remains of prehistoric plants and animals that lived between 100 million and 600 million years ago.
22. The unit commonly used to measure the energy rating of an electrical appliance is the kilowatt hour (kWh).
23. Energy is the capacity to do work, and power is the rate at which energy is transformed or the rate at which work is done.

Understanding

24. Answers may vary. Sample answers:
    (a) No work is done on a wheelbarrow full of soil when it is pushed forward horizontally at constant velocity on a frictionless surface.
    (b) Pushing a wheelbarrow full of soil with increasing speed and pushing a wheelbarrow uphill both do work.
25. Sample answer: I would multiply the force exerted on the handle by \( \cos 30° \).
26. Given: \( m = 2100 \, \text{kg}; \, v_i = 0; \, a = 2.6 \, \text{m/s}^2; \, \Delta t = 4.0 \, \text{s} \)
    Required: \( W \)
    Analysis: \( \Delta d = v_i t + \frac{1}{2} at^2; \, F_{net} = ma; \, W = F \Delta d \)
    Solution:
    \[
    \Delta d = v_i t + \frac{1}{2} at^2 = 0 + \frac{1}{2} \left( 2.6 \, \text{m/s} \right)(4.0 \, \text{s}) = 10.4 \, \text{m} \\
    F = ma = (2000 \, \text{kg})(2.6 \, \text{m/s}^2) = 5200 \, \text{kg} \cdot \text{m} / \text{s}^2 \\
    F = \frac{5200 \, \text{kg} \cdot \text{m}}{\text{s}^2} = 5460 \, \text{N}
    \]
20. Given: $m = 68 \text{ kg}$; $h = 320 \text{ m}$; $v = 1.5 \text{ m/s}$; $g = 9.8 \text{ m/s}^2$

Required: $E_m$

Analysis: $E_m = E_k + E_g$

Solution:

$$E_m = \frac{1}{2}mv^2 + mgh$$

$$= \frac{1}{2}(68 \text{ kg})(1.5 \text{ m/s})^2 + (68 \text{ kg})(9.8 \text{ m/s}^2)(320 \text{ m})$$

$$= 76.5 \text{ kg} \cdot \text{m}^2/\text{s}^2 + 213,248 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

$$= 213,324.5 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

$$= 213,324.5 \text{ J}$$

$E_m = 210 \text{ kJ}$

Statement: The total mechanical energy of the rock climber is 210 kJ.

31. Given: $m = 2600 \text{ kg}$; $F_t = 8200 \text{ N}$; $g = 9.8 \text{ m/s}^2$

$$v_i = \frac{72 \text{ km}}{\text{h}} \times \frac{1000 \text{ m}}{\text{km}} \times \frac{\text{h}}{3600 \text{ s}}$$

$$v_i = 20 \text{ m/s}$$

Required: $\Delta t$

Analysis: $W = E_{k\text{ final}} - E_{k\text{ initial}}$; $W = F\Delta d$

Solution:

$$W = E_{k\text{ final}} - E_{k\text{ initial}}$$

$$= 0 - \frac{1}{2}mv_i^2$$

$$= -\frac{1}{2}(2600 \text{ kg})(20 \text{ m/s})^2$$

$$= 520 \text{ 000 kg} \cdot \text{m}^2/\text{s}^2$$

$$W = 520 \text{ kJ}$$

$$W = F\Delta d$$

$$\Delta d = \frac{W}{F}$$

$$= \frac{520 \text{ 000 J}}{8200 \text{ N}}$$

$$= 63.4 \text{ m}$$

$\Delta d = 63 \text{ m}$

Statement: It takes 63 m for the truck to stop.
32. Answers may vary. Sample answer:
The potential energy of the water raised behind the
dam is transformed into kinetic energy as it falls
toward the turbine. Kinetic energy is transferred to
the turbine, and the turbine transforms the kinetic
energy into electrical energy.
33. Answers may vary. Sample answers:
(a) The grass converts radiant (solar) energy into
chemical energy and converts chemical energy into
mechanical energy to grow.
(b) Mechanical energy from the vibrating string
transfers into sound energy throughout the air.
(c) The stuntman starts with gravitational
potential energy, which is converted into kinetic
energy as he falls. Then the kinetic energy from the stuntman
is transferred into elastic energy in the springs of
the trampoline.
(d) Solar (radiant) energy is transferred into
thermal energy on the asphalt.
34. Given: \( m = 73 \text{ kg}; \Delta d = 120 \text{ m}; v_i = 0; \)
g = 9.8 m/s²
Required: \( v_f \)
Analysis: Use the lower position just before the
bungee catches as the reference level for height.
Assume that the jumper starts from rest.
\[
E_{\text{top}} = E_{\text{bottom}}, \quad E_{k, \text{top}} + E_{g, \text{top}} = E_{k, \text{bottom}} + E_{g, \text{bottom}}
\]
Solution:
\[
E_{\text{top}} = E_{\text{bot}} \\
E_{k, \text{top}} + E_{g, \text{top}} = E_{k, \text{bottom}} + E_{g, \text{bottom}}
\]
\[
\frac{1}{2}mv_i^2 + mgh_{\text{top}} = \frac{1}{2}mv_f^2 + mgh_{\text{bottom}}
\]
\[
0 + mgh_{\text{top}} = \frac{1}{2}mv_f^2 + 0
\]
\[
v_f^2 = 2gh_{\text{top}}
\]
\[
v_f = \sqrt{2gh_{\text{top}}}
\]
\[
= \sqrt{2(9.8 \text{ m/s}^2)(120 \text{ m})}
\]
\[
= \sqrt{2352 \text{ m}^2/\text{s}^2}
\]
\[
= 48.49 \text{ m/s}
\]
Statement: The speed of the jumper just before
the bungee catches is 48 m/s.
35. (a) The energy transformations that take place
in a light bulb are as follows: electrical energy is
converted to radiant energy and thermal energy.
(b) Incandescent light bulbs are inefficient at
producing radiant energy but efficient at producing
thermal energy. They typically transform only
about 5 % of the electrical energy into radiant
energy. The remaining 95 % is transformed into
thermal energy. Fluorescent and compact
fluorescent lamps (CFLs) are more efficient at
producing radiant energy. These types of lamps
can transform up to 25 % of the electrical energy
into radiant energy.
36. Answers may vary. Sample answers:
(a) A renewable energy resource is one that is
replenished continuously in a short amount of time
or is available in inexhaustible quantities.
Wood is an example of a renewable energy resource.
(b) A non-renewable energy resource is one that is
available in finite, dwindling quantities or is
replenished over very long time periods. Oil is an
example of a non-renewable energy resource.
37. Given: \( h = 55 \text{ m}; \) efficiency = 50.0 %;
g = 9.8 N/m
Required: \( v_f \)
Analysis: \( \text{efficiency} = \frac{E_k}{E_g}; \quad E_k = \frac{1}{2}mv^2, \quad E_g = mgh \)
Solution:
\[
\text{efficiency} = \frac{E_k}{E_g}
\]
\[
E_k = 0.50
\]
\[
\frac{mv_f^2}{2mgh} = 0.50
\]
\[
\frac{mv_f^2}{2} = 0.50 \cdot mgh
\]
\[
v_f = \sqrt{\frac{2(0.50 \cdot mgh)}{m}}
\]
\[
= \sqrt{2(0.50)(9.8 \text{ N/m})(55 \text{ m})}
\]
\[
= 23.2 \text{ m/s}
\]
\[
v_f = 23 \text{ m/s}
\]
Statement: The velocity of the roller coaster at the
bottom of the first low point is 23 m/s.
38. (a) **Given**: efficiency = 17.0 %; $E_{\text{out}} = 252$ J  
**Required**: $E_{\text{in}}$  
**Analysis**: efficiency = $\frac{E_{\text{out}}}{E_{\text{in}}} \times 100$ %  
**Solution**: The energy input to produce 252 J of light energy:  
$$E_{\text{in}} = E_{\text{out}} + E_{\text{waste}}$$  
$$E_{\text{waste}} = E_{\text{in}} - E_{\text{out}}$$  
$$= 1482.3$ J  
$$E_{\text{in}} = 1480$ J  
**Statement**: The energy input required is 1480 J.  
(b) The waste energy is thermal energy.  
**Given**: $E_{\text{in}} = 1482.3$ J; $E_{\text{out}} = 252$ J  
**Required**: $E_{\text{waste}}$  
**Analysis**: $E_{\text{in}} = E_{\text{out}} + E_{\text{waste}}$  
**Solution**:  
$$E_{\text{in}} = E_{\text{out}} + E_{\text{waste}}$$  
$$E_{\text{waste}} = E_{\text{in}} - E_{\text{out}}$$  
$$= 1482.3$ J – $252$ J  
$$= 1230.3$ J  
$$E_{\text{waste}} = 1230$ J  
**Statement**: A total of 1230 J would be wasted.

39. **Given**: efficiency = 12 %; $F = 18$ 000 N;  
$v = 21$ m/s; $\Delta d = 450$ m  
**Required**: $E_{\text{in}}$  
**Analysis**: The energy output of the car is equal to the work done: $E_{\text{out}} = W; E_{\text{out}} = F\Delta d$;  
**efficiency**: $\frac{E_{\text{out}}}{E_{\text{in}}} \times 100$ %  
**Solution**:  
$$E_{\text{out}} = W$$  
$$= F\Delta d$$  
$$= (18$ 000 N)(450 m)  
$$= 8$ 100 $000$ N$\cdot$m  
$$E_{\text{out}} = 8.1$ MJ

40. **Table 1**

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Renewable or non-renewable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>biofuel</td>
<td>renewable</td>
</tr>
<tr>
<td>coal</td>
<td>non-renewable</td>
</tr>
<tr>
<td>geothermal</td>
<td>renewable</td>
</tr>
<tr>
<td>hydroelectric</td>
<td>renewable</td>
</tr>
<tr>
<td>natural gas</td>
<td>non-renewable</td>
</tr>
<tr>
<td>nuclear</td>
<td>non-renewable</td>
</tr>
<tr>
<td>oil</td>
<td>non-renewable</td>
</tr>
<tr>
<td>solar</td>
<td>renewable</td>
</tr>
<tr>
<td>wind</td>
<td>renewable</td>
</tr>
<tr>
<td>wood</td>
<td>renewable</td>
</tr>
</tbody>
</table>

41. Answers may vary. Sample answers:  
(a) **Hydroelectric**. Flowing water has gravitational (potential) energy. As the water falls, the potential energy is converted to kinetic energy. This kinetic energy is captured in the hydroelectric plant, and converted to electrical energy.  
(b) **Tidal**. Water on Earth has potential energy because of the Moon’s gravity. As the water moves toward the Moon, the potential (gravitational) energy is converted to kinetic energy. This is captured by turbine and converted to electrical energy. Water’s potential energy also gets converted to kinetic energy as the water falls to low tide.  
(c) **Geothermal**. Matter deep inside the Earth has a great deal of thermal energy. This can be used directly to heat buildings on the Earth’s surface or used to heat water. As the water boils, the thermal energy is converted to kinetic energy, which is captured by a turbine and converted to electrical energy.  
(d) **Wind**. Moving air (wind) has kinetic energy. This is converted to electrical energy.
42. Given: \( W = 600.0 \, \text{N} \); \( h = 3.0 \, \text{m} \); \( \Delta t = 5.0 \, \text{s} \)
Required: \( P \)
Analysis: \( W = F \Delta d \); \( P = \frac{W}{\Delta t} \)
Solution:
\[
W = F \Delta d \\\n\frac{P}{\Delta t} = \frac{W}{\Delta t} = \frac{(600.0 \, \text{N})(3.0 \, \text{m})}{5.0 \, \text{s}} = 360 \, \text{N}\cdot\text{m} \, \text{s}^{-1} = 360 \, \text{W}
\]
Statement: The man’s power is 360 W.
43. Given: \( F = 120 \, \text{N} \); \( \Delta d = 6.0 \, \text{m} \); \( \Delta t = 2.0 \, \text{s} \)
Required: \( P \)
Analysis: \( W = F \Delta d \); \( P = \frac{W}{\Delta t} \)
Solution:
\[
W = F \Delta d = (120 \, \text{N})(6.0 \, \text{m}) = 720 \, \text{N}\cdot\text{m} = 720 \, \text{J}
\]
\[
\frac{P}{\Delta t} = \frac{W}{\Delta t} = \frac{720 \, \text{J}}{2.0 \, \text{s}} = 360 \, \text{W} \, \text{s}^{-1} = 360 \, \text{J} \, \text{s}^{-1} = 360 \, \text{W}
\]
Statement: The girl’s power is 360 W.
44. Given: \( P = 4.0 \times 10^{3} \, \text{W} \);
\( \Delta t = 0.70 \, \text{ms} = 0.70 \times 10^{-3} \, \text{s} \);
\( \Delta d = 1.4 \, \text{cm} = 1.4 \times 10^{-2} \, \text{m} \);
\( m = 145 \, \text{g} = 145 \times 10^{-3} \, \text{kg} \)
Required: \( F_{\text{net}} \), \( a_{\text{avg}} \)
Analysis: \( P = \frac{E}{\Delta t} \); \( E = \frac{F_{\text{net}} \Delta d}{\Delta t} \); \( F_{\text{net}} = ma \)
Solution:
\[
\frac{P}{\Delta t} = \frac{E}{\Delta t} = \frac{F_{\text{net}} \Delta d}{\Delta t} = \frac{F_{\text{net}} \Delta d}{\Delta t} = \frac{F_{\text{net}} \Delta d}{\Delta t} = \frac{F_{\text{net}} \Delta d}{\Delta t}
\]
\[
F_{\text{net}} = \frac{P \Delta t}{\Delta d} = \frac{(4.0 \times 10^{5} \, \text{W})(0.70 \times 10^{-3} \, \text{s})}{1.4 \times 10^{-2} \, \text{m}} = 20000 \, \text{W} \cdot \text{s}^{-1} = 20000 \, \text{N}
\]
\( F_{\text{net}} = 2.0 \times 10^{4} \, \text{N} \)
\[
F_{\text{net}} = ma = \frac{20000 \, \text{N}}{145 \times 10^{-3} \, \text{kg}} = 137931 \, \text{N} \, \text{kg}^{-1} = 137931 \, \text{m} \, \text{s}^{-2} \]
\[
a = 1.4 \times 10^{5} \, \text{m} \, \text{s}^{-2}
\]
Statement: The net force applied to the ball is \( 2.0 \times 10^{4} \, \text{N} \), and the average acceleration is \( 1.4 \times 10^{5} \, \text{m} \, \text{s}^{-2} \).

Analysis and Application
45. Answers may vary. Sample answer:
A waiter carrying a tray of food over his head across a room and travelling at a constant velocity.
46. Answers may vary. Sample answers:
(a) Posing as a still model for portrait painting is paid as work, but is not work in the sense that the force on the bags of cement is perpendicular to the direction of motion.
(b) Digging holes with a shovel is work in both senses because soil is being lifted against the force of gravity and is gaining potential energy.
Throwing cement bags onto a truck is work as they accelerate. Carrying bags of cement is work, but is not work in the sense that the force on the bags of cement is perpendicular to the direction of motion.

47. Given: \( h = 2.2 \, \text{m} \); \( F = 98 \, \text{N} \); \( m = 10.0 \, \text{kg} \);
\( g = 9.8 \, \text{m} \, \text{s}^{-2} \)
Required: \( W_{\text{man}} \), \( W_{\text{gravity}} \), \( W_{\text{net}} \)
Analysis: \( W = F \Delta d \); \( W_{g} = mgh \)
(a) The work done by the man lifting the box:
Solution:
\[
W = F_{\text{net}} \Delta d = (98 \, \text{N})(2.2 \, \text{m}) = 215.6 \, \text{N}\cdot\text{m}
\]
\( W = 220 \, \text{J} \)
**Statement:** The work done by the man lifting the box was 220 J.

(b) The work done by gravity:

**Solution:**

\[ W_g = mgh \]

\[ = (10 \text{ kg})(-9.8 \text{ m/s}^2)(2.2 \text{ m}) \]

\[ = -215.6 \text{ J} \]

\[ W_g = -220 \text{ J} \]

**Statement:** The work done by gravity was –220 J.

(c) The net work done on the box:

**Solution:**

\[ W_{net} = W_{man} + W_g \]

\[ = 215.6 \text{ J} + (-215.6 \text{ J}) \]

\[ W_{net} = 0 \text{ J} \]

**Statement:** The net work done on the box was 0 J.

(d) Yes, it is possible to know the net work done on the box without knowing the mass or the force exerted. Since you are told that the man moves the box at a constant velocity, then the net force on the box must be zero. If the net force is zero, then the net work must also be zero.

48. **Given:** \( m = 155 \text{ kg}; \) \( F = 1910 \text{ N}; \) \( h = 2.80 \text{ m}; \) \( g = 9.8 \text{ m/s}^2 \)

**Required:** \( F_{net}; \) \( F-d \) graph

**Analysis:** the net force acting on the weight when lifted is \( F_{net} = F_{lift} - F_g; \) the net force acting on the weight when dropped is \( F_{net} = ma = mg \)

(i) The net force acting on the weight for the lift:

**Solution:**

\[ F_{net} = F_{lift} - F_g \]

\[ = F_{lift} - mg \]

\[ = 1910 \text{ N} - (155 \text{ kg})(9.8 \text{ m/s}^2) \]

\[ = 391.0 \text{ N} \]

\[ F_{net} = 3.9 \times 10^2 \text{ N} \]

(ii) The net force acting on the weight for the drop:

**Solution:**

\[ F_{net} = F_g \]

\[ = mg \]

\[ = (155 \text{ kg})(9.8 \text{ m/s}^2) \]

\[ = 1519 \text{ kg} \cdot \text{m/s}^2 \]

\[ = 1519 \text{ N} \]

\[ F_{net} = 1.5 \times 10^3 \text{ N} \]

49. **Given:** \( m = 0.50 \text{ kg}; \) \( h = 22 \text{ m}; \) \( g = 9.8 \text{ m/s}^2 \)

**Required:** \( E_g; \) \( E_k; \) \( v_t \)

**Analysis:** \( E_g = mgh; \) \( E_k = \frac{mv^2}{2} \)

(a) Initial potential energy of the rock:

**Solution:**

\[ E_g = mgh \]

\[ = (0.50 \text{ kg})(9.8 \text{ m/s}^2)(22 \text{ m}) \]

\[ = 107.8 \text{ J} \]

\[ E_g = 110 \text{ J} \]

**Statement:** The initial potential energy of the rock is 110 J.

(b) The kinetic energy of the rock just before it hits the water:

**Solution:**

\[ E_{k_final} + E_{k_initial} = E_{k_final} + E_{k_initial} \]

\[ 0 + E_{k_final} = E_{k_final} + 0 \]

\[ E_{k_final} = E_{k_final} \]

\[ E_{k_final} = 110 \text{ J} \]

**Statement:** The kinetic energy of the rock just before it hits the water is 110 J.

(c) The final speed of the rock:

**Solution:**

\[ \frac{1}{2}mv^2 = mgh \]

\[ v_f = \sqrt{2gh} \]

\[ = \sqrt{2(9.8 \text{ m/s}^2)(22 \text{ m})} \]

\[ = 20.7 \text{ m/s} \]

\[ v_f = 21 \text{ m/s} \]

**Statement:** The final speed of the rock is 21 m/s.
50. **Given:** \( m = 1800 \text{ kg}; h_{\text{initial}} = 450 \text{ m}; \) 
\( v_i = 42 \text{ m/s}; v_f = 64 \text{ m/s}; \Delta h = 120 \text{ m}; g = 9.8 \text{ m/s}^2 \)  
**Required:** \( E_{g \text{ initial}}; E_{g \text{ final}}; E_{k \text{ initial}}; E_{k \text{ final}}; W_{\text{total}} \)  
**Analysis:** \( E_{g \text{ initial}} = mgh; E_{k} = \frac{mv^2}{2}; \) 
\( W = E_{k \text{ final}} - E_{k \text{ initial}} \)  
(a) **Initial and final potential energy:**  
**Solution:** 
\[ E_{g \text{ initial}} = mgh \]  
\[ = (1800 \text{ kg})(9.8 \text{ m/s}^2)(450 \text{ m}) \]  
\[ = 7 938 000 \text{ kg}\cdot\text{m}^2/\text{s}^2 \]  
\( E_{g \text{ initial}} = 7.9 \times 10^6 \text{ J}, \text{ or } 7.9 \text{ MJ} \)  
\[ E_{g \text{ final}} = mgh_{\text{final}} \]  
\[ E_{g \text{ final}} = (1800 \text{ kg})(9.8 \text{ m/s}^2)(450 \text{ m} - 120 \text{ m}) \]  
\[ = 5 821 200 \text{ J} \]  
\( E_{g \text{ final}} = 5.8 \times 10^6 \text{ J}, \text{ or } 5.8 \text{ MJ} \)  
**Statement:** The initial potential energy of the plane is \( 7.9 \times 10^6 \text{ J}, \text{ or } 7.9 \text{ MJ}. \text{ The final potential energy of the plane is } 5.8 \times 10^6 \text{ J}, \text{ or } 5.8 \text{ MJ}. \)  
(b) **Initial and final kinetic energy:**  
**Solution:** 
\[ E_{k \text{ initial}} = \frac{mv_i^2}{2} \]  
\[ = (1800 \text{ kg})(42 \text{ m/s})^2 \]  
\[ = 1 587 600 \text{ kg}\cdot\text{m}^2/\text{s}^2 \]  
\( E_{k \text{ initial}} = 1.6 \times 10^6 \text{ J}, \text{ or } 1.6 \text{ MJ} \)  
\[ E_{k \text{ final}} = \frac{mv_f^2}{2} \]  
\[ = (1800 \text{ kg})(64 \text{ m/s})^2 \]  
\[ = 3 686 400 \text{ kg}\cdot\text{m}^2/\text{s}^2 \]  
\( E_{k \text{ final}} = 3.7 \times 10^6 \text{ J}, \text{ or } 3.7 \text{ MJ} \)  
**Statement:** The initial kinetic energy of the plane is \( 1.6 \times 10^6 \text{ J}, \text{ or } 1.6 \text{ MJ}. \text{ The final kinetic energy of the plane is } 3.7 \times 10^6 \text{ J}, \text{ or } 3.7 \text{ MJ}. \)  
(c) **The total work done on the plane:**  
**Solution:** 
\[ W = E_{k \text{ final}} - E_{k \text{ initial}} \]  
\[ = 3.7 \text{ MJ} - 1.6 \text{ MJ} \]  
\( W = 2.1 \text{ MJ} \)  
**Statement:** The total work done on the plane is 2.1 MJ.  
51. Answers may vary. Sample answers:  
(a) The engine did work when the car accelerated to pass the other car because the kinetic energy was increasing. The engine did work when the car went up the hill because the gravitational potential energy was increasing.  
(b) When the car accelerated to pass, chemical energy in the fuel was being converted into kinetic energy. When the car went up the hill, chemical energy in the fuel was being converted into potential energy.  
(c) When travelling at a constant speed on a flat highway, chemical energy was being converted into thermal energy because of friction and waste heat from the engine. When the car coasted down the hill, gravitational potential energy was being converted into kinetic energy.  
52. Answers may vary. Sample answers:  
(a) Solar cells and photosynthesis operate on solar energy, which is virtually inexhaustible. Fossil fuels are finite and exhaustible.  
(b) Plants (biofuels) are replaced in a matter of months or years, but fossil fuels take millions of years to form.  
53. **Given:** \( m = 11 \text{ kg}; F_{\text{friction}} = 86 \text{ N}; d = 22 \text{ m} \)  
**Required:** \( F_{\text{min}}; \Delta E; \text{ efficiency} \)  
**Analysis:** \( E = W; W = F\Delta d; \)  
\[ \text{efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \% \]  
(a) **Solution:** The minimal force needed would be the force to overcome \( F_{\text{friction}} \) of 86 N; \( F_{\text{min}} = 86 \text{ N} \)  
(b) **Minimum amount of energy:**  
**Solution:** 
\[ \Delta E = W \]  
\( W = F\Delta d \)  
\[ \Delta E = F\Delta d \]  
\[ = (86 \text{ N})(22 \text{ m}) \]  
\[ = 1892 \text{ J} \]  
\( \Delta E = 1900 \text{ J} \)  
**Statement:** The minimum amount of energy is 1900 J.
(c) The man’s efficiency: The output energy or work done is only the minimum work required to push against friction.

**Solution:**

\[ \text{efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \% \]

\[ = \frac{1892}{2180} \times 100 \% \]

\[ = 86.7 \% \]

**Statement:** The man’s efficiency is 87 %.

54. Answers may vary. Sample answers:

(a) In the summer, when the Sun is high, the porch roof shades the interior and reduces the need for air conditioning. In the winter, when the Sun is low, the rays can pass under the porch roof and help heat the interior.

(b) Deciduous trees shade the house in summer and cool it, and when they lose their leaves in the winter, they allow sunlight to help warm the house. Evergreen trees shade the house all year long.

55. Answers may vary. Sample answers:

(a) \[ \text{efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \% \]

\[ = \frac{\frac{1}{2} m v^2}{mgh} \times 100 \% \]

\[ = \frac{v^2}{2gh} \times 100 \% \]

Mass is not needed because it cancels out.

(b) **Given:** \( v_f = 5.0 \text{ m/s}; h = 3.0 \text{ m}; g = 9.8 \text{ m/s}^2 \)

**Required:** efficiency

**Analysis:** \( \text{efficiency} = \frac{v^2}{2gh} \times 100 \% \)

**Solution:**

\[ \text{efficiency} = \frac{v^2}{2gh} \times 100 \% \]

\[ = \left( \frac{5.0}{3.0} \right)^2 \left( \frac{9.8}{3.0} \right) \times 100 \% \]

\[ = 42.5 \% \]

**Statement:** The efficiency of the energy transformation is 43 %.

(c) One factor that contributes to loss of efficiency is the friction that occurs between the slide and the slider’s clothing. Friction transforms the kinetic energy into thermal energy.

(d) Potential energy was converted to thermal energy.

(e) Potential energy = kinetic energy + thermal energy

(f) The law of conservation of energy was not violated because the loss of mechanical energy was equal to the thermal energy released into the surroundings.

56. Answers may vary. Sample answer:

Three ways I could conserve electrical energy are as follows: taking quick showers instead of long baths, not blow drying my hair, and turning off the computer when I am not using it.

57. **Given:** efficiency = 5.0 %; \( P = 100.0 \text{ W}; t = 1.0 \text{ h} \)

**Required:** \( E_{\text{waste}} \)

**Analysis:** \( W = P \Delta t; \) \( \text{efficiency} = \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \% \)

**Solution:**

\[ W = P \Delta t \]

\[ = 100.0 \text{ W} \times 1.0 \text{ h} \]

\[ W = 100.0 \text{ J} \] (two extra digits carried)

\[ E_{\text{waste}} = (0.95)(100.0 \text{ J}) \]

\[ E_{\text{waste}} = 95 \text{ J} \]

**Statement:** The amount of waste thermal energy is 95 J.

58. Answers may vary. Sample answers:

(a) Nuclear energy is converted into thermal energy, which is converted into mechanical energy. The mechanical energy is converted into electrical energy.

(b) Two disadvantages of using nuclear power as a source of electrical energy are as follows: The water used to cool the nuclear power plant can cause thermal pollution in streams when it is released. Radioactive waste remains hazardous for thousands of years and is very difficult to store safely.
59. (a) **Given:** \( P = 1275 \text{ W} = 1.275 \text{ kW} \); rate of electricity = 5¢/kWh; 
\( \Delta t = 2 \text{ min} \)
\[
\Delta t = 2 \text{ min} \times \frac{1 \text{ h}}{60 \text{ min}} = 0.03 \text{ h}
\]
**Required:** cost of heating a cup of soup

**Analysis:** \( P = \frac{\Delta E}{\Delta t} \)

cost = number of kilowatt hours × rate

**Solution:**
\[
P = \frac{\Delta E}{\Delta t}
\]
\[
\Delta E = P \Delta t
\]
\[
= 1.275 \text{ kW} \times 0.03 \text{ h}
\]
\[
= 0.038 \text{ kWh}
\]
\[
\Delta E = 0.04 \text{ kWh}
\]

cost = \( \Delta E \times \text{ rate} \)
\[
= 0.038 \text{ kWh} \left( \frac{5 \text{ ¢}}{5 \text{ kWh}} \right)
\]
\[
= 0.19 \text{ ¢}
\]
cost = 0.2¢

**Statement:** The cost of heating a cup of soup is 0.2¢.

(b) Answers may vary. Sample answer: “Hidden” costs of heating the cup of soup in the microwave are as follows: the cost of manufacturing the microwave oven and the environmental damage caused by generating the electricity using fossil fuels.

60. Answers may vary. Sample answer:
Plants transform radiant energy from the Sun into chemical energy, which is converted into another form of chemical energy when the plant food is eaten and stored in a person’s cells. The person’s muscles convert the chemical energy into kinetic energy, which is converted into electrical and then chemical energy and stored in the batteries of the radio. This chemical energy is converted into electrical energy, which is then converted into sound energy.

61. Answers may vary. Sample answers:
(a) Sunlight is converted into chemical energy in plants, which can be processed to make biofuels. The Sun causes uneven heating of the Earth, which causes winds to blow. The kinetic energy of wind is transformed into electrical energy by wind turbines.

(b) Tidal energy has gravitational energy as its source.

(c) Both coal and oil store chemical energy that was originally stored in plants. The plants transformed solar energy by photosynthesis.

(d) Plants store energy in a matter of months or years, so the energy is renewable and can be replenished with the growth of a plant. Fossil fuels are non-renewable because they are used in energy transforming processes and so these fuels cannot be replenished.

62. Answers may vary. Sample answers:
(a) Biofuels are combustible gases or liquids manufactured by processing plants. This fuel can be transported as easily as gasoline, so it can be used anywhere, but its most efficient use would be near the location the plants were grown.

(b) Geothermal energy is energy from Earth, such as hot springs. Geothermal heat can be used to produce steam, which is used to generate electricity. Its most practical use is near geothermal vents, which are mostly in British Columbia.

(c) Tidal power harnesses the kinetic energy of the rising and falling ocean surface, so its most practical use is along the ocean coastlines.

(d) Wind is used to turn electrical generators powered by wind turbines. Wind power is most practical in the windiest parts of Canada, including the Plains and the North.

63. **Given:** \( m = 610 \text{ kg} \); \( v_i = 0 \text{ m/s} \); \( v_f = 14 \text{ m/s} \); \( t = 1.1 \text{ s} \)

**Required:** \( d; \Delta E; P \)

**Analysis:** \( d = \frac{v_i + v_f}{2} \Delta t \); \( E_k = \frac{mv^2}{2} \); \( P = \frac{\Delta E}{\Delta t} \)

(a) The distance required by the horse:

**Solution:**
\[
d = \left( \frac{v_i + v_f}{2} \right) \Delta t
\]
\[
= \left( \frac{14 \text{ m} + 0 \text{ m}}{2} \right) (1.1 \text{ s})
\]
\[
d = 7.7 \text{ m}
\]

**Statement:** The distance required by the horse is 7.7 m.
(b) The minimum amount of energy required:

Solution:
\[ \Delta E = E_{k\text{ final}} - E_{k\text{ initial}} \]
\[ = \frac{mv_{f}^{2}}{2} - 0 \]
\[ = \frac{(610 \text{ kg})(14 \text{ m/s})^{2}}{2} \]
\[ = 59 \text{ 780 J} \]
\[ \Delta E = 6.0 \times 10^{4} \text{ J} \]

Statement: The minimum amount of energy required by the horse is 6.0 \times 10^{4} \text{ J}.

(c) The horse’s power:

Solution:
\[ P = \frac{\Delta E}{\Delta t} \]
\[ = \frac{59 \text{ 780 J}}{1.1 \text{ s}} \]
\[ = 54 \text{ 345.4 J/s} \]
\[ P = 54 \text{ 000 W}, \text{ or } 54 \text{ kW} \]

Statement: The horse’s power is 54 kW.

64. Given:
- \( P = 3.0 \times 10^{2} \text{ W} \);
- efficiency = 92 \%;
- \( t = 4.0 \text{ s} \);
- \( m = 78 \text{ kg} \)

\( v_{i} = 21 \text{ km/h} \)
\[ = 21 \text{ km} \times \frac{1 \text{ km}}{3600 \text{ s}} \times 1000 \text{ m/} \text{ km} \]
\[ = 5.83 \text{ m/s} \]

Required: \( v_{f} \)

Analysis: \( P = \frac{\Delta E}{\Delta t} \); efficiency = \( \frac{E_{\text{out}}}{E_{\text{in}}} \times 100 \% \);

\[ E_{k} = \frac{mv^{2}}{2} \]

Solution:
\[ \Delta E_{\text{out}} = P\Delta t \]
\[ = (3.0 \times 10^{2} \text{ W})(4.0 \text{ s}) \]
\[ = 1200 \text{ W/s} \]
\[ \Delta E_{\text{out}} = 1200 \text{ J} \]

efficiency = \( \frac{\Delta E_{\text{out}}}{\Delta E_{\text{in}}} \times 100\% \)
\[ \Delta E_{\text{in}} = (\text{efficiency})(E_{\text{in}}) \]
\[ = (92 \%)(1200 \text{ J}) \]
\[ = 1104 \text{ J} \]

Statement: The cyclist will be travelling at 7.9 \text{ m/s}.

Evaluation

65. Answers may vary. Sample answers:
(a) Fossil fuels should be phased out and replaced with wind power everywhere. Geothermal and solar energy could be used in the places where they are most practical.
(b) Fossil fuels cause more pollution and release greenhouse gases, which contribute to climate change. Fossil fuels are not renewable and are in shorter supply than nuclear fuels.
(c) Wind power is practical for most parts of Ontario and has relatively little environmental impact. The source is inexhaustible.
(d) Solar power is not a practical alternative in most parts of Ontario because of short winter daylight hours. Burning biofuels and wood releases greenhouse gases.

66. Answers may vary. Sample answers:
(a) Advantages: Photovoltaic cells are an inexhaustible source of energy, and the operation of the cells causes no waste products.
Disadvantages: Solar cells only work when the Sun is shining. Electricity must be transmitted from the source.
(b) The manufacture of photovoltaic cells uses energy and produces waste that must be disposed of. Materials must be shipped by highway and by train. Energy is lost during transmission, which is often from remote desert locations.
(c) Canada’s energy needs are greatest in winter when energy is needed for heating. This is also the time of year when solar energy is least available because of Canada’s latitude. Solar energy would be most useful in southern Canada and in areas with little cloud cover, like the central Plains.
Reflect on Your Learning

67. Answers may vary. Sample answer:
I learned that some energy transformations were not as efficient as I thought they would be, for example, photosynthesis. I also learned that others, for example, bicycles, are much more efficient than I thought.

68. Answers may vary. Sample answer:
(a) I still wonder why no work is done when you hold a heavy object stationary in the air. It feels like work.
(b) I can read the textbook again on the work and look at the examples of work and try to figure out why my example from part (a) is not an example of work. By comparing the different factors in each example, I should be able figure it out.

69. Answers may vary. Sample answer:
Yes. I used to believe that all renewable energy sources were more environmental friendly than non-renewable energy sources. I now know that renewable energy sources can have negative environmental consequences, too. For example burning wood releases carbon dioxide (a greenhouse gas) into the atmosphere.

70. Answers may vary. Sample answers:
(a) Thermal energy can be considered potential energy because it can give substances the ability to do work. For example, when enough heat is added to water it can become vaporized and can be used to turn generators, and the heat that is added to the air in hot-air balloons causes them to lift off.
(b) Nuclear energy can be considered potential energy because it does not directly create kinetic or electrical energy, but can give off large amounts of heat, which can then be used to turn generators. An example would be a nuclear power plant.
(c) Chemical energy can be considered potential energy because it has the ability to be converted to mechanical energy and do work. An example would be gasoline. Gasoline alone does not do anything, but when ignited it can power a car.

Research

71. Answers may vary. Students should define and describe the oil sands, discuss its advantages and disadvantages in terms of cost, practicality, and environmental impact; and compare it to other energy sources.

72. Answers may vary. Students should describe hydroelectric power, identify areas of Canada where hydroelectric power is currently providing power, and discuss environmental advantages and disadvantages, such as altering the flow of rivers. Reports should also include discussion of the possibilities of expanding Canadian hydroelectric power.

73. Answers may vary. Students should describe how energy-efficient appliances minimize waste heat loss. They should also describe ways to prevent heat loss and gain to houses, such as installing double-glazed windows, improving home insulation, and using passive solar architecture.

74. Answers may vary. Students should describe how animals create and use bioluminescence. The main uses include mating and hunting. Bioluminescence is close to 100% efficient. Students may include information about genetic sequencing and how the principles of bioluminescence have been adapted in genetic research and other areas.

75. Answers may vary. Some suggested topics are: rechargeable batteries, the flywheel storage capabilities of cars, and compressed air storage. The page should describe the basics of how the technology works and its applications and limitations.