43. $E_p = mgh$

$= (750\text{ N})(15.0\text{ m})$

$= 1.13 \times 10^4\text{ J}$

E_p is converted from E_k,
therefore $E_k = 1.13 \times 10^4$ J

$$v = \sqrt{\frac{2E_k}{m}}$$

$$= \sqrt{2(1.13\times10^4\text{ J})\left(\frac{750\text{ N}}{9.81\frac{\text{m}}{\text{s}^2}}\right)}$$

$= 17.2$ m/s

44. i) a) This is gravitational potential energy
   b) When the water in the reservoir is allowed to flow downhill, the gravitational potential energy can be made to move some device, converting the potential energy into kinetic energy.
   c) This potential energy can be converted to electrical energy, as in a hydro-electric power station.
 ii) a) The rocket has chemical potential energy.
   b) When the chemical reaction occurs, the rocket will rise into the air.
   c) The chemical potential energy was first converted into kinetic energy, which in turn was converted into gravitational potential energy.
 iii) a) The toy gun has elastic potential energy.
   b) When released, the elastic potential energy can move the dart.
   c) The elastic potential energy is converted first to kinetic energy.

45. a) The initial source of energy is chemical potential energy. It is potential energy because it is stored energy.
   b) The battery is still functional after a long period because the chemical reaction inside the battery does not occur unless there is a drain of the energy.
   c) The stored chemical energy is converted to electrical energy.

46. $E_k = \frac{1}{2}mv^2$

$$= \frac{1}{2}(0.300\text{ kg})\left[\left(747\frac{\text{km}}{\text{h}}\right)\left(\frac{1000\text{ m}}{1\text{ km}}\right)\left(\frac{1\text{ h}}{3600\text{ s}}\right)\right]^2$$

$= 6.46 \times 10^3$ J

But E_k is converted to E_p,
therefore $E_p = 6.46 \times 10^3$ J

$$h = \frac{E_{p(grav)}}{mg}$$

$$h = \frac{6.46\times10^3\text{ J}}{(0.300\text{ kg})(9.81\text{ m/s}^2)}$$

$= 2.19 \times 10^3$ m

47. Step 1: Find the work done in lifting the object to a height.
Step 2: Equate the work done W_{done} with E_p, which equals E_k.
Step 3: Once you know the E_k you can determine the speed.

48. Step 1: Determine the E_k.
Step 2: Equate the E_k with E_p.
Step 3: Once you know the E_p, you can determine the height. You must ignore friction.

49. Students' answers will vary but could be the following. Energy is used to heat water in a hot-water tank and the only purpose for the hot water in most homes is for washing. Once used, this waste hot water could be piped throughout the home for heating.

50. Mechanical energy in the movement of the match is first converted to heat to ignite the match. This initial heat is then converted to chemical energy due to combustion, and the chemical energy is then converted to heat and light energy.

51. The extra energy will be stored as chemical potential energy in the form of fat.

52. a) You cannot have an efficiency of over 100% because, according to the first law of thermodynamics, the energy in a system and its surroundings must remain constant. To have an efficiency of over 100%, energy would have to be created, which is impossible.
   b) ii) A steam engine can extract heat from a combustion reaction and use it to heat steam, and the steam can then be used to do work.
   iii) Only a hypothetical perpetual motion machine can convert mechanical energy to mechanical energy with no loss.

53. $$\text{percent efficiency} = \frac{\text{useful energy output}}{\text{total heat input}} \times 100\%$$

$$= \frac{350\text{ J}}{1000\text{ J}} \times 100\%$$

$= 35.0\%$

54. $$\text{work}_{input} = \frac{\text{work}_{output}}{\text{efficiency}}$$

$\text{work}_{output} = Fd$

$= 400\text{ N} \times 3.50\text{ m}$

$= 1400$ J

$$\text{work}_{\text{input}} = \frac{\text{work}_{\text{output}}}{\text{efficiency}} = \frac{1400 \text{ J}}{0.15} = 9.33 \times 10^3 \text{ J}$$

55. a) The surroundings are the air and blankets that surround the hot-water bottle.
    b) It is a closed system because energy is transferred to the surroundings, not matter.
    c) It would then be an open system, since there is an exchange of both matter and energy
56. If energy from the Sun originated from the combustion of matter, then the Sun should have burned out after about 1000 years.
57. a) Combustion chamber, turbine, generator
    b) Combustion chamber: Heat energy is produced which can be useful in heating water to steam and wasted through the exhaust system.
    Turbine: The energy in the steam can be useful in rotating the turbines and wasted in friction and lost heat.
    Generator: The mechanical energy of the rotating turbine in a magnetic coil can produce useful electrical energy and wasted in energy lost to friction.
58. Waste heat from the combustion chamber and from the steam in the turbines can be recycled and used to heat the power plant. There is not much energy to recover from the generator itself.
59.

	Risk	Benefit	Sustainability
Wood	Produces a lot of waste ash and polluting gases	Cheap and easy to obtain	Sustainable since it can be replaced in a relatively short time
Coal	Produces a lot of waste ash and polluting gases	Cheap and burns hotter	Not sustainable but there are still large supplies remaining
Gas	Only produces polluting gases	Cheap and cleaner burning	Not sustainable and only small supplies remaining

60. A pump system must be devised to keep the warm water tank constantly filled with warm water and the cold water tank filled with cold water. However, very powerful pumps must be used if water is to be pumped through great distances. Secondly, the flow of energy from the hot tank to the cold tank is necessary to turn the turbines that drive the propeller. However, the force of the flow of energy will not be powerful enough to turn a turbine to rotate a propeller.

Extensions

61. Students' answers may vary but they are likely to include the example in the student book: steam engines. In trying to develop better systems to pump water, steam engines were developed to move the piston back and forth to pump water.
62. For every new development in a technology, there is a scientific principle to explain its operation. Technologies are always being developed to exploit scientific principles.
63. Students' answers may vary, but one example may be the following. The most important technology has been the internal combustion engine. Efficient engines have resulted in modern industrialized societies that are totally reliant on this technology.
64. Students' answers will vary but could include the following:
    a) Heat can produce steam that, in a steam engine, is used to propel a vehicle.
    b) Heat can produce the combustion of gases that, in a rocket engine, may propel a rocket upwards, changing the rocket's position.
    c) Heat from a stove element can increase the temperature of a pot on the stove.
65. Hot-water heaters are usually the most inefficient energy consumers in the home. Possible ways to improve efficiency would be:
    - Improve the tank's insulation.
    - Turn down the temperature of water.
    - Use an electric heating element rather than a gas-powered element.
66. Initially, the object has kinetic energy. As the object rises, the kinetic energy is converted to potential energy. At the highest point in its rise, it only has potential energy. The mechanical energy involves both potential and kinetic energy, and each can convert into the other, so in this situation the mechanical energy remains constant.
67. Total $E_p = mgh$ (at the top)

$$= (0.0100 \text{ kg})(9.81 \text{ m/s}^2)(1.30 \text{ m}) = 0.128 \text{ J}$$

At the point that the $E_k = E_p$, the $E_{p(grav)} = \frac{0.128 \text{ J}}{2} = 0.0638 \text{ J}$

$$h = \frac{E_{p(grav)}}{mg} = \frac{0.0638 \text{ J}}{(0.0100 \text{ kg})\left(9.81 \frac{\text{m}}{\text{s}^2}\right)} = 0.650 \text{ m}$$

At this height, both the kinetic and potential energy are equal.