sustainable: processes that will not compromise future generations
system: set of interconnected parts; in studies of work and energy transfers, object or objects involved in a transfer
uniform motion: travel at a constant rate of motion in a straight line
velocity: speed and direction of an object
work: a force moving an object through a distance

Knowledge

B1.0

2. Students' answers will vary for the examples given in parentheses below.
   a) scalar (10 m)
   b) vector (10 m [E])
   c) scalar (10 m/s)
   d) vector (10 m/s [E])
   e) vector (10 m/s^2 [E])
   f) scalar (10 J)
   g) scalar (10 J)
   h) vector (10 N [E])
3. You must measure the distance travelled and the time in which the distance was travelled.
4. Acceleration is the rate of change in speed. It may be speeding up or slowing down. Uniform motion is motion in which the object maintains the same speed over a time interval.
5. a) If a force is applied in the same direction as the motion, then the object will speed up.
   b) If a force is applied in the opposite direction to the motion, then the object will slow down.
6. Work is done on an object when a force moves an object through a distance. The force and the distance moved must be in the same direction.
7. If you carry an object while moving forward, the force applied on the object is vertical to overcome the gravitational force on the object, while the distance travelled is horizontal.
8. $W = Fd$
   $= (20.0\text{ N})(1.30\text{ m})$
   $= 26.0\text{ J}$

B2.0

9. $1\text{ J} = 1\ \frac{\text{kg} \cdot \text{m}^2}{\text{s}^2}$
10. Kinetic energy is energy due to the motion of an object.
11. Gravitational and elastic are two forms of potential energy.
12. The weight of an object is the force necessary to move an object against the opposing force of gravity. If an object is lifted vertically, then this force is equivalent to the weight, and the distance the object moves vertically determines the work done on an object.
13. If you stretch the elastic more, it has more elastic potential energy. This transforms into more kinetic energy in the rock, so the rock will have a greater speed.
14. Kinetic energy is greatest at the time that the rock leaves the catapult. The gravitational potential energy is greatest at the highest point the rock reaches.
15. Students' answers will vary but could include the following:
   a) Solar energy is converted to electrical energy in a solar cell.
   b) Light energy is converted to stored chemical energy in plants through photosynthesis.
   c) Chemical energy in a battery is converted to electrical energy.
16. Solar energy is converted to electrical energy.
17. Hydro-electric power stations do not involve combustion of fuels. This combustion results in a large loss of heat to the surroundings. So hydro is more efficient.
18. When you turn a page, chemical energy within the cells of your body is converted to the mechanical energy of your muscles that cause your hand to move. The mechanical energy from your hand does work in turning the page and thus gives the page mechanical energy.

B3.0

19. A heat engine uses heat to produce mechanical energy, and a heat pump uses mechanical energy to transfer heat. Students' examples will vary but could include: a jet engine is a heat engine, and an air conditioner is a heat pump.
20. They both stipulate that in any conversion to other types of energy, energy must be conserved.
21. Students' answers may vary but could include the following. A hot-water heater uses heat to heat up water. It illustrates the first law of thermodynamics because not all the heat that is put into the system heats up the water. Some of the heat will be lost to the surroundings.
22. If heat were added to a perpetual motion machine, all the heat should be completely transformed into mechanical energy with no heat lost to other forms of energy.
23. They both describe the behaviour of heat in transfers or transformations.
24. Students' answers will vary but may include the following. In the home, heat flows into a thermostat causing the metal strip to expand and

in the expansion, the strip moves, indicating a gain in mechanical energy.

25. Students' drawings should resemble Figure B3.14 on page 208 of the student book. A boiler produced steam that forced a piston up a cylinder. When cold water was sprayed on the outside of the cylinder, the steam would condense, and the piston would move back down the cylinder. The piston rod was connected to a pivoting beam, which in turn was connected to the mine pump. The up-and-down motion of the piston drove the pump.
26. A Watt engine uses steam power to drive a piston, while the internal combustion engine uses the gases produced from the combustion of fuels to drive a piston. An internal combustion engine produces much more heat than a steam engine.
27. Coal is formed from plants that used solar energy in the process of photosynthesis millions of years ago.
28. Students' answers will vary but could include the following. Gas furnaces, gas stoves, gas water heaters, etc., could all be converted to electrical devices. The electricity supplied to the home could come from hydro-electric or wind power stations.
29. Cogeneration is a process of using waste energy from one process to power another process. In some schools, water is heated to supply the hot water necessary for showers, etc. Once used, this hot water could be piped throughout the school to heat the building.

Applications

30. The three lines on the graphs should all be straight lines. The line with the steeper slope depicts the faster car, the line with the shallower slope depicts the slower car, and a horizontal line depicts the car at rest.
31. $\Delta t = \dfrac{\Delta d}{v}$

$= \dfrac{180 \text{ km}}{90.0 \text{ km/h}}$

$= 2.00 \text{ h}$

32. a) $\Delta d = \Delta d_1 + \Delta d_2$

$= 10.0 \text{ m} + 10.0 \text{ m}$

$= 20.0 \text{ m}$

b) $\Delta \vec{d} = \Delta \vec{d}_1 + \Delta \vec{d}_2$

$= \Delta 10.0 \text{ m [down]} + 10.0 \text{ m [up]}$

$= 0 \text{ m}$

c) $v = \dfrac{\Delta d}{\Delta t}$

$= \dfrac{20.0 \text{ m}}{4.00 \text{ s}}$

$= 5.0 \text{ m/s}$

d) $\vec{v} = \dfrac{\Delta \vec{d}}{\Delta t}$

$= \dfrac{0 \text{ m}}{4.00 \text{ s}}$

$= 0.0 \text{ m/s}$

33. $\vec{a} = \dfrac{\vec{v}_f - \vec{v}_i}{\Delta t}$

$= \dfrac{50 \frac{\text{m}}{\text{s}} \text{[N]} - 0 \frac{\text{m}}{\text{s}}}{6.00 \text{ s}}$

$= 8.33 \text{ m/s}^2 \text{ [N]}$

34. $W = Fd$

$= (6.0 \text{ N})(0.33 \text{ m})$

$= 2.0 \text{ J}$

35. The chain and the sign are pulling forces, while the beam is a pushing force on the ring.
36. $W = Fd$

$= (100 \text{ N})(5.00 \text{ m})$

$= 500 \text{ J}$

37. By storing the water in high towers, the water gains the necessary gravitational potential energy to flow through the water system in the community.
38. The object gains kinetic energy because of its motion, but does not gain any gravitational potential energy.
39. $E_k = \dfrac{1}{2} mv^2$

$E_k = \dfrac{1}{2}(0.00230 \text{ kg})(2.50 \text{ m/s})^2$

$= 7.19 \times 10^{-3} J$

40. $v = \sqrt{\dfrac{2E_k}{m}}$

$= \sqrt{\dfrac{2(4.00 \times 10^5 J}{2.00 \times 10^3 kg}}$

$= 20.0 \text{ m/s}$

41. $E_p = mgh$

$= (0.400 \text{ kg})(9.81 \text{ m/s}^2)(500 \text{ m})$

$= 1.96 \text{ x } 10^3 \text{ J}$

42. $h = \dfrac{E_{p(grav)}}{mg}$

$= \dfrac{7.90 \times 10^5 J}{800 N}$

$= 988 \text{ m}$