Solutions

Each answer shows the steps, then the **result**.

2.1

- $W = Fs\cos\theta$

$$W = 250 \times 12 \times \cos 35^\circ = \mathbf{2.46 \times 10^3}\ \mathrm{J}$$

2.2

(a) $W = Fs = 45 \times 8.0 = \mathbf{360}$ J

(b) friction does $-\mathbf{360}$ J of work

- the speed is constant, so there is no gain in kinetic energy: the energy becomes thermal energy in the box and the floor

2.3

(a) efficiency $= 900/1200 = \mathbf{0.75}$, or 75%

(b) wasted power $= 1200 - 900 = 300$ W

- energy $= 300 \times 5.0 \times 60 = \mathbf{9.0 \times 10^4}$ J

2.4

- at a steady speed the pull of the cable equals the weight: $F = mg = 72 \times 9.81 = 706$ N

$$P = Fv = 706 \times 0.80 = \mathbf{565}\ \mathrm{W}$$

2.5

- resistive forces such as air resistance and friction act against the motion and do negative work on the car, taking energy from it
- the driving force must do positive work at the same rate to keep the kinetic energy constant; the energy ends as thermal energy in the air and the tyres

3.1 C

- $W = Fs\cos\theta$, so $F = \dfrac{1200}{40 \times \cos 60^\circ} = 60$ N
- **A** leaves out $\cos 60^\circ$ and **B** uses $\sin 60^\circ$

3.2 C

- useful power $= mgv = 50 \times 9.81 \times 0.30 = 147$ W, and the input is $147/0.60 = 245$ W
- **A** multiplies by the efficiency instead of dividing, and **B** is the useful output

3.3

(a) component $= mg\sin\theta$

$$1200 \times 9.81 \times \sin 5.0^\circ = \mathbf{1.03 \times 10^3}\ \mathrm{N} \approx 1.0\ \mathrm{kN}$$

(b) driving force $= 1026 + 800 = \mathbf{1.83 \times 10^3}$ N

(c) $P = Fv$

$$P = 1826 \times 15 = \mathbf{2.7 \times 10^4}\ \text{W}$$

(d) input = useful output ÷ efficiency

$$\frac{2.74 \times 10^4}{0.30} = \mathbf{9.1 \times 10^4}\ \text{W}$$

(e) energy cannot be created or destroyed, only transferred from one form to another, so the total stays the same

- of the 91 kW, $1026 \times 15 = 15$ kW raises the car's gravitational potential energy, $800 \times 15 = 12$ kW becomes thermal energy through the resistive forces, and the other 64 kW is wasted as thermal energy in the engine

3.4

(a) power = mass per second $\times g \times h$

$$1500 \times 9.81 \times 120 = \mathbf{1.77 \times 10^6}\ \text{W}$$

(b) $0.85 \times 0.95 = \mathbf{0.81}$

(c) electrical power $= 0.8075 \times 1.766 \times 10^6$

- $= \mathbf{1.43 \times 10^6}$ W

(d) wasted power $= 1.766 \times 10^6 - 1.426 \times 10^6 = 3.40 \times 10^5$ W

- energy $= 3.40 \times 10^5 \times 3600 = \mathbf{1.22 \times 10^9}$ J

3.5

(a) $W = Fs$, so $P = W/t = Fs/t$

- $s/t = v$, so $P = Fv$

(b) the component of the tension along the motion is $3000 \cos 20° = 2.82 \times 10^3$ N

$$P = 2819 \times 4.0 = \mathbf{1.13 \times 10^4}\ \text{W}$$

(c) the engine also does work against the resistive forces on the tractor itself, such as friction at its wheels and air resistance, and some energy is wasted in its gears