

Solutions

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

2.1

- $W = Fs \cos \theta$
 $W = 250 \times 12 \times \cos 35^\circ = \mathbf{2.46 \times 10^3 \text{ J}}$

2.2

- (a) $W = Fs = 45 \times 8.0 = \mathbf{360 \text{ J}}$
- (b) friction does $\mathbf{-360 \text{ J}}$ 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 = $1200 - 900 = 300 \text{ W}$
 - energy = $300 \times 5.0 \times 60 = \mathbf{9.0 \times 10^4 \text{ J}}$

2.4

- at a steady speed the pull of the cable equals the weight: $F = mg = 72 \times 9.81 = 706 \text{ N}$
 $P = Fv = 706 \times 0.80 = \mathbf{565 \text{ W}}$

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 $F = \frac{1200}{40 \times \cos 60^\circ} = 60 \text{ N}$
- A** leaves out $\cos 60^\circ$ and **B** uses $\sin 60^\circ$

3.2 C

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

3.3

- (a) component = $mg \sin \theta$
 $1200 \times 9.81 \times \sin 5.0^\circ = \mathbf{1.03 \times 10^3 \text{ N}} \approx 1.0 \text{ kN}$

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

- (c) $P = Fv$

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

- (d) input = useful output $\div$ 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, $1026 \times 15 = 15 \text{ kW}$ raises the car's gravitational potential energy, $800 \times 15 = 12 \text{ kW}$ 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 = $0.8075 \times 1.766 \times 10^6$

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

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

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

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 $3000 \cos 20^\circ = 2.82 \times 10^3 \text{ N}$

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

- (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