

Solutions

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

2.1

- work = force $\times$ displacement **in the direction of the force** ($W = Fs \cos \theta$)

2.2

- $W = Fs \cos \theta$

$$W = (20 \text{ N})(5.0 \text{ m})(\cos 60^\circ) = 20 \times 5.0 \times 0.50 = \mathbf{50 \text{ J}}$$

2.3

- power is the **work done (energy transferred) per unit time**, unit **watt** ($W = \text{J s}^{-1}$)

2.4

- energy cannot be **created or destroyed**, only **transferred**; the total energy of a closed system is constant

3.1 C

- $W = Fs \cos \theta$ and $\cos 90^\circ = 0$, so a force at right angles to the motion does **no work**
- **B** is only true when $\theta = 0$

3.2

- energy conservation: $mgh = \frac{1}{2}mv^2$ (the m cancels)

$$v = \sqrt{2gh} = \sqrt{2(9.81 \text{ m s}^{-2})(1.2 \text{ m})} = \mathbf{4.9 \text{ m s}^{-1}}$$

3.3

- (a) useful work = mgh

$$W = (50 \text{ kg})(9.81 \text{ m s}^{-2})(8.0 \text{ m}) = 3924 \text{ J}$$

$$P = \frac{W}{t} = \frac{3924 \text{ J}}{10 \text{ s}} = \mathbf{392 \text{ W}}$$

- (b)

$$\text{efficiency} = \frac{392 \text{ W}}{500 \text{ W}} = 0.78 = \mathbf{78\%}$$

3.4

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

3.5

- (a) the product of the force and the **displacement in the direction of the force**
- (b) constant speed $\Rightarrow$ upward force = weight mg

- gain in PE = work done by that force, so $\Delta E_P = mg\Delta h$

- (c)(i)

$$W = mg\Delta h = (450 \text{ kg})(9.81 \text{ m s}^{-2})(24 \text{ m}) = \mathbf{1.1 \times 10^5 \text{ J}}$$

- (c)(ii)

$$P = \frac{W}{t} = \frac{1.06 \times 10^5 \text{ J}}{40 \text{ s}} = \mathbf{2.6 \times 10^3 \text{ W}}$$

- (c)(iii)

$$\text{efficiency} = \frac{P_{\text{useful}}}{P_{\text{input}}} = \frac{2650 \text{ W}}{3600 \text{ W}} = 0.74 = \mathbf{74\%}$$

- (c)(iv) input energy = $(3600 \text{ W})(40 \text{ s}) = 1.44 \times 10^5 \text{ J}$

- wasted = $1.44 \times 10^5 \text{ J} - 1.06 \times 10^5 \text{ J} = \mathbf{3.8 \times 10^4 \text{ J}}$
- it becomes **thermal energy** in the motor, gearbox and cable