

Solutions

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

2.1

(a) $m = W/g = 12 \text{ N}/4.0 \text{ N kg}^{-1} = \mathbf{3.0 \text{ kg}}$

(b) the mass does not change, so $W = mg = 3.0 \text{ kg} \times 9.81 \text{ N kg}^{-1} = \mathbf{29 \text{ N}}$

2.2

(a) $T_H = 50 \text{ N} \times \cos 25^\circ = \mathbf{45 \text{ N}}$

(b) resultant force $= 45.3 \text{ N} - 20 \text{ N} = 25.3 \text{ N}$, so $a = 25.3 \text{ N}/12 \text{ kg} = \mathbf{2.1 \text{ m s}^{-2}}$

2.3

(a) up positive: $T - mg = ma$

$$T = 800 \text{ kg} \times (9.81 + 0.60) \text{ m s}^{-2} = \mathbf{8330 \text{ N}}$$

(b) constant speed, so the resultant force is zero: $T = mg = 800 \text{ kg} \times 9.81 \text{ m s}^{-2} = \mathbf{7850 \text{ N}}$

2.4

(a) both blocks together: $a = \frac{18 \text{ N}}{(4.0 + 2.0) \text{ kg}} = \mathbf{3.0 \text{ m s}^{-2}}$

(b) the only horizontal force on B is the push of A: $F = 2.0 \text{ kg} \times 3.0 \text{ m s}^{-2} = \mathbf{6.0 \text{ N}}$

2.5

(a) $F = \frac{\Delta m}{\Delta t} \Delta v = 0.30 \text{ kg s}^{-1} \times 40 \text{ m s}^{-1} = \mathbf{12 \text{ N}}$

(b) **12 N**, **opposite** to the direction in which the air leaves the blower (Newton's third law)

3.1 C

- the lift slows down while it moves up, so its acceleration and the resultant force are **downwards**: $W > T$
- A** is a lift speeding up on the way up, **B** a lift at constant velocity, and **D** a lift in free fall

3.2 B

- swap the two objects: the horse pulls the cart, so the partner is the cart pulling the horse
- A**, **C** and **D** involve other objects or other types of force

3.3 C

- the forces are at right angles: resultant $= \sqrt{6.0^2 + 8.0^2} = 10 \text{ N}$, so $a = 10 \text{ N}/2.5 \text{ kg} = 4.0 \text{ m s}^{-2}$
- D** adds the forces as plain numbers, **B** uses only the 6.0 N force, and **A** subtracts them

3.4

(a) the pack pushes the water downwards, changing the momentum of the water

- by Newton's third law, the water pushes the pack **upwards** with an equal force

(b) at a steady height, upward force = weight $= 90 \text{ kg} \times 9.81 \text{ m s}^{-2} = 883 \text{ N}$, so $\Delta m/\Delta t = 883 \text{ N}/20 \text{ m s}^{-1} = \mathbf{44 \text{ kg s}^{-1}}$

(c) upward force $= m(g + a) = 90 \text{ kg} \times (9.81 + 1.5) \text{ m s}^{-2} = 1018 \text{ N}$, so $\Delta m/\Delta t = 1018 \text{ N}/20 \text{ m s}^{-1} = \mathbf{51 \text{ kg s}^{-1}}$

3.5

(a) the resultant force on an object is equal to its **rate of change of momentum**

(b) resultant force $= 2600 - 350 - 450 = 1800 \text{ N}$, so $a = 1800 \text{ N}/2000 \text{ kg} = \mathbf{0.90 \text{ m s}^{-2}}$

(c) caravan on its own: $T - 450 \text{ N} = 900 \text{ kg} \times 0.90 \text{ m s}^{-2}$, so $T = 810 \text{ N} + 450 \text{ N} = \mathbf{1260 \text{ N} \approx 1300 \text{ N}}$

(d) **1260 N backwards**

- Newton's **third** law

(e) the resultant force is zero, so the driving force $= 350 + 450 = \mathbf{800 \text{ N}}$

3.6

(a) gradient of the graph: $a = \frac{2.0 \text{ m s}^{-1}}{2.0 \text{ s}} = \mathbf{1.0 \text{ m s}^{-2}}$

(b)(i) up positive: $R - mg = ma$

$$R = 55 \text{ kg} \times (9.81 + 1.0) \text{ m s}^{-2} = \mathbf{595 \text{ N}}$$

(ii) constant velocity: $R = mg = 55 \text{ kg} \times 9.81 \text{ m s}^{-2} = \mathbf{540 \text{ N}}$

(iii) $a = \frac{0 - 2.0 \text{ m s}^{-1}}{4.0 \text{ s}} = -0.50 \text{ m s}^{-2}$

$$R = 55 \text{ kg} \times (9.81 - 0.50) \text{ m s}^{-2} = \mathbf{512 \text{ N}}$$

(c) the lift slows down while it moves up, so the student's acceleration is **downwards**

- by the second law the resultant force on the student is downwards, so $W > R$ and the scales read less than the weight