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) $T_\text{H} = 50\text{ N} \times \cos 25° = \mathbf{45}\text{ N}$

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

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

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

(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 $= \sqrt{6.0^2 + 8.0^2} = 10$ 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 kg$\times$9.81 m s^{-2} = 883 N, so $\Delta m/\Delta t$ = 883 N/20 m s^{-1} = **44** kg s^{-1}

(c) upward force = $m(g + a)$ = 90 kg $\times$ (9.81 + 1.5) m s^{-2} = 1018 N, so $\Delta m/\Delta t$ = 1018 N/20 m s^{-1} = **51** 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 N, so a = 1800 N/2000 kg = **0.90** m s^{-2}

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

(d) 1260 N **backwards**

- Newton's **third** law

(e) the resultant force is zero, so the driving force = 350 + 450 = **800** N

3.6

(a) gradient of the graph: $a = \dfrac{2.0 \text{ m s}^{-1}}{2.0 \text{ s}}$ = **1.0** 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 kg $\times$ 9.81 m s^{-2} = **540** N

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

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

(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