Solutions

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

2.1

- Newton's first law: an object stays at **rest** or moves at **constant velocity** unless a **resultant (external) force** acts on it

2.2

- $p = mv$

$$p = (1500\ \text{kg})(20\ \text{m s}^{-1}) = \mathbf{3.0 \times 10^4}\ \text{kg m s}^{-1}$$

2.3

- $F = ma \Rightarrow a = F/m$

$$a = \frac{5.0\ \text{N}}{2.0\ \text{kg}} = \mathbf{2.5}\ \text{m s}^{-2}$$

2.4

- weight $W = mg$

$$W = (60\ \text{kg})(9.81\ \text{m s}^{-2}) = \mathbf{590}\ \text{N}$$

3.1 B

- kg m s^{-1} is mass × velocity, which is **momentum** $p = mv$
- **A** force is kg m s^{-2} (rate of change of momentum)
- **C** energy is kg m^2 s^{-2}; **D** power is one more s^{-1}

3.2

- Newton's third law: when A exerts a force on B, B exerts an **equal and opposite** force on A (same type, different bodies)
- example: a rocket pushes gas down, the gas pushes the rocket up (or foot / ground)

3.3

- take rebound as positive: $u = -8.0\ \text{m s}^{-1}$, $v = +6.0\ \text{m s}^{-1}$

$$\Delta p = m(v - u) = (0.20\ \text{kg})\big(6.0\ \text{m s}^{-1} - (-8.0\ \text{m s}^{-1})\big) = 2.8\ \text{kg m s}^{-1}$$

$$F = \frac{\Delta p}{\Delta t} = \frac{2.8\ \text{kg m s}^{-1}}{0.050\ \text{s}} = \mathbf{56}\ \text{N}$$

3.4

- $F = \Delta p / \Delta t$
- for the same Δp, a larger contact time Δt gives a **smaller** F

3.5

- **mass stays the same**
- **weight decreases**, because g is smaller on the Moon

3.6

(a) momentum is the **product of mass and velocity**

(b) $v = p/m$

$$v = \frac{3.6\ \text{kg m s}^{-1}}{1.2\ \text{kg}} = \mathbf{3.0}\ \text{m s}^{-1}$$

(c) $\Delta p = (-2.4\ \text{kg m s}^{-1}) - (+3.6\ \text{kg m s}^{-1}) = -6.0\ \text{kg m s}^{-1}$

- change of magnitude **6.0** kg m s^{-1}

(d) $F = \Delta p/\Delta t =$ gradient of the p–t graph

$$F = \frac{6.0\ \text{kg m s}^{-1}}{10\ \text{s}} = \mathbf{0.60}\ \text{N}$$

(e) the trolley slows **uniformly** (straight line ⇒ constant force)

- it is momentarily at rest at $t = 6.0$ s

(f) the line is **straight**, so the resultant force is constant; air resistance would get **smaller** as it slows

- at $t = 6.0$ s the trolley is at rest, so air resistance would be **zero**, yet the gradient is unchanged

(g)

- axes labelled displacement and time / s
- from the origin the line rises with a **decreasing** positive gradient, maximum at $t =$ 6.0 s
- after 6.0 s displacement **falls** (gradient of increasing magnitude) but is still positive at $t = 10$ s

(h) at $t = 2.0$ s, $p = +2.4$ kg m s^{-1}; at $t = 8.0$ s, $p = -1.2$ kg m s^{-1}

- the magnitude has halved **and** the **direction has reversed** — momentum is a vector