

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 $\times$ velocity, which is **momentum** $p = mv$
- A** force is kg m s^{-2} (rate of change of momentum)
- C** energy is $\text{kg m}^2 \text{s}^{-2}$; **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: $u = -8.0 \text{ m s}^{-1}$, $v = +6.0 \text{ m s}^{-1}$

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

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

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 $\Rightarrow$ constant force)

- it is momentarily at rest at $t = 6.0 \text{ s}$

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

- at $t = 6.0 \text{ s}$ 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 $t = 6.0 \text{ s}$
- after 6.0 s displacement **falls** (gradient of increasing magnitude) but is still positive at $t = 10 \text{ s}$

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

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