Solutions

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

2.1

- $p = mv$

$$p = mv = (0.40\ \text{kg})(5.0\ \frac{\text{m}}{\text{s}}) = \mathbf{2.0}\ \text{kg m/s}$$

2.2

- when no external force acts, the total momentum before a collision equals the total momentum after

2.3

- $p = mv$

$$p = mv = (1200\ \text{kg})(15\ \text{m/s}) = \mathbf{1.8 \times 10^4}\ \text{kg m/s}$$

2.4

- impulse is force × time, $F\Delta t$, equal to the change in momentum
- unit: N s

3.1 B

- momentum = mass × velocity

3.2

(a) total momentum before

$$p = m_1u_1 + m_2u_2 = (3.0\ \text{kg})(4.0\ \frac{\text{m}}{\text{s}}) + (1.0\ \text{kg})(0) = \mathbf{12}\ \text{kg m/s}$$

(b) conservation of momentum, $p = (m_1 + m_2)v$: $12\ \text{kg m/s} = (3.0\ \text{kg} + 1.0\ \text{kg})v$

$$v = \frac{p}{m_1 + m_2} = \frac{12\ \text{kg m/s}}{4.0\ \text{kg}} = \mathbf{3.0}\ \frac{\text{m}}{\text{s}}$$

3.3

- $F = \Delta p/\Delta t$

$$\Delta p = m\,\Delta v = (2.0\ \text{kg})(6.0\ \frac{\text{m}}{\text{s}}) = 12\ \text{kg m/s}$$

$$F = \frac{\Delta p}{t} = \frac{12\ \text{kg m/s}}{0.10\ \text{s}} = \mathbf{120}\ \text{N}$$

3.4

- total momentum before, keeping the signs: $p = m_1u_1 + m_2u_2$

$$p = (3.0\ \text{kg})(+2.0\ \text{m/s}) + (1.0\ \text{kg})(-2.0\ \text{m/s}) = 4.0\ \text{kg m/s}$$

- conservation of momentum: $v = \dfrac{p}{m_1 + m_2}$

$$v = \frac{p}{m_1 + m_2} = \frac{4.0\ \text{kg m/s}}{4.0\ \text{kg}} = \mathbf{1.0}\ \text{m/s}$$

- positive, so the trolleys move to the **right**
- opposite velocities have opposite momenta; adding the speeds as if both were positive loses the direction and gives the wrong total

3.5

(a) take the direction towards the wall as positive, so the rebound velocity is -10 m/s

$$\Delta p = m(v - u) = (0.20\ \text{kg})(-10\ \text{m/s} - 15\ \text{m/s}) = \mathbf{-5.0}\ \text{kg m/s}$$

- a change of 5.0 kg m/s, directed away from the wall

(b) $F = \Delta p/\Delta t$, using the size of the change in momentum

$$F = \frac{\Delta p}{\Delta t} = \frac{5.0\ \text{kg m/s}}{0.050\ \text{s}} = \mathbf{100}\ \text{N}$$

3.6

- the airbag increases the time taken for the driver to stop
- the change in momentum is the same, so by $F = \Delta p/\Delta t$ the force is smaller