

Momentum conservation, impulse and collision types

Physics grades 11-12 (A Level · IB · Class 11-12) · Test answers (mark scheme)

The model answers show the method and the final result in bold. Marks are given for the working as well as the result, so write each step. Check the sign of every velocity and the unit of every answer.

Level: Physics grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** IB A.2

Question 1 Definitions (2 marks)

- Impulse is force multiplied by the time for which it acts; it equals the change in momentum.
- The total momentum of a system is constant if no external resultant force acts on it.

Marking: 1 mark each; accept $F \Delta t = \Delta p$ for (a).

Question 2 Hammer and nail (3 marks)

- $\Delta p = 0 - 2.0 \times 5.0 = -10 \text{ kg m/s}$, a loss of **10 kg m/s**.
- $F = \Delta p \div \Delta t = 10 \div 0.0040 = \textbf{2500 N}$.

Marking: (a) 1 mark; (b) 1 mark for the formula, 1 mark for the result.

Question 3 Pucks sticking together (3 marks)

- $0.30 \times 4.0 = 0.90 v$, so $v = 1.2 \div 0.90 = \textbf{1.3 m/s}$.
- Before: $\frac{1}{2} \times 0.30 \times 16 = 2.4 \text{ J}$. After: $\frac{1}{2} \times 0.90 \times 1.33^2 = 0.80 \text{ J}$. Lost = **1.6 J**.

Marking: (a) 1 mark for conservation equation, 1 for result; (b) 1 mark.

Question 4 Elastic collision (3 marks)

- Before: $3.0 \times 4.0 = 12 \text{ kg m/s}$. After: $3.0 \times 2.0 + 1.0 \times 6.0 = 12 \text{ kg m/s}$. **Conserved**.
- Approach 4.0 m/s; separation $6.0 - 2.0 = 4.0 \text{ m/s}$. **Equal**.
- Before: $\frac{1}{2} \times 3.0 \times 16 = 24 \text{ J}$. After: $\frac{1}{2} \times 3.0 \times 4 + \frac{1}{2} \times 1.0 \times 36 = 6 + 18 = 24 \text{ J}$. **Conserved**.

Marking: 1 mark for each part.

Question 5 Force-time graph (3 marks)

- a. Impulse = area = $\frac{1}{2} \times 0.010 \times 600 = \mathbf{3.0 \text{ N s}}$.
- b. $v = J \div m = 3.0 \div 0.50 = \mathbf{6.0 \text{ m/s}}$.
- c. $F = 3.0 \div 0.010 = \mathbf{300 \text{ N}}$.

Marking: 1 mark for each part.

Question 6 Rocket in space (2 marks)

The rocket expels exhaust gas backwards, giving the gas backward momentum. The total momentum of rocket and gas stays constant, so the rocket gains an equal forward momentum and **accelerates forwards**.

Marking: 1 mark for gas gaining momentum backwards; 1 mark for conservation giving forward momentum to the rocket.

Question 7 Pucks at right angles (3 marks)

- a. $p_x = 0.60$, $p_y = 0.80$, so $p = \sqrt{(0.60^2 + 0.80^2)} = \mathbf{1.0 \text{ kg m/s}}$.
- b. $v = 1.0 \div 0.40 = \mathbf{2.5 \text{ m/s}}$.
- c. $\tan \theta = 0.80 \div 0.60$, so $\theta = \mathbf{53^\circ \text{ north of east}}$.

Marking: 1 mark for each part.

Question 8 Kinetic energy and sticking (1 mark)

No. In a perfectly inelastic collision, kinetic energy is transferred to thermal energy and deformation, so it is **not conserved**.

Marking: 1 mark for no, with a correct reason.