

Exercise walk-through

5.9

Momentum – HT only (4.5.7)

AQA · GCSE · Physics

Exercises 2.1·2.3

2.1 Calculate the momentum of a 60 kg runner at 8.0 m/s. [2]

2.2 State the conservation of momentum rule for a closed system. [1]

2.3 Explain how a cycle helmet protects the head, using $F = m\Delta v/\Delta t$. [3]

3 Exam-style questions

Exercises 2.1·2.3

2.1 Calculate the momentum of a 60 kg runner at 8.0 m/s. [2]

2.1 $p = mv = 60 \times 8.0 = \mathbf{480}$ kg m/s (C1, A1).

2.2 State the conservation of momentum rule for a closed system. [1]

2.2 In a closed system the total momentum before an event equals the total momentum after it.

2.3 Explain how a cycle helmet protects the head, using $F = m\Delta v/\Delta t$. [3]

3 Exam-style questions

2.3 The helmet's foam deforms, increasing the time over which the head's momentum changes; in $F = m\Delta v/\Delta t$ the same $m\Delta v$ over a longer Δt gives a smaller force on the head.

Exercise 3.1

3.1 Two trolleys collide and stick. A: 2.0 kg at 3.0 m/s right; B: 1.0 kg at rest.

- (a) Calculate the total momentum before the collision. [2]
- (b) Calculate their common velocity after. [2]
- (c) State one assumption. [1]

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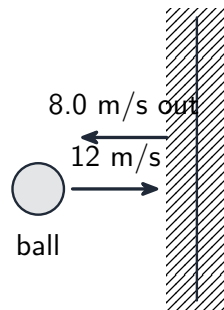
(c) State one assumption. [1]

3.1 (a) $p = 2.0 \times 3.0 + 1.0 \times 0 = \mathbf{6.0}$ kg m/s (right) (C1, A1). (b) $3.0v = 6.0$ so $v = \mathbf{2.0}$ m/s right (C1, A1). (c) Closed system – no external horizontal forces (or friction negligible).

Exercise 3.2

3.2 A 0.16 kg ball hits a wall at 12 m/s and rebounds at 8.0 m/s; contact lasts 0.020 s.

- (a) Calculate the change of momentum, taking right as positive (in at +12, out at -8). [3]
- (b) Calculate the force on the ball. [2]
- (c) State the size and direction of the force on the wall. [2]



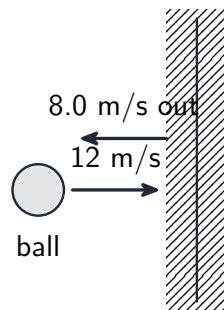
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3.2 (a) Change = $m(v_{after} - v_{before}) = 0.16 \times (-8.0 - 12) = 0.16 \times (-20) = -\mathbf{3.2}$ kg m/s (sign convention C1, substitution C1, answer A1). (b) $F = \Delta p / \Delta t = -3.2 / 0.020 = -\mathbf{160}$ N – 160 N on the ball, to the left (C1, A1). (c) By the third law the wall feels an **equal and opposite** force: 160 N to the right.

Exercise 3.3

3.3 In a crash test a 1200 kg car at 15 m/s is stopped in 0.12 s without a crumple zone and 0.30 s with one.

- (a) Calculate the momentum change. [2]
- (b) Calculate both forces. [3]
- (c) Explain, using the numbers, why the crumple zone reduces injury, and name the physics store that takes the energy. [3]

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3.3 (a) $\Delta p = m\Delta v = 1200 \times 15 = \mathbf{18\,000}$ kg m/s (C1, A1). (b) Without: $F = 18\,000/0.12 = \mathbf{150\,000}$ N (C1); with: $F = 18\,000/0.30 = \mathbf{60\,000}$ N. (c) The same momentum change spread over more than double the time cuts the force by 60 % (C1 for the comparison), far below the injury threshold of body structures; the kinetic store of the car empties into the **thermal** store of the deforming metal (and some sound).