

Exercise walk-through

# 1.3

## Momentum and moments (P)

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The method

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## Method — Momentum is conserved

$$p = mv \quad F = \frac{mv - mu}{t}$$

In a collision the total momentum before equals the total after. **Worked check.**  
A 2 kg trolley at 3 m/s hits a stationary 1 kg trolley and they stick: before  
 $= 2 \times 3 = 6$ ; after, mass 3 kg moves at  $6/3 = 2$  m/s.

## Method — Safety features buy time

Crumple zones, airbags and seat belts all **lengthen the collision time**; since  $\text{force} = \text{change in momentum} \div \text{time}$ , the same change spread over more time means a smaller force.

## Exercises 2.1·2.3

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**2.1** Calculate the momentum of a 0.5 kg ball moving at 6 m/s. [2]

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**2.2** (P) State Newton's third law. [1]

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**2.3** A 4 kg object at 5 m/s is brought to rest in 2.5 s. Calculate the force. [3]

## Exercises 2.1·2.3

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**2.1** Calculate the momentum of a 0.5 kg ball moving at 6 m/s. [2]

**2.1**  $p = 0.5 \times 6 = 3 \text{ kg m/s}.$

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**2.2** (P) State Newton's third law. [1]

**2.2** (P) For every action there is an equal and opposite reaction.

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**2.3** A 4 kg object at 5 m/s is brought to rest in 2.5 s. Calculate the force. [3]

**2.3** Momentum change  $= 4 \times 5 = 20 \text{ kg m/s}; F = 20/2.5 = 8 \text{ N}.$

## Exercises 2.4·3.1

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**2.4** State the principle of moments. [1]

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**2.5** Through what point does the weight of a body act? [1]

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**3.1** A 900 kg car at 20 m/s collides with a stationary 1100 kg car; they move off together. Calculate their common speed and the total momentum before and after. [4]

## Exercises 2.4·3.1

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**2.4** State the principle of moments. [1]

**2.4** For equilibrium, the sum of clockwise moments about a point equals the sum of anticlockwise moments.

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**2.5** Through what point does the weight of a body act? [1]

**2.5** Its centre of gravity.

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**3.1** A 900 kg car at 20 m/s collides with a stationary 1100 kg car; they move off together. Calculate their common speed and the total momentum before and after. [4]

**3.1** Before:  $p = 900 \times 20 = 18\,000 \text{ kg m/s}$ . After, combined mass 2000 kg:  $v = 18\,000/2000 = 9 \text{ m/s}$ ; momentum is conserved – after = 18 000 too.

## Exercises 3.2·3.3

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**3.2** Explain, using momentum ideas, how an airbag reduces injury. [3]

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**3.3** A uniform 4 m beam rests on supports at its ends. A 600 N load sits 1 m from the left support. Taking moments, find the force each support exerts. [4]

## Exercises 3.2·3.3

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**3.2** Explain, using momentum ideas, how an airbag reduces injury. [3]

**3.2** The passenger's momentum change in the crash is fixed; the airbag slows them over a longer time;  $\text{force} = \text{change in momentum} \div \text{time}$ , so the force on the body is smaller.

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**3.3** A uniform 4 m beam rests on supports at its ends. A 600 N load sits 1 m from the left support. Taking moments, find the force each support exerts. [4]

**3.3** Moments about the left support: load  $600 \times 1 = 600$  N m clockwise; right support force  $R$  at 4 m:  $4R = 600 \rightarrow R = 150$  N. Left support:  $600 - 150 = 450$  N.