# Exercise walk-through

## Momentum ▪ 3.6

eXercise

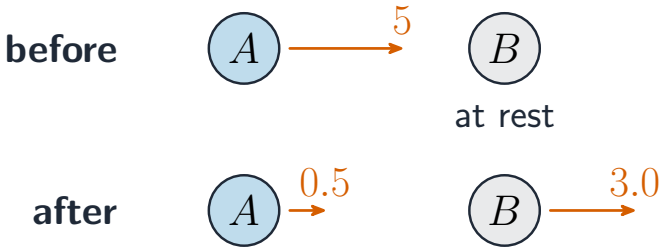
# You must be able to

- apply conservation of momentum to a collision
- use $e = \dfrac{\text{speed of separation}}{\text{speed of approach}}$
- resolve velocities for an oblique impact

## Method — Restitution

$A$ **(**$2$ **kg,** $5$ **m s**$^{-1}$**) hits stationary** $B$ **(**$3$ **kg),** $e = 0.5$**:** momentum $2(5) = 2v_A + 3v_B$; restitution $v_B - v_A = 0.5(5) = 2.5$. Solve: $v_A = 0.5$, $v_B = 3.0$ m s$^{-1}$.

# Method — Restitution




$$e = \frac{\text{speed of separation}}{\text{speed of approach}} = \frac{3.0 - 0.5}{5} = 0.5$$

*Two spheres before and after a collision, moving apart at different speeds*

## Practice 2.1 ▪ 1 mark

State the range of possible values of the coefficient of restitution $e$.

# Solution 2.1

**Worked steps**

$0 \leqslant e \leqslant 1$ B1.

## Practice 2.2 ▪ 2 marks

Two balls approach at a combined closing speed of $8$ m s$^{-1}$ with $e = 0.25$. Find their separation speed.

# Solution 2.2

**Worked steps**

separation $= e\times$ approach $= 0.25 \times 8 = 2$ m s$^{-1}$ M1 A1.

## Exam-style 3.1 ▪ 1 mark

A perfectly elastic collision has a coefficient of restitution:

**A** $0$

**B** $0.5$

**C** $1$

**D** $2$

# Solution 3.1

Method: Restitution

**A** $0$

**B** $0.5$

**C** $1$ ✓

**D** $2$

## Worked steps

**C**. A perfectly elastic collision has $e = 1$.

## Exam-style 3.2 ▪ 3 marks

A sphere $P$ of mass $3$ kg moving at $4$ m s$^{-1}$ collides directly with a sphere $Q$ of mass $1$ kg moving towards it at $2$ m s$^{-1}$. The coefficient of restitution is $0.5$.

(a) Write the momentum and restitution equations.

(b) Find the velocities of $P$ and $Q$ after impact.

# Solution 3.2

Method: Restitution

**Worked steps**

(a) take $P$'s direction positive: momentum $3(4)+1(-2) = 3v_P+1v_Q$, i.e. $3v_P+v_Q = 10$ M1 M1; restitution $v_Q - v_P = 0.5(4-(-2)) = 3$ M1.

(b) from the two equations: $v_Q = v_P + 3$; $3v_P + v_P + 3 = 10 \Rightarrow 4v_P = 7 \Rightarrow v_P = 1.75$ m s$^{-1}$ M1 M1; $v_Q = 4.75$ m s$^{-1}$ A1 A1.

## Exam-style 3.3 ▪ 4 marks

A ball is dropped from a height of $2$ m onto the floor, with coefficient of restitution $0.8$ between ball and floor. Find the height of the first bounce.

# Solution 3.3

**Worked steps**

speed hitting floor: $v = \sqrt{2g(2)} = \sqrt{40} = 6.32$ m s$^{-1}$ M1; rebound speed $= ev = 0.8(6.32) = 5.06$ m s$^{-1}$ M1; bounce height $= \dfrac{(ev)^2}{2g} = \dfrac{25.6}{20} = 1.28$ m M1 A1.