

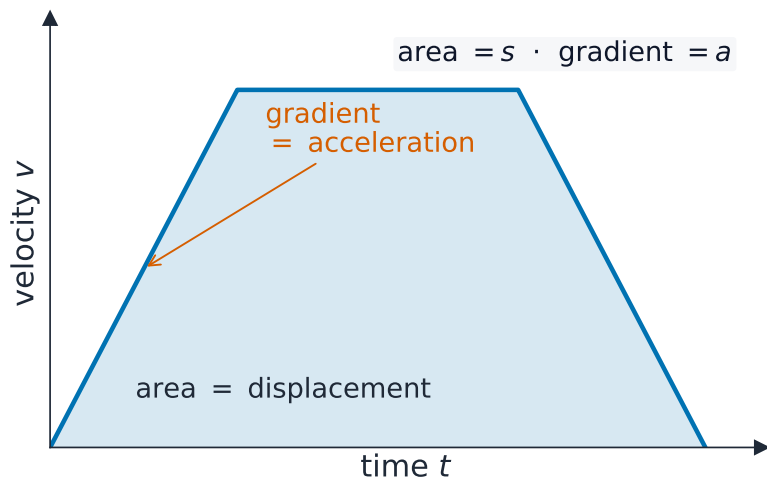
Exercise walk-through

4.3

Momentum

A-Level Mathematics

Kinematics



v - t graph: area = displacement,
gradient = acceleration.

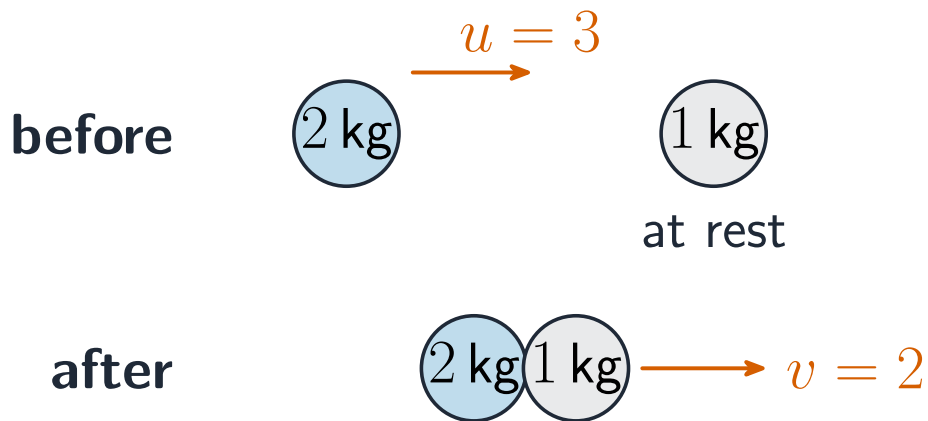
$$v = u + at, \quad s = ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as.$$

Rest, $a = 2.5$, $t = 4$ s

$v = 10$ m/s, $s = 20$ m

The shaded area gives the distance travelled; the slope of the line gives the acceleration.

Momentum



$$2(3) + 1(0) = (2 + 1)v$$

Conservation of momentum :

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2.$$

2 kg at 3 hits still 1 kg, stick

$$v = \frac{6}{3} = 2 \text{ m/s}$$

Worked example – a perfectly inelastic collision

A 2 kg body at 3 m s^{-1} hits a stationary 1 kg body and they stick together. Find the common speed.

- **conservation of linear momentum** :

$$m_1 u_1 = (m_1 + m_2) v$$

- $2(3) = 3v$

- $v = 2 \text{ m s}^{-1}$

Momentum is conserved;
kinetic energy is not.

Here 9 J before becomes
6 J after – the missing
3 J went into deformation
and heat.

Exercises 2.1·2.2

2.1 Find the momentum of a 0.5 kg ball moving at 8 m s^{-1} . [1]

2.2 State what physical quantity is conserved in a collision with no external horizontal force. [1]

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2.1

- $p = mv = 0.5 \times 8 = 4 \text{ kg m s}^{-1}$
-

2.2 State what physical quantity is conserved in a collision with no external horizontal force. [1]

2.2

- (linear) momentum

Exercises 3.1·3.2

3.1 A 3 kg body at 4 m s^{-1} collides with a 2 kg body at rest and they coalesce. Their common speed is: [1]

☐

A 1.2 m s^{-1}

B 2.0 m s^{-1}

C 2.4 m s^{-1}

D 4.0 m s^{-1}

3.2 A particle *A* of mass 0.4 kg moving at 5 m s^{-1} collides directly with particle *B* of mass 0.6 kg moving in the **opposite** direction at 2 m s^{-1} . After the collision they move together.

(a) Find their common velocity, stating its direction.

[4]

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A 1.2 m s^{-1}

B 2.0 m s^{-1}

C 2.4 m s^{-1}

D 4.0 m s^{-1}

3.1 C

- $3(4) = (3 + 2)v \Rightarrow v = \frac{12}{5} = 2.4 \text{ m s}^{-1}$

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(a) Find their common velocity, stating its direction. [4]

3.2

- take *A*'s direction positive: $0.4(5) + 0.6(-2) = (0.4 + 0.6)v$; $2 - 1.2 = 1.0v \Rightarrow v = 0.8$;
 0.8 m s^{-1} in *A*'s original direction

Exercise 3.3

3.3 A 2 kg ball moving at 6 m s^{-1} strikes a 4 kg ball at rest. After the collision the 2 kg ball continues in the same direction at 1 m s^{-1} . Find the speed of the 4 kg ball. [3]

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3.3

- $2(6) + 4(0) = 2(1) + 4v; 12 = 2 + 4v \Rightarrow v = \frac{10}{4} = 2.5 \text{ m s}^{-1}$