

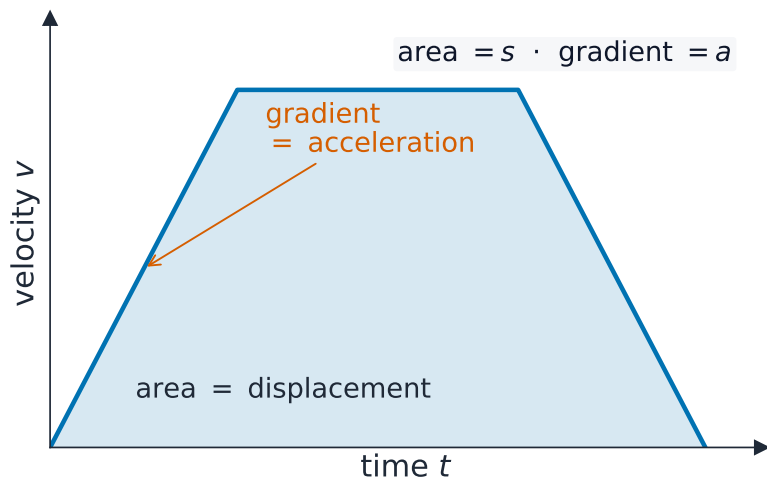
Exercise walk-through

4.2

Kinematics of motion in a straight line

A-Level Mathematics

Kinematics



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

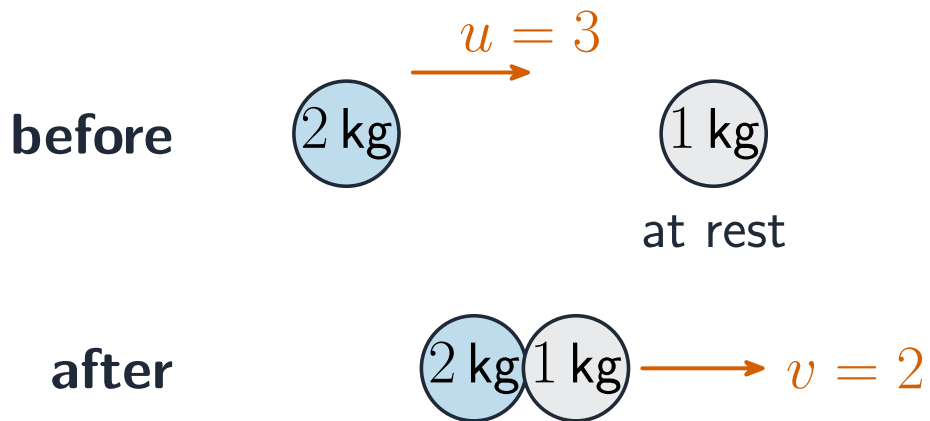
$$v = u + at, \quad s = ut + \frac{1}{2}at^2, \quad v^2 = u^2 + 2as.$$

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 A particle accelerates from 4 m s^{-1} at 3 m s^{-2} for 5 s. Find its final velocity. [2]

2.2 A $v-t$ graph is a straight line from $(0, 2)$ to $(6, 14)$. Find the acceleration. [2]

Exercises 2.1·2.2

2.1 A particle accelerates from 4 m s^{-1} at 3 m s^{-2} for 5 s. Find its final velocity. [2]

2.1

- $v = u + at = 4 + 3(5) = 19 \text{ m s}^{-1}$

2.2 A v - t graph is a straight line from $(0, 2)$ to $(6, 14)$. Find the acceleration. [2]

2.2

- $\text{gradient} = \frac{14 - 2}{6 - 0} = 2 \text{ m s}^{-2}$

Exercise 3.1

3.1 A stone is dropped from rest. After 3 s its speed is ($g = 10$):

[1]

☐

A 10 m s^{-1}

B 20 m s^{-1}

C 30 m s^{-1}

D 45 m s^{-1}

Exercise 3.1

3.1 A stone is dropped from rest. After 3 s its speed is ($g = 10$): [1]

☐

A 10 m s^{-1}

B 20 m s^{-1}

C 30 m s^{-1}

D 45 m s^{-1}

3.1 C

- $v = u + gt = 0 + 10(3) = 30 \text{ m s}^{-1}$

Exercise 3.2 (a)

3.2 A car travelling at 30 m s^{-1} brakes with constant deceleration and stops in 75 m.

(a) Find the deceleration.

[3]

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[3]

(a)

- $v^2 = u^2 + 2as$: $0 = 30^2 + 2a(75)$; $a = -\frac{900}{150} = -6$, so deceleration 6 m s^{-2}

Exercise 3.2 (b)

3.2 A car travelling at 30 m s^{-1} brakes with constant deceleration and stops in 75 m.

(b) Find the time taken to stop.

[2]

Exercise 3.2 (b)

3.2 A car travelling at 30 m s^{-1} brakes with constant deceleration and stops in 75 m.

(b) Find the time taken to stop.

[2]

(b)

- $v = u + at$: $0 = 30 - 6t \Rightarrow t = 5 \text{ s}$

Exercise 3.3 (a)

3.3 A particle moves so that its velocity is $v = 12t - 3t^2$ m s⁻¹ at time t s.

(a) Find the time when the particle is instantaneously at rest (other than $t = 0$). [2]

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3.3 A particle moves so that its velocity is $v = 12t - 3t^2$ m s⁻¹ at time t s.

(a) Find the time when the particle is instantaneously at rest (other than $t = 0$). [2]

(a)

- $v = 0$: $12t - 3t^2 = 0 \Rightarrow 3t(4 - t) = 0 \Rightarrow t = 4$ s

Exercise 3.3 (b)

3.3 A particle moves so that its velocity is $v = 12t - 3t^2$ m s⁻¹ at time t s.

(b) Find the distance travelled in the first 4 seconds.

[4]

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(b) Find the distance travelled in the first 4 seconds.

[4]

(b)

- $v \geq 0$ for $0 \leq t \leq 4$, so distance = $\int_0^4 (12t - 3t^2) dt = [6t^2 - t^3]_0^4 = 96 - 64 = 32$ m