

Exercise walk-through

1.2

Motion

IGCSE Physics

Measurement

Five SI base units used here:

m

length

kg

mass

s

time

A

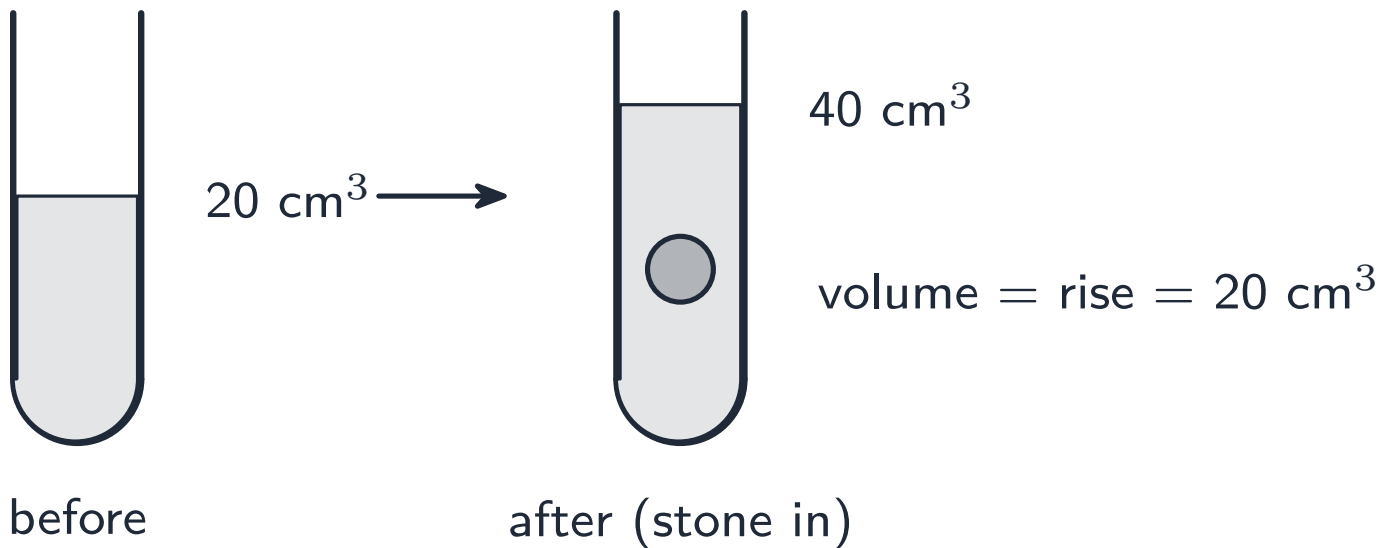
current

K

temperature

Measure **many** and divide: 100 sheets → one thickness; 20 swings → one **period**. Quote a unit and consider the instrument resolution and the measurement method.

Length and volume



The water an irregular solid pushes up gives its volume

Measuring several to estimate one

Paper and pendulum measurements

A stack of 100 sheets, without covers, is 10.0 mm thick.

Three timings of 20 complete pendulum oscillations are 31.8 s, 32.2 s and 32.0 s.

Find the average thickness of one sheet and the mean period of the pendulum. Explain why measuring only one sheet or one oscillation would be less suitable with the same instruments.

Average thickness from a stack

A ruler cannot resolve this individual sheet well. Measuring a stack gives a larger length to read.

$$\text{mean thickness} = \frac{\text{stack thickness}}{\text{number of sheets}}$$

$$\text{mean thickness} = \frac{10.0 \text{ mm}}{100} = 0.100 \text{ mm}$$

Count the sheets, exclude the covers, align the stack and read the ruler at eye level. Avoid gaps or uneven compression. Repeat the measurement to check consistency.

The result is an average thickness. Dividing does not remove a ruler zero error or a systematic error in the stack measurement.

Mean period from repeated oscillations

Time from a marked position until the pendulum returns to that position in the same direction 20 times. Count complete cycles, not half-swings.

$$\text{mean time} = \frac{t_1 + t_2 + t_3}{3} = \frac{31.8 \text{ s} + 32.2 \text{ s} + 32.0 \text{ s}}{3} = 32.0 \text{ s}$$

$$T = \frac{\text{mean time}}{N} = \frac{32.0 \text{ s}}{20} = 1.60 \text{ s}$$

The **period** is the time for one complete oscillation. A similar start/stop timing error has a smaller effect per oscillation when a longer interval is divided by 20.

Timing multiples and repeating trials serve different purposes. Neither repairs a miscount of the oscillations.

Exercises 2.1·2.2

2.1 A runner covers 100 m in 12.5 s. Find the average speed.

[2]

2.2 State what the area under a speed–time graph represents.

[1]

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[2]

2.1

- $v = s/t$

$$v = \frac{s}{t} = \frac{100 \text{ m}}{12.5 \text{ s}} = \mathbf{8.0} \frac{\text{m}}{\text{s}}$$

2.2 State what the area under a speed–time graph represents.

[1]

2.2

- the distance travelled

Exercises 2.3·2.4

2.3 A car slows from $18 \frac{\text{m}}{\text{s}}$ to $6.0 \frac{\text{m}}{\text{s}}$ in 4.0 s. Calculate its acceleration and state what the sign means. [3]

2.4 State how you find the distance travelled from a speed-time graph. [1]

Exercises 2.3·2.4

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2.3

- $a = \Delta v / \Delta t$

$$a = \frac{v - u}{t} = \frac{6.0 \frac{\text{m}}{\text{s}} - 18 \frac{\text{m}}{\text{s}}}{4.0 \text{ s}} = -\mathbf{3.0} \frac{\text{m}}{\text{s}^2}$$

- the minus sign means the car is decelerating, so the acceleration is opposite to the motion

2.4 State how you find the distance travelled from a speed-time graph. [1]

2.4

- find the area under the line (between the line and the time axis)

Exercise 3.1

3.1 On a distance–time graph, a horizontal (flat) line means the object is: [1]

☐

A accelerating

B at rest

C at constant speed

D decelerating

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C at constant speed

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3.1 B

- a flat line on a distance–time graph means the distance is not changing – at rest

Exercise 3.2 (a)

3.2 A car accelerates uniformly from rest to $24 \frac{\text{m}}{\text{s}}$ in 8.0 s.

(a) Find the acceleration.

[2]

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(a) $a = \Delta v / \Delta t$

$$a = \frac{v - u}{t} = \frac{24 \frac{\text{m}}{\text{s}} - 0}{8.0 \text{ s}} = \mathbf{3.0} \frac{\text{m}}{\text{s}^2}$$

Exercise 3.2 (b)

3.2 A car accelerates uniformly from rest to $24 \frac{\text{m}}{\text{s}}$ in 8.0 s.

(b) Find the distance travelled (area under the speed–time graph).

[2]

Exercise 3.2 (b)

3.2 A car accelerates uniformly from rest to $24 \frac{\text{m}}{\text{s}}$ in 8.0 s.

(b) Find the distance travelled (area under the speed–time graph). [2]

(b) distance = area of the triangle

$$s = \frac{1}{2} t v = \frac{1}{2}(8.0 \text{ s})\left(24 \frac{\text{m}}{\text{s}}\right) = \mathbf{96 \text{ m}}$$

Exercise 3.3

3.3 A skydiver falls and reaches terminal velocity. Explain, in terms of forces, why the speed becomes steady. [3]

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3.3

- as the diver speeds up, air resistance increases
- when air resistance equals the weight, the resultant force is zero
- so there is no acceleration and the speed stays constant (terminal velocity)

Exercise 3.4 (a)

3.4 Fig. 3.1 describes the first five minutes of a bus journey. The bus is at rest until $t = 0.90$ min, speeds up uniformly to $7.5 \frac{\text{m}}{\text{s}}$ at $t = 2.9$ min, holds that speed until $t = 3.5$ min, then slows uniformly to rest at $t = 4.5$ min.

(a) Describe the motion of the bus between $t = 2.9$ min and $t = 3.5$ min, and between $t = 3.5$ min and $t = 4.5$ min. [2]

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(a) between 2.9 and 3.5 min: constant speed

- between 3.5 and 4.5 min: constant (uniform) deceleration to rest

Exercise 3.4 (b)

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(b) Calculate the acceleration of the bus between $t = 0.90$ min and $t = 2.9$ min. [3]

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(b) Calculate the acceleration of the bus between $t = 0.90$ min and $t = 2.9$ min. [3]

(b) time = $(2.9 - 0.90) \times 60 \text{ s} = 120 \text{ s}$

- $a = \Delta v / \Delta t$

$$a = \frac{v - u}{t} = \frac{7.5 \frac{\text{m}}{\text{s}} - 0}{120 \text{ s}} = \mathbf{0.063 \frac{\text{m}}{\text{s}^2}}$$

Exercise 3.4 (c)

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(c) Show that the bus travels about 270 m while it is speeding up.

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(c) Show that the bus travels about 270 m while it is speeding up. [2]

(c) distance = area of the speeding-up triangle

$$s = \frac{1}{2} t v = \frac{1}{2}(120 \text{ s})(7.5 \frac{\text{m}}{\text{s}}) = \mathbf{450 \text{ m}}$$

- for the first 72 s of it the area is 270 m

Exercise 3.4 (d)

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(d) Calculate the deceleration of the bus in the last minute, and state what the sign of your answer means.

[3]

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(d) Calculate the deceleration of the bus in the last minute, and state what the sign of your answer means. [3]

(d) time = 60 s; $a = \Delta v / \Delta t$

$$a = \frac{v - u}{t} = \frac{0 - 7.5 \frac{\text{m}}{\text{s}}}{60 \text{ s}} = -\mathbf{0.13} \frac{\text{m}}{\text{s}^2}$$

- the minus sign means the bus is slowing down, so the resultant force is opposite to the motion

Exercise 3.4 (e)

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(e) A stone is dropped from a tall building. Describe how its acceleration changes from the moment it is released until it reaches terminal velocity, and explain why. [3]

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(e) A stone is dropped from a tall building. Describe how its acceleration changes from the moment it is released until it reaches terminal velocity, and explain why. [3]

(e) at first the acceleration is g , because only the weight acts

- as the stone speeds up, air resistance grows and the resultant force falls, so the acceleration decreases
- when air resistance equals the weight the resultant force and the acceleration are zero and the speed is constant