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Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

6615129029

PHYSICS **5054/42**

Paper 4 Alternative to Practical **May/June 2025**

1 hour

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages. Any blank pages are indicated.

DC (WW/FC) 346841/4

1 A student investigates the refraction of a ray of light passing through a transparent block and determines the refractive index *n* of the block.

The student's ray-trace sheet is shown full size in Fig. 1.1.

The outline of the transparent block is shown by the rectangle ABCD. A line SR that meets side AD of the block is also marked.

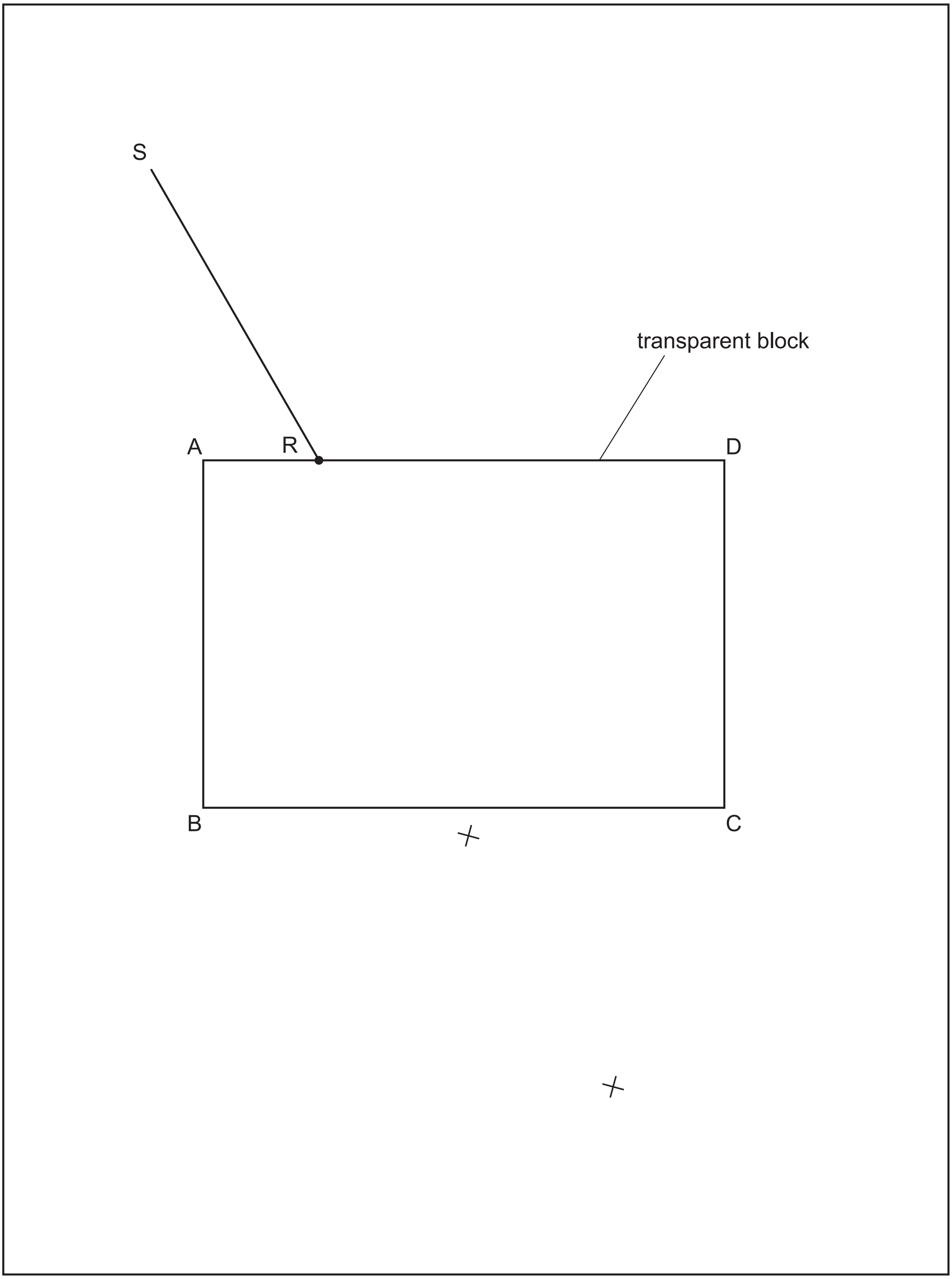

Fig. 1.1

(a) On Fig. 1.1, draw a normal to the block at the point R. Extend your normal 6 cm above side AD and below side BC.

Label the point where the normal crosses side BC of the block with the letter T.

Measure the angle θ between SR and the normal.

θ = ...° [1]

(b) The student:

- positions an illuminated slit on the ray-trace sheet so that a ray of light passes along the line SR towards R
- marks with small crosses (x) two points on the ray that leaves side BC of the block
- removes the transparent block.

On Fig. 1.1, draw a straight line through the two crosses to meet side BC of the block.

Label the point where this line meets side BC with the letter E.

Label the other end of this line as F.

Draw a straight line from E to R.

This shows the path of the ray of light through the block.

[1]

(c) **(i)** Measure the length *a* of line ET on Fig. 1.1.

a = ... cm [1]

(ii) Measure the length *b* of line ER on Fig. 1.1.

b = ... cm [1]

(d) On Fig. 1.1, extend the line FE into the block, until it meets the line RT.

Label the point where FE meets RT with the letter G.

Measure the length *c* of line EG on Fig. 1.1.

c = ... cm [1]

(e) **(i)** Use your values from **(c)(i)** and **(c)(ii)** to calculate a first value n_1 for the refractive index of the block.

Use the equation shown.

$$n_1 = \frac{b}{2a}$$

n_1 = ... [1]

(ii) Use your values from **(c)(ii)** and **(d)** to calculate a second value n_2 for the refractive index of the block.

Use the equation shown.

$$n_2 = \frac{b}{c}$$

n_2 = ... [1]

(f) Two quantities can be considered to be the same within the limits of experimental accuracy if their values are within 10% of each other.

Compare your value n_1 for the refractive index calculated in **(e)(i)** with the value n_2 calculated in **(e)(ii)**.

State if your two values can be considered to be the same.

Support your statement with a calculation.

calculation

statement ....

[2]

(g) One source of inaccuracy in this experiment is careless measurement.

Suggest **another** source of inaccuracy in this experiment.

....

.... [1]

[Total: 10]

2 A student investigates the resistance of a thermistor at different temperatures.

The student constructs the circuit shown in Fig. 2.1.

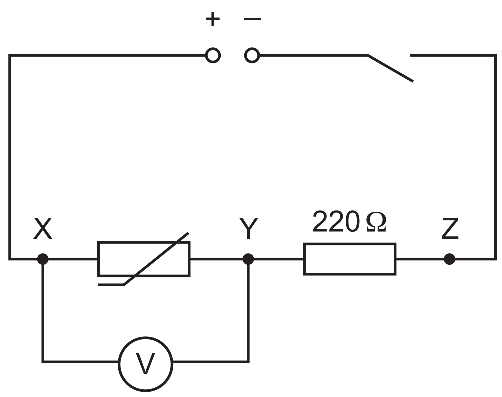

Fig. 2.1

The thermistor shown in Fig. 2.1 is placed in an empty beaker and is at room temperature.

(a) The student measures the room temperature θ_R.

The thermometer is shown in Fig. 2.2.

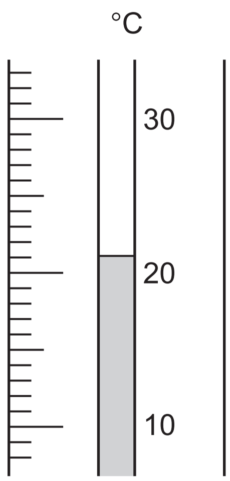

Fig. 2.2

Record the reading of θ_R on the answer line.

θ_R = ... °C [1]

(b) **(i)** The student:

- closes the switch
- records the potential difference across the thermistor V_{XY} while the thermistor is at room temperature θ_R in the top row of Table 2.1
- opens the switch.

The voltmeter is shown in Fig. 2.3.

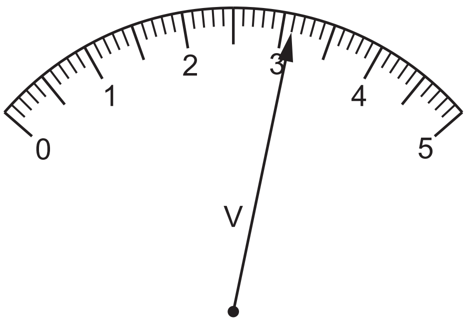

Fig. 2.3

Record the potential difference V_{XY} while the thermistor is at room temperature θ_R in Table 2.1.

Table 2.1

	V_{XY}/V	V_{YZ}/V	I/A
thermistor at room temperature θ_R	....	1.4	....
thermistor at temperature of hot water θ_H	1.2	3.3	....

[1]

(ii) The student:

- disconnects the voltmeter from points X and Y
- reconnects the voltmeter across the 220 Ω resistor between points Y and Z
- closes the switch and records the potential difference across the 220 Ω resistor V_{YZ} while the thermistor is at room temperature θ_R in the top row of Table 2.1.

Re-draw the circuit shown in Fig. 2.1 on page 5 to show the voltmeter connected to measure the potential difference across the 220 Ω resistor.

[1]

(c) The student:

- pours some hot water into the beaker containing the thermistor
- places the thermometer into the hot water and stirs the water gently
- waits for 30 s
- measures the temperature of the hot water θ_H
- measures new values for potential differences V_{XY} and V_{YZ} while the thermistor is at the temperature of the hot water θ_H.

The temperature of the hot water θ_H is 83 °C.

The student's measurements are recorded in the bottom row of Table 2.1.

(i) Explain why the student waits for 30 s before measuring the temperature of the hot water.

....

.... [1]

(ii) Explain why the student stirs the water before reading the temperature of the hot water from the thermometer.

....

.... [1]

(d) Examine the data in Table 2.1.

Compare the reading for the potential difference across the thermistor V_{XY} at room temperature θ_R with the reading for the potential difference across the thermistor V_{XY} at the temperature of the hot water θ_H.

Suggest what causes the difference in the readings.

....

.... [1]

(e) The current I in the circuit is calculated using the equation:

$$I = \frac{V_{YZ}}{R}$$

where R = 220 Ω.

Use the measurements recorded in Table 2.1 to calculate the current I at room temperature θ_R **and** at the temperature of the hot water θ_H.

Record your answers in Table 2.1. [1]

(f) The resistance R_T of the thermistor is calculated using the equation:

$$R_T = \frac{V_{XY}}{I}$$

Use the data in Table 2.1 on page 6 to calculate R_T at room temperature θ_R and at the temperature of the hot water θ_H.

R_T at room temperature θ_R = ... Ω

R_T at temperature of hot water θ_H = ... Ω

[1]

(g) Calculate α, the average change in the resistance of the thermistor per degree Celsius, for the thermistor as the temperature of the thermistor rises from room temperature θ_R to the temperature of the hot water θ_H.

Use the equation shown.

$$\alpha = \frac{\text{change in resistance of thermistor}}{\text{change in temperature}}$$

Give your answer to 2 significant figures.

α = ... Ω / °C [2]

[Total: 10]

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3 A student investigates the stretching of a spring.

The student suspends the spring from the clamp of a retort stand as shown in Fig. 3.1.

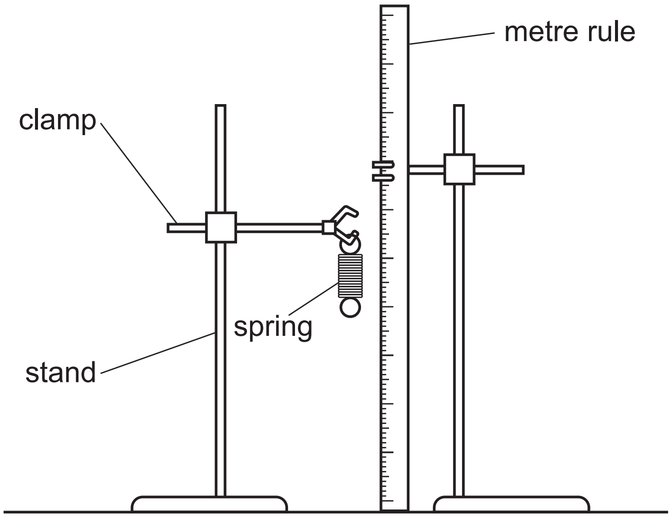

Fig. 3.1

(a) The student takes readings from the metre rule to determine the length of the spring.

(i) On Fig. 3.2, take readings from the metre rule level with the top of the spring and level with the bottom of the spring.

Do **not** include the loops at the top and the bottom of the spring in your measurements.

Record your readings to the nearest 0.1 cm.

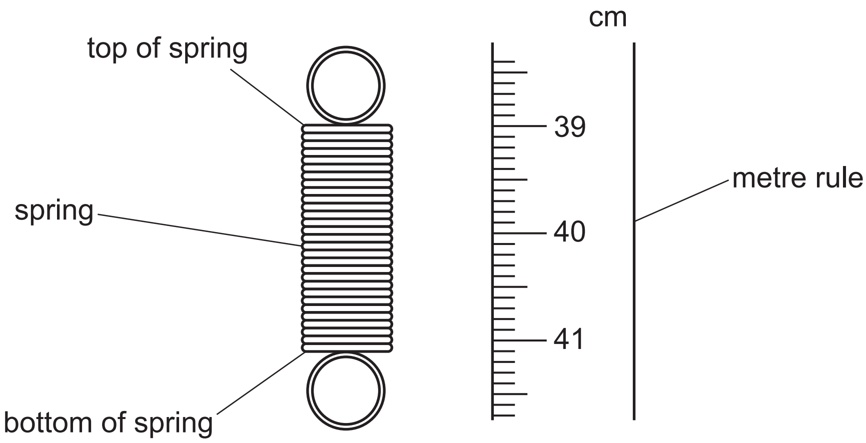

Fig. 3.2

reading level with top of spring = ... cm

reading level with bottom of spring = ... cm
[2]

(ii) Draw on Fig. 3.2 to show how the student uses a set-square to take a reading from the metre rule level with the bottom of the spring. [1]

(b) **(i)** Calculate the length l of the coiled part of the spring. Use the equation shown.

l = reading level with bottom of spring – reading level with top of spring

Show your working.

Record l in Table 3.1 on page 12 for a load L = 0.0 N. [1]

(ii) The student:

- places a load L = 1.0 N on the spring
- takes readings to determine the new length l of the spring.

The top of the spring does not move but the bottom of the spring moves downwards.

The student determines that the new reading on the rule level with the bottom of spring is 45.2 cm.

Calculate the new length l of the spring.

Record your answer for the new length l for a load L = 1.0 N in Table 3.1 on page 12. [1]

(c) The student repeats the procedure in **(b)(ii)** for loads L = 2.0 N, 3.0 N, 4.0 N and 5.0 N. The results are shown in Table 3.1.

Table 3.1

load L / N	0	1.0	2.0	3.0	4.0	5.0
length l / cm	....	....	10.0	14.0	18.2	21.9

On the grid provided in Fig. 3.3 on page 13, plot a graph of l on the y-axis against L on the x-axis.

Start from the origin (0, 0).

Draw the straight line of best fit. [4]

(d) Use the data in Table 3.1 and the graph in Fig. 3.3 to determine the **extension** of the spring when a load of 3.5 N is added to the spring.

Show your working.

extension = ... cm [2]

(e) A student suggests that the stretched length l of the spring is proportional to load L.

State if the data in Table 3.1 supports this suggestion. Justify your statement using the data in Table 3.1 or the graph in Fig. 3.3.

statement ....

justification ....

....

....
[1]

(f) Line of sight (parallax) errors can occur when readings are taken from the metre rule.

State one practical technique, other than using a set square, that ensures accurate readings are taken from a metre rule.

....

.... [1]

(g) The student repeats the procedure described in **(c)** two more times and averages the readings before calculating the spring lengths l for each load L.

Explain why the student does this.

....

.... [1]

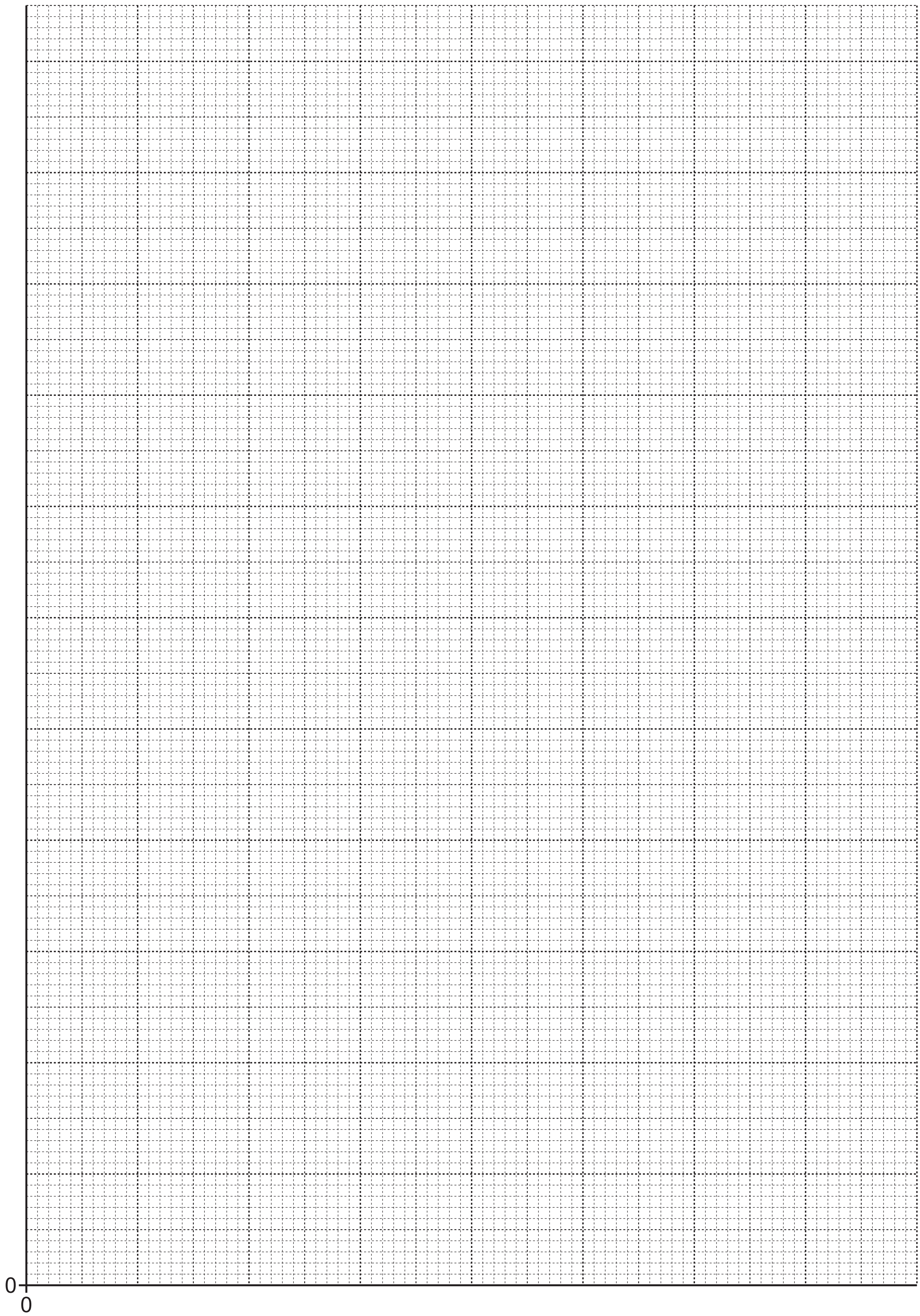

Fig. 3.3

[Total: 14]

4 As a metal ball falls through a liquid, it experiences a frictional force from the liquid that opposes the motion of the metal ball.

Plan an experiment to determine the relationship between the density of a liquid contained in a measuring cylinder and the average speed of a metal ball falling through the liquid from the surface of the liquid to the bottom of the cylinder.

The average speed of the ball is calculated using the equation:

$$\text{average speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

The arrangement of the apparatus is shown in Fig. 4.1.

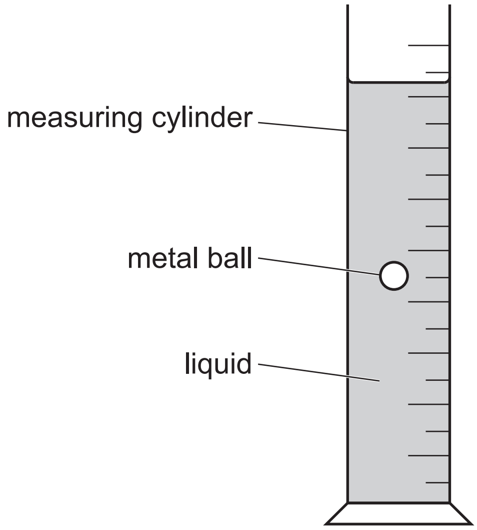

Fig. 4.1

The apparatus available includes:

- a measuring cylinder
- a metal ball
- a selection of different liquids whose densities are known.

You may also use any other apparatus commonly found in a school laboratory.

In your plan, include:

- any other apparatus needed
- a brief description of the method, including what you will measure and how you make sure that your measurements are accurate
- the variables you will control
- a results table to record your measurements (you are not required to enter any readings in the table)
- how you will process your results to draw a conclusion.

[6]