



GCSE

3420UA0-1

MONDAY, 20 JUNE 2022 – MORNING

**PHYSICS – Unit 1:
Electricity, Energy and Waves**

HIGHER TIER

1 hour 45 minutes plus your additional time allowance

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

ADDITIONAL MATERIALS

In addition to this paper you may require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball-point pen or your usual method.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question 5.

(Turn over)

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	7	
2.	13	
3.	11	
4.	7	
5.	6	
6.	15	
7.	10	
8.	11	
Total	80	

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Equations

$$\text{current} = \frac{\text{voltage}}{\text{resistance}} \quad I = \frac{V}{R}$$

$$\text{total resistance in a series circuit} \quad R = R_1 + R_2$$

$$\text{total resistance in a parallel circuit} \quad \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\text{energy transferred} = \text{power} \times \text{time} \quad E = Pt$$

$$\text{power} = \text{voltage} \times \text{current} \quad P = VI$$

$$\text{power} = \text{current}^2 \times \text{resistance} \quad P = I^2R$$

$$\% \text{ efficiency} = \frac{\text{energy [or power] usefully transferred}}{\text{total energy [or power] supplied}} \times 100$$

$$\text{density} = \frac{\text{mass}}{\text{volume}} \quad \rho = \frac{m}{V}$$

$$\text{units used (kWh)} = \text{power (kW)} \times \text{time (h)}$$

$$\text{cost} = \text{units used} \times \text{cost per unit}$$

wave speed = wavelength \times frequency $v = \lambda f$

speed = $\frac{\text{distance}}{\text{time}}$

pressure = $\frac{\text{force}}{\text{area}}$

$$p = \frac{F}{A}$$

p = pressure

V = volume

T = kelvin temperature

$$\frac{pV}{T} = \text{constant}$$

$$T / \text{K} = \theta / ^\circ\text{C} + 273$$

change in thermal energy = mass \times specific heat capacity \times change in temperature

$$\Delta Q = mc\Delta\theta$$

thermal energy for a change of state = mass \times specific latent heat $Q = mL$

(Turn over)

force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength \times current \times length

$$F = B I l$$

V_1 = voltage across the primary coil

V_2 = voltage across the secondary coil

N_1 = number of turns on the primary coil

N_2 = number of turns on the secondary coil

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

SI multipliers

Prefix	Multiplier
p	1×10^{-12}
n	1×10^{-9}
μ	1×10^{-6}
m	1×10^{-3}

Prefix	Multiplier
k	1×10^3
M	1×10^6
G	1×10^9
T	1×10^{12}

Answer ALL questions.

- 1 (a) The mains electricity supply to homes is at a voltage of 230 V a.c.
In contrast to this, batteries supply d.c.
These are each shown in DIAGRAM 1.**

**An alternating voltage changes in size, but a direct voltage keeps the same size.
State ONE other difference between the two.
[1 mark]**

1 (b) Household circuits may be protected by a series of devices. These include:

- a miniature circuit breaker (mcb)
- a fuse in a plug
- a residual current circuit breaker (rccb).

The list below gives three situations in which one or another of these devices stop the power from being supplied.

- 1. An electric lawn mower cuts through the cable.**
- 2. Too much current flows in a ring main because too many appliances are being used at the same time.**
- 3. The live wire in a kettle touches its neutral wire.**

(i) Select and explain one situation above that puts the USER in danger of an electric shock AND which one of the devices should be used to keep the user safe. [2 marks]

1 (b)(ii)

State TWO advantages of an mcb over a fuse in a household circuit. [2 marks]

1. _____

2. _____

(c) Describe the function of the live and neutral wires in household circuits. [2 marks]

Live wire:

Neutral wire:

7

(Turn over)

- 2 P and S waves are produced during an earthquake. They travel at different speeds.**

The graph in DIAGRAM 2 shows how the speed of P and S waves change with depth below the Earth's surface.

- (a) P waves are longitudinal waves. Explain what is meant by a longitudinal wave. [2 marks]**

- (b) Use the graph to calculate the difference in speed between the P wave and the S wave at a depth of 100 km. [2 marks]**

Speed difference = _____ km/s

(Turn over)

2 (c)(i) Bob claims that the maximum speed of P waves is greater in solids than in liquids. Explain, using data from the graph, whether Bob's claim is correct. [2 marks]

2 (c)(ii)

A P wave (shown in DIAGRAM 3) travels a distance of 6 300 km in a straight line to the centre of the Earth in a time of 550 s.

Bob states that the mean speed of the P wave over this distance is equal to its actual speed only at the depth of 3 500 km. Use an equation from page 3, 4 or 5 to show whether Bob's statement is correct. [3 marks]

Space for calculations.

(Turn over)

2 (d) **DIAGRAM 4** shows waves passing through the Earth following an earthquake at point X.

Monitoring stations at A, B and C detect the earthquake by signals that they receive.

- (i) Use the time given in part (c)(ii) to state the time taken for the P wave to travel from X TO C (ignore the Earth's crust in this).
[1 mark]

Time = _____ s

- (ii) The signals received at monitoring stations A and B are shown in **DIAGRAM 5**.
ADD TO DIAGRAM 5 the signal that you would expect to be received at station C.
[3 marks]

13

3 This question is about geostationary and geosynchronous satellites.

- (a) PLACE A TICK (✓) OR A CROSS (X) IN EACH BOX in the table below.
One box has been completed for you.
[4 marks]**

	Geosynchronous satellite	Geostationary satellite
Stays above the same point on Earth at all times	X	
Orbits Earth once in 24 hours		
Orbits above the equator		
Must pass over the North pole and South pole		

(Turn over)

- 3 (b) **DIAGRAM 6** shows a communications satellite relaying a signal between ground stations A and B.
- (i) Satellite communication uses microwaves of wavelength of 0.08 m.

Use the equation:

wave speed = frequency \times wavelength

to calculate the frequency of the microwaves and state its unit.

(Speed of light, $c = 3 \times 10^8$ m/s) [4 marks]

Frequency = _____

Unit = _____

(Turn over)

3 (b)(ii)

The time delay between transmitting the signal at A and receiving it back on Earth at B is 0.24 s.

Use an equation from page 3, 4 or 5 to calculate the distance from the satellite to the ground stations. [3 marks]

(Speed of light, $c = 3 \times 10^8$ m/s)

Distance = _____ m

11

(Turn over)

4 A group of students investigate density using an electronic balance, a measuring cylinder, water and some small steel ball bearings.

THEY SET THE BALANCE TO ZERO AND PLACE A MEASURING CYLINDER ON TO THE BALANCE.

They then add water at 10 cm^3 intervals and record both the mass and volume.

At some point they start adding the steel ball bearings instead of water, and record the mass and volume each time the water level rises by 10 cm^3 .

They continue until the final volume of 100 cm^3 is reached.

The arrangement is shown in DIAGRAM 7.

The students produce a table of their results, which is shown in DIAGRAM 8.

(a) One member of the group claims that water has a density value of 1 g/cm^3 .

Explain whether her claim is correct.
[No calculations are required.] [1 mark]

4 (b)(i) State the volume at which they start adding the steel ball bearings. [1 mark]

Volume = _____ cm³

(ii) Give a reason for your answer. [1 mark]

(c) Use an equation from page 3, 4 or 5 to calculate the density of steel. [2 marks]

Density of steel = _____ g/cm³

(Turn over)

4 (d) State TWO improvements that could be made to this experiment that would lead to a more accurate value for the density of steel. [2 marks]

1. _____

2. _____

7

6 A student sets up the following experiment to find how current is related to the number of identical resistors, R , in the circuit. She uses a power supply that provides a constant voltage, V , and includes a safety resistor, r , in the circuit as shown in **DIAGRAM 9**.

(a) The moveable connector is moved to point **X** in the circuit. Explain why the ammeter might be damaged if there was no safety resistor, r , included in the circuit. [2 marks]

- 6 (b) The student takes a series of readings of current as the number of resistors in the circuit is increased.

Her results are shown in the table in **DIAGRAM 10**.

Refer to the table to answer the following questions.

- (i) **COMPLETE** the missing mean value in the table. [1 mark]
Space for calculation.

- (ii) State the value of the resistance of the safety resistor, r . [1 mark]

Resistance = _____ Ω

- (iii) Determine the value of the resistance of each resistor, R . [1 mark]

Resistance = _____ Ω

- (iv) Plot the results on the grid in **DIAGRAM 11** and draw a suitable line. [3 marks]

(Turn over)

- 6 (c) Use your answer to part (b)(iii) and the graph in DIAGRAM 11 to determine the current when 3 of the resistors labelled R are included in the circuit. [3 marks]

Current = _____ A

6 (d)(i) The gradient of the graph gives the value of the voltage of the battery.

Calculate its value and show your workings.
[2 marks]

Voltage = _____ V

(ii) Describe ONE other way that the battery voltage could be calculated. [2 marks]
No calculations are required.

15

7 **DIAGRAM 12** shows a simple d.c. electric motor consisting of a single turn of wire **ABCD**.

(a) Describe how Fleming's left-hand rule can be used to show that the side **AB** of the wire moves upwards. [3 marks]

7 (b) By considering the current in **AB**, explain how the split ring allows the coil to continue to rotate. [2 marks]

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force on a conductor (at right angles to a magnetic field) carrying a current = magnetic field strength \times current \times length

- 7 (c) The sides AB and CD have lengths of 6.0 cm and the side BC has a length of 3.0 cm. The magnetic field has a strength of 0.04 T and a current of 0.7 A passes through the coil.
- (i) Use the equation opposite to calculate the force on side **AB** of the coil. [3 marks]

Force = _____ N

- (ii) Describe the effect on the force, on side **AB** of the coil, of doubling **BOTH** the battery voltage **AND** the number of coils. [2 marks]

8 (a) The volume of a gas is related to its pressure. A mass of air is contained in a glass tube that is attached to a pressure gauge.

This apparatus is shown in DIAGRAM 13.

(i) When the pressure shown by the pressure gauge increases and the temperature is constant, the volume of the column of air decreases.

Describe the effect, if any, on the motion of the molecules and on the collisions with the container. [2 marks]

8 (a)(ii)

At a pressure of $1.2 \times 10^5 \text{ Pa}$, the volume is 18 cm^3 .

Explain, without calculation, what happens to the volume when the pressure is increased to $2.4 \times 10^5 \text{ Pa}$ at constant temperature.

[2 marks]

(Turn over)

8 (b) In another experiment, air initially at 27°C is kept at constant volume.

The air pressure is increased from $2.4 \times 10^5 \text{ Pa}$, to $3.0 \times 10^5 \text{ Pa}$.

(i) State the initial temperature in Kelvin. [1 mark]

Temperature = _____ K

(ii) Use an equation from page 3, 4 or 5 to calculate the **CHANGE IN TEMPERATURE** of the air. [3 marks]

Change in temperature = _____ K

(Turn over)

- 8 (c) A mass of 5×10^{-3} kg of air requires 105.5 J of thermal energy to increase its temperature by 21°C .

Use the equation:

$$\Delta Q = mc\Delta\theta$$

to calculate the specific heat capacity, c , of air. [3 marks]

Specific heat capacity =

_____ J/kg $^\circ\text{C}$

11

END OF PAPER

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

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Diagram Booklet

Surname _____

First name(s) _____

Centre Number _____

Candidate Number **0** _____

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DIAGRAM 1

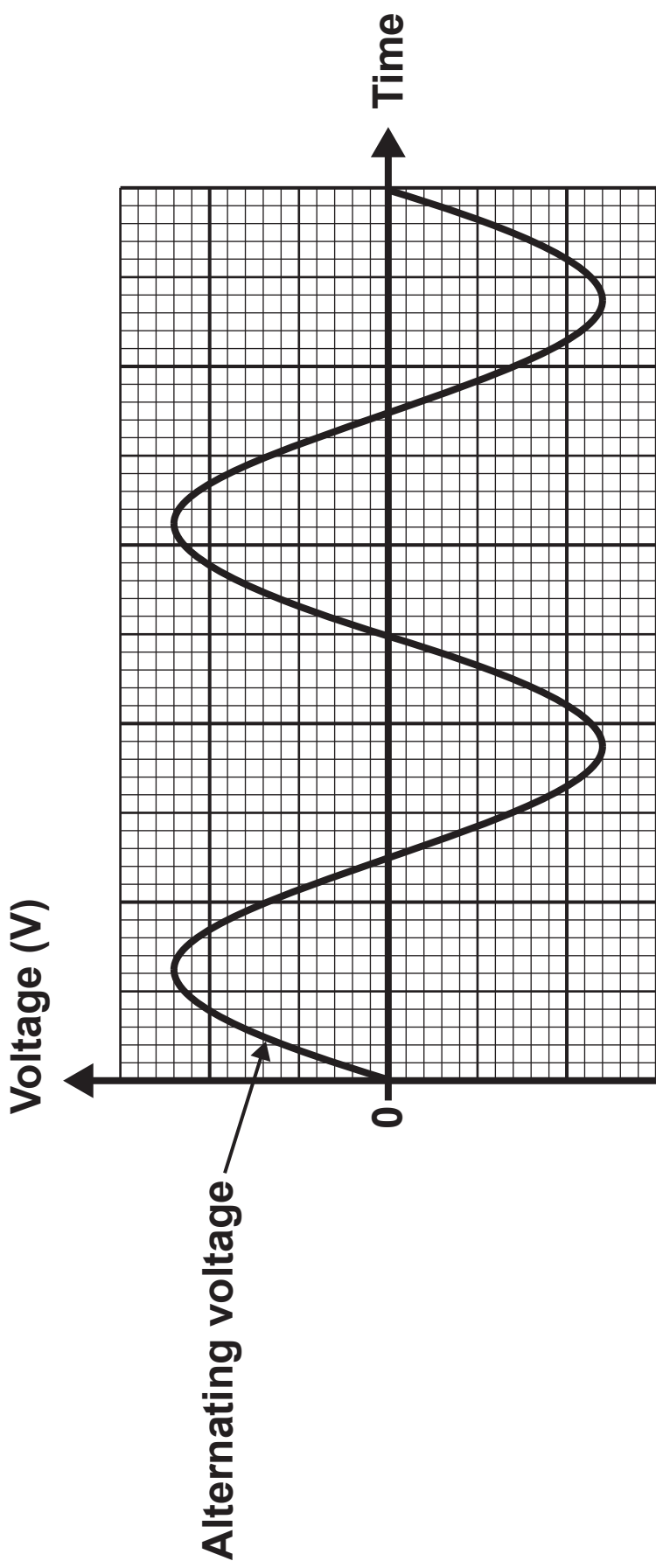


DIAGRAM 1 (continued)

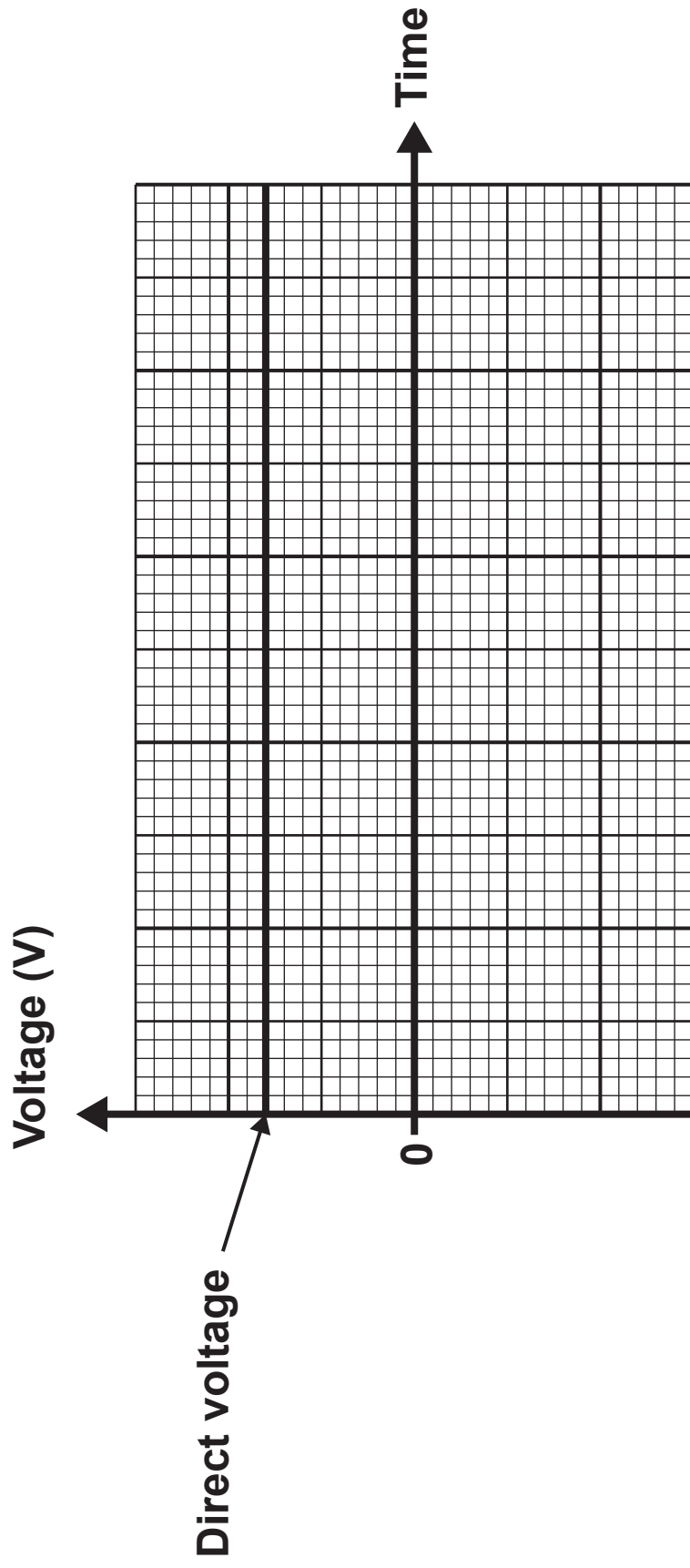


DIAGRAM 2

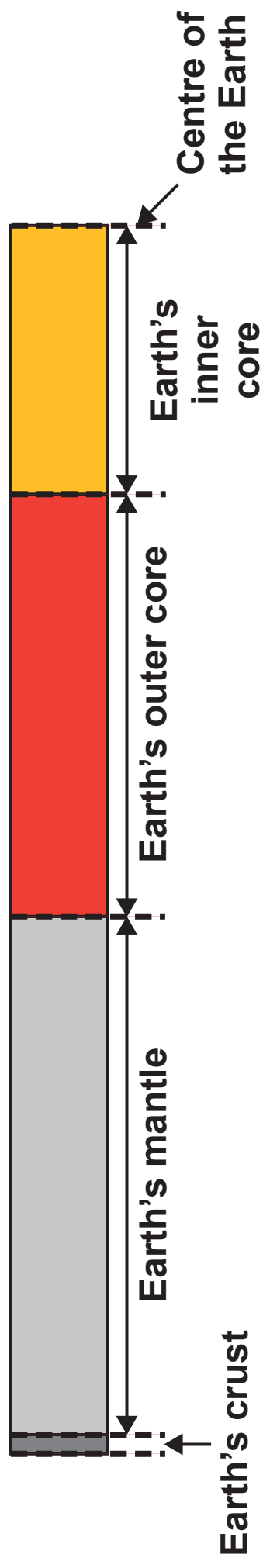
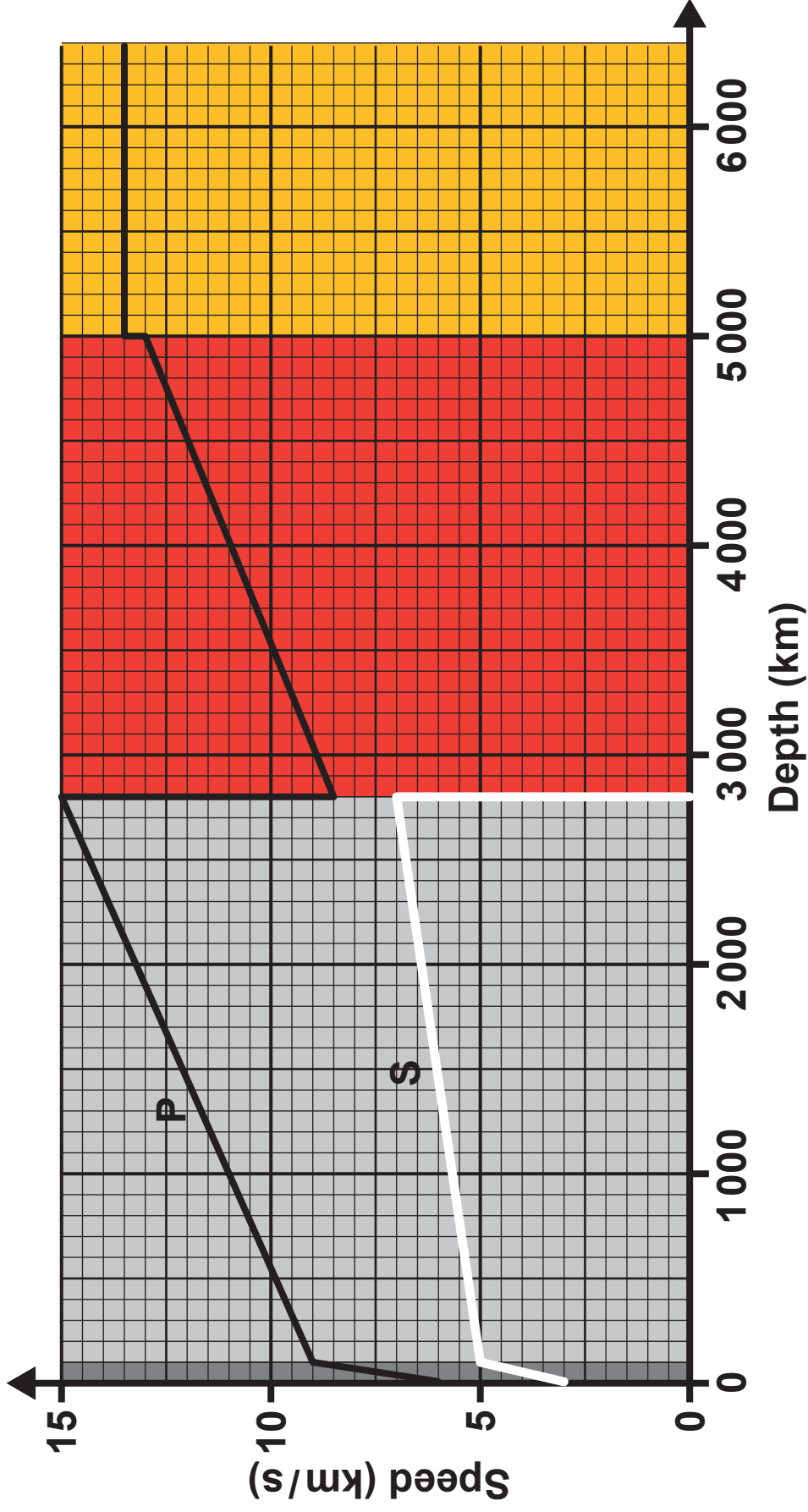


DIAGRAM 3

Crust

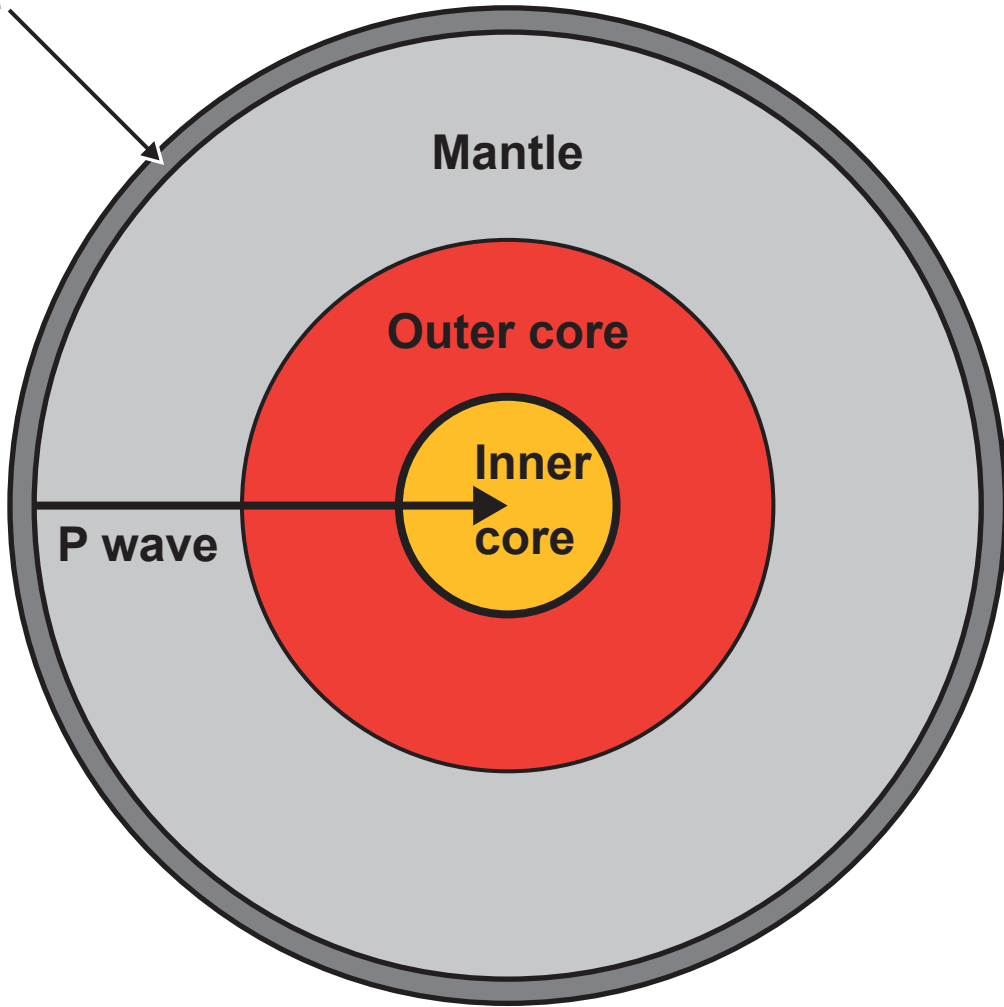


DIAGRAM 4

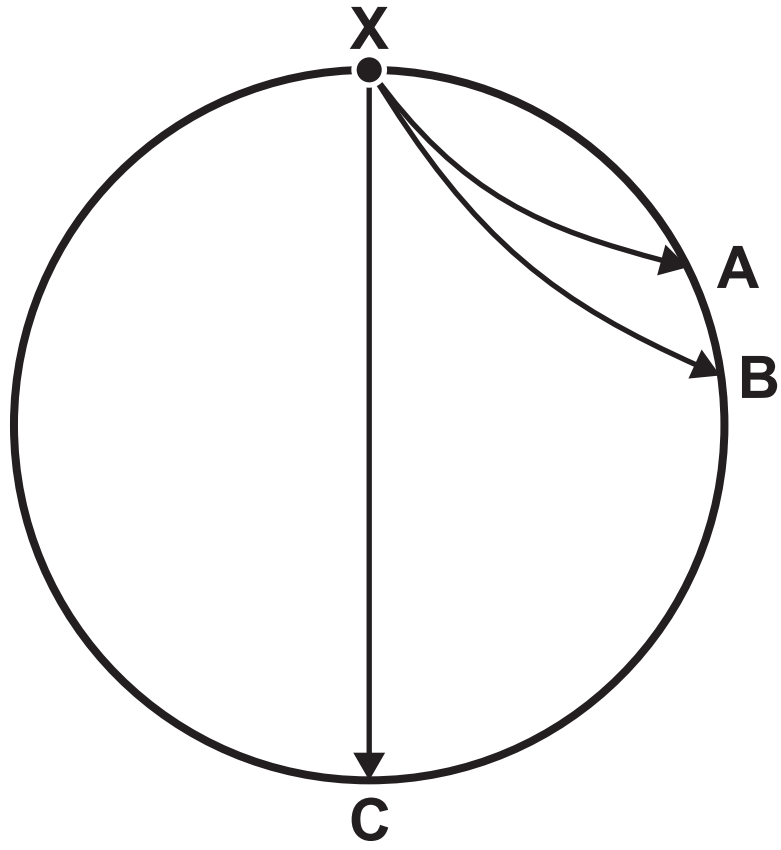


DIAGRAM 5

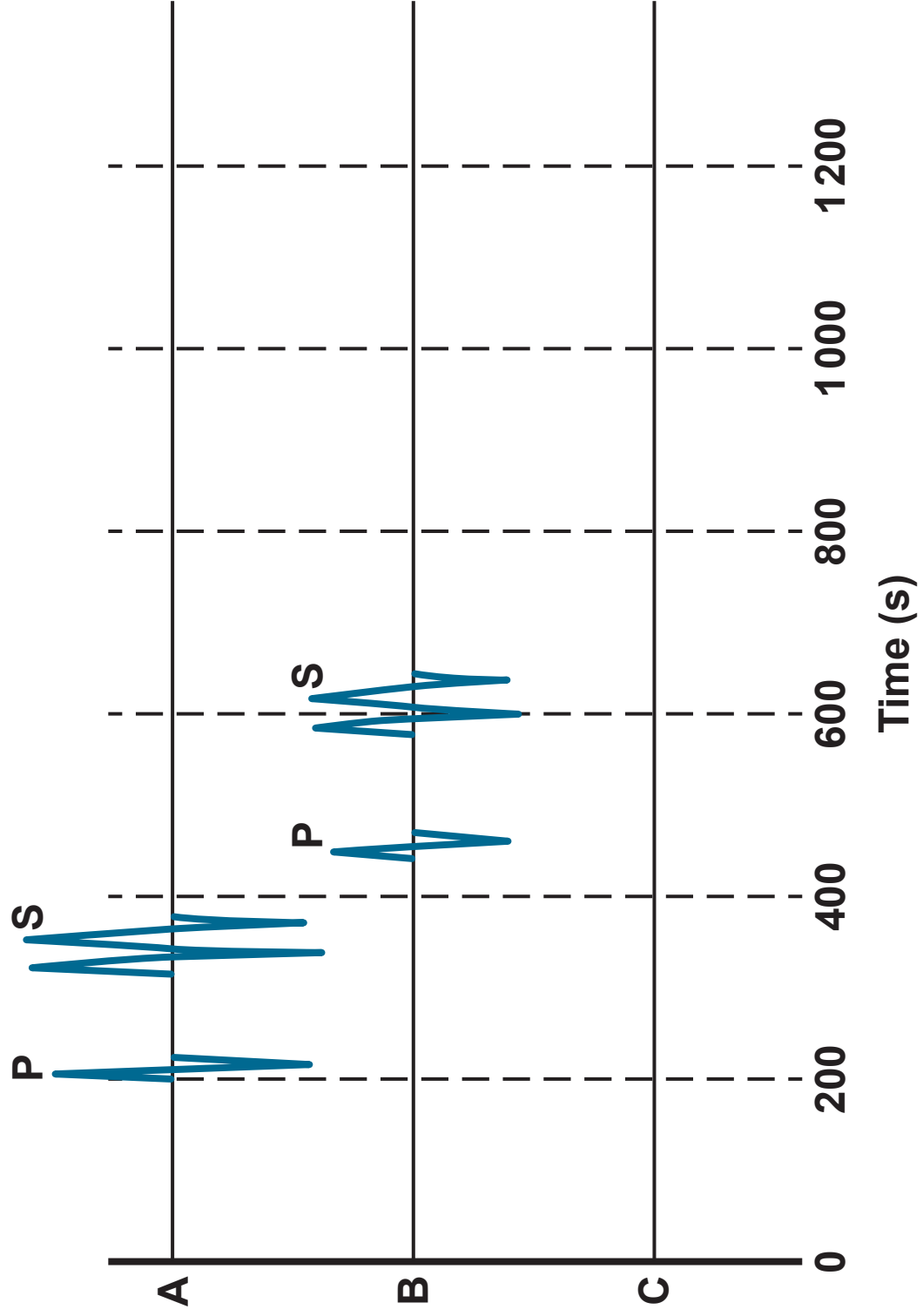
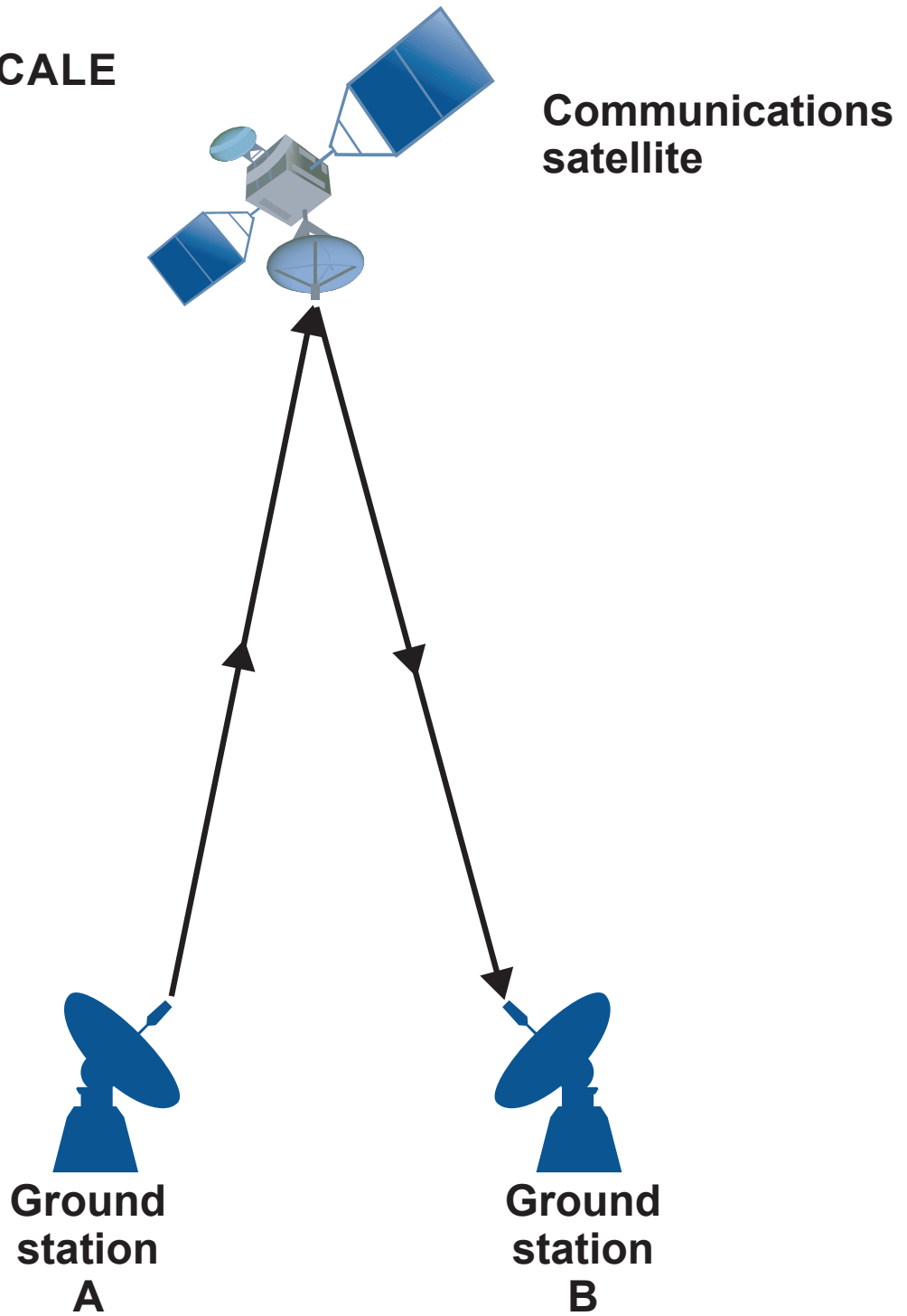


DIAGRAM 6

**DIAGRAM
NOT TO SCALE**



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DIAGRAM 7

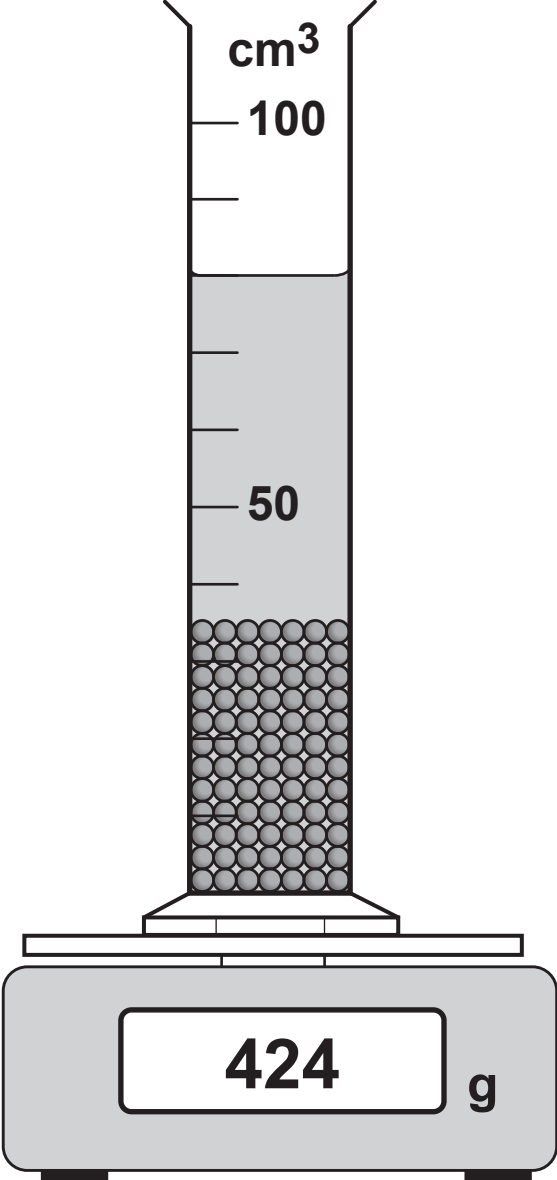
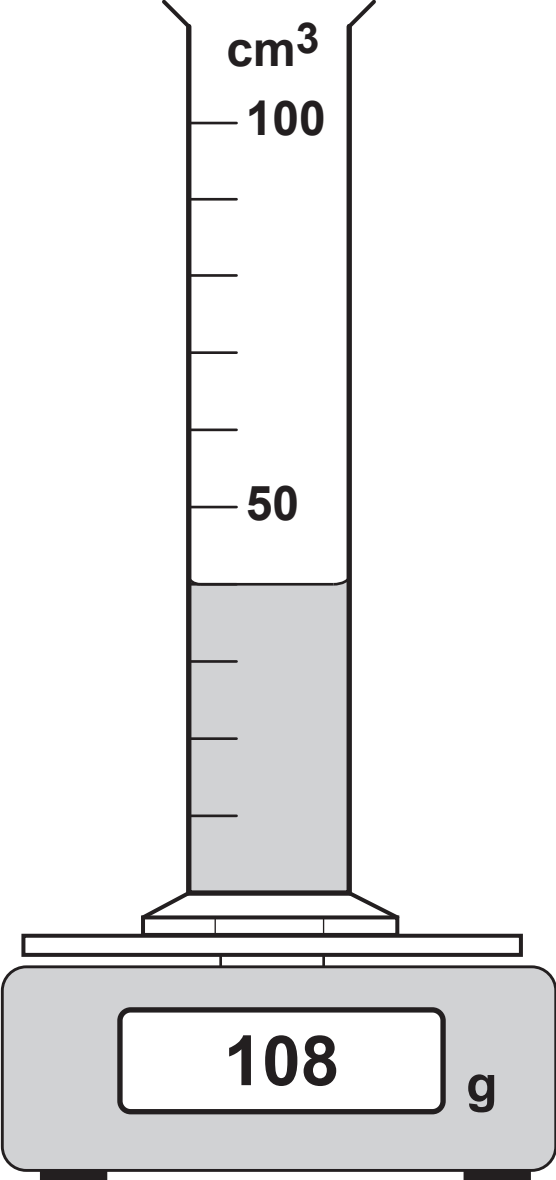
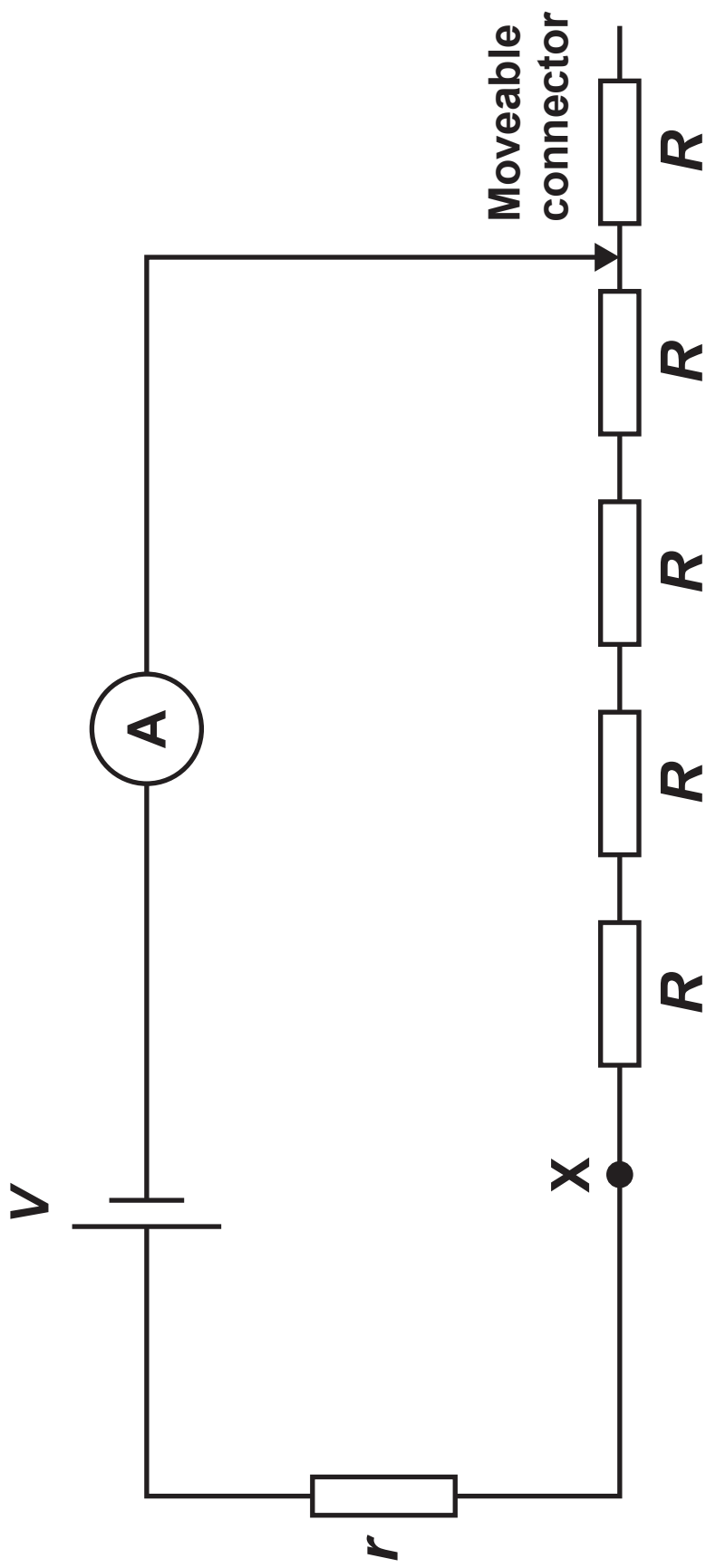


DIAGRAM 8

Volume (cm³)	Mass (g)
0	68
10	78
20	88
30	98
40	108
50	187
60	266
70	345
80	424
90	503
100	582

DIAGRAM 9



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DIAGRAM 10

Number of resistors, R	Total circuit resistance (Ω)	Current, I (A)			$\frac{1}{\text{current}} \left(\frac{1}{\text{A}}\right)$
		First reading	Second reading	Mean	
0	10	1.200	1.200	1.200	0.83
1	30	0.390	0.410	_____	2.5
2	50	0.230	0.250	0.240	4.2
4	90	0.133	0.133	0.133	7.5
5	110	0.110	0.108	0.109	9.2

DIAGRAM 11

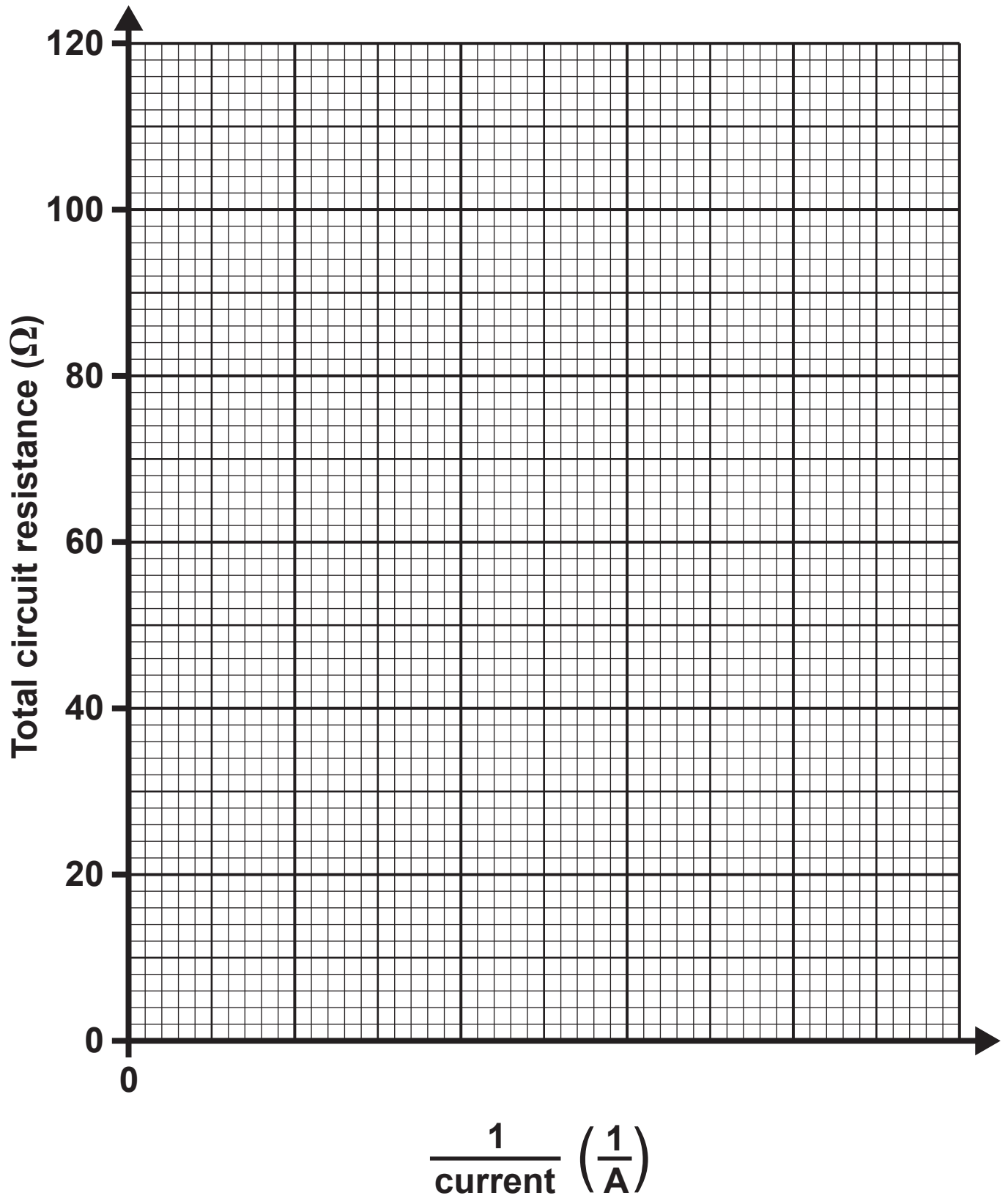


DIAGRAM 12

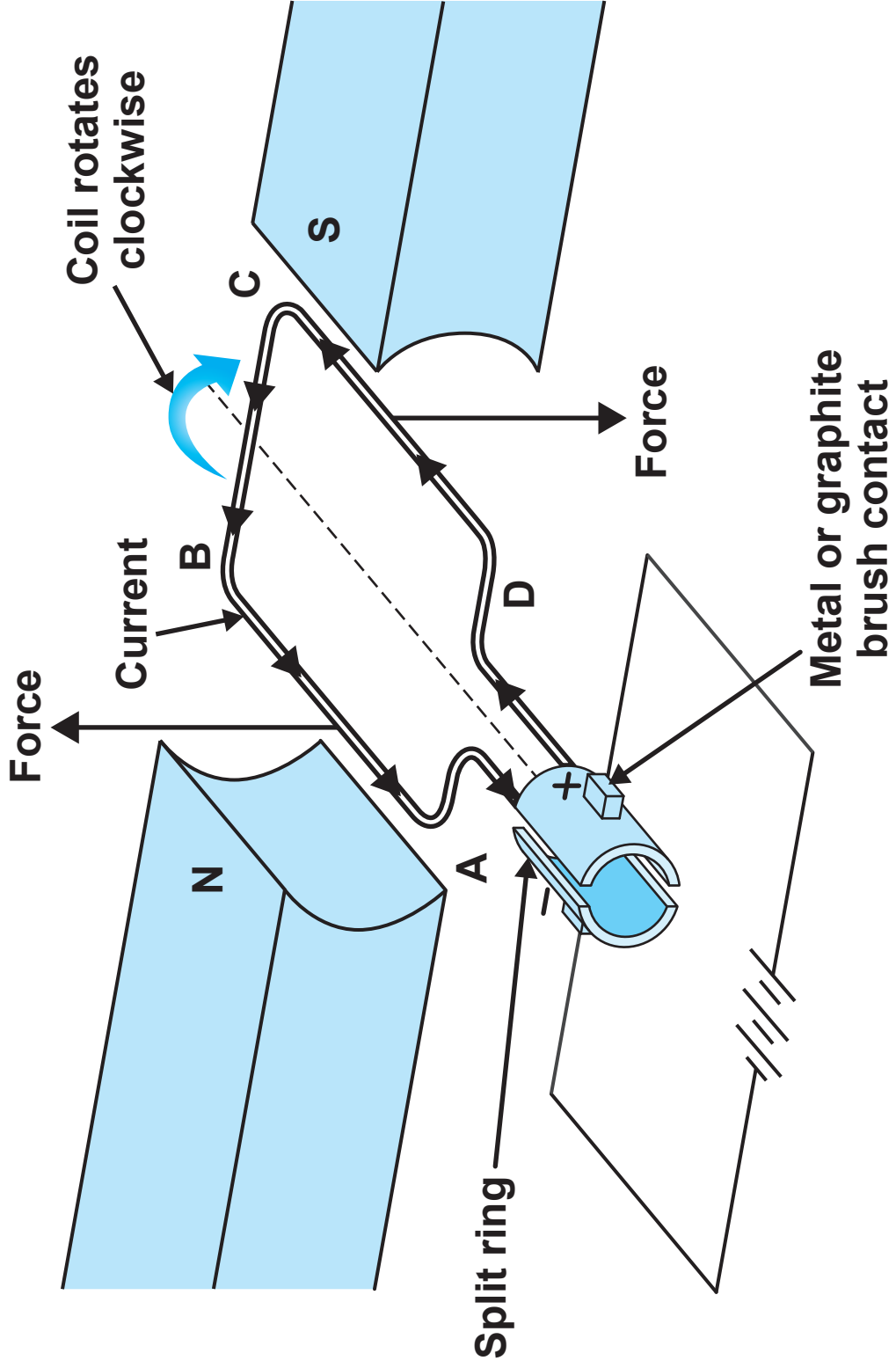


DIAGRAM 13

