



GCSE

3420UA0-1

MONDAY, 16 JUNE 2025 – 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 will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

A separate Data 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 4.

(Turn over)

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	11	
2.	9	
3.	5	
4.	6	
5.	11	
6.	16	
7.	6	
8.	10	
9.	6	
Total	80	

Answer ALL questions.

- 1** In the UK, domestic electricity has a voltage of 230 V and a frequency of 50 Hz. It is an alternating current (a.c.) supply, rather than a direct current (d.c.) supply.

- (a)** State the difference between a.c. and d.c.
[1 mark]

- 1 (b) A science class investigates the cost and efficiency of different kettles. They collect and compare data for two different kettles as shown in TABLE 1.1 in the separate diagram booklet.**
- (i) Not all of the heat energy transferred by the kettle is transferred to the water.**
- I. Use data from TABLE 1.1 and an equation from the separate data booklet to calculate the total electrical energy transferred by kettle X when it is boiled ONCE. [2 marks]**

**total electrical energy
transferred by kettle X = _____ J**

- II. Use data from TABLE 1.1, an equation from the separate data booklet and your answer to part (i) I to determine the % efficiency of kettle X. [2 marks]**

% efficiency = _____

(Turn over)

1 (b)(ii)

The students compare the cost of using each of the kettles.

They estimate that each kettle will be boiled 10 times per day.

- I. Calculate the time that each kettle is used per day in hours. [1 mark]**

time = _____ hours

- II. Use equations from the separate data booklet to calculate the cost of using kettle Y per day if 1 unit of electricity costs 30 p. [3 marks]**

cost per day = _____ p

(Turn over)

1 (b)(iii)

It is suggested that kettle X will cost more to use per day, than kettle Y, when used for the same time.

Explain whether you agree with this suggestion. [2 marks]

11

- 2** Drax power station is a fuel-burning power station.
In 1986, Drax was the largest power station in the UK.
It consisted of 6 coal-fired generators with a total capacity of about 4000 MW, powering millions of homes.
By 2018, Drax had converted four of the coal-fired generators to run on biomass, producing 70% of its electrical power through burning compressed wood pellets.

- (a)** **DIAGRAM 2.1** in the separate diagram booklet is a simplified diagram of a fuel-burning power station.

Describe the processes involved in producing electrical power from a fuel. [3 marks]

continue answer on the next page

(Turn over)

- 2 (b) Burning biomass does not produce sulfur dioxide.
State AND explain another environmental advantage of burning biomass rather than coal. [2 marks]**

- 2 (c) The demand for electricity depends on the weather.**
In the winter, demand increases by 750 MW for every degree the temperature drops below 14 °C.
In the summer, demand increases by 350 MW for every degree rise over 20 °C, from a mean demand of 40 000 MW.
- (i) Suggest why demand for electricity increases as the temperature increases above 20 °C in the summer. [1 mark]**

2 (c)(ii)

On one summer's day, the demand for electricity increased to 45 600 MW.

Chris suggests that the temperature must have risen to 30°C, but Ella states that it must be 36°C.

Determine who is correct. [3 marks]

Space for calculations.

9

(Turn over)

3 The apparatus shown in DIAGRAM 3.1 in the separate diagram booklet can be used to demonstrate heat transfer in water.

(a) Name the heat transfer process being demonstrated. [1 mark]

(b)(i) Describe what happens to the water particles when the water is heated. [2 marks]

3 (b)(ii)

Explain, in terms of density, why the water moves in the direction shown by the arrow when it is heated. [2 marks]

5

4 Describe the properties of P and S waves AND explain how a model of the structure of the Earth has been produced from seismic records. [6 marks QER]

[illegible]

continue answer on the next page

(Turn over)

6

- 5** A class investigates series and parallel circuits and sets up the circuit in **DIAGRAM 5.1** in the separate diagram booklet.

(a) Use the equation:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

to determine the resistance of the **PARALLEL** combination. [3 marks]

resistance = _____ Ω

(Turn over)

- 5 (b) Use an equation from the separate data booklet to calculate the total resistance of the circuit. [1 mark]**

total resistance = _____ Ω

- (c) Use an equation from the separate data booklet to calculate the current measured by the ammeter. [2 marks]**

current = _____ A

- 5 (d) Use an equation from the separate data booklet to calculate the voltage across the $6\ \Omega$ resistor. [3 marks]**

voltage = _____ V

- (e) Explain how you could use your answer to part (d) to determine the current through the $20\ \Omega$ resistor. [2 marks]
Calculations are not required.**

- 6 (a) DIAGRAM 6.1** in the separate diagram booklet represents an electromagnetic (em) wave.

Use the diagram and an equation from the separate data booklet to determine the frequency of the wave.

The speed of light, $c = 3.0 \times 10^8 \text{ m/s}$. [3 marks]

frequency = _____ Hz

- 6 (b) DIAGRAM 6.2 in the separate diagram booklet is an unlabelled diagram of the em spectrum.**
It shows typical frequencies of the different regions of the spectrum.
An em wave has a frequency of 2×10^{15} Hz.
Determine what type of em radiation it is.
[1 mark]

type of radiation = _____

- (c) Most waves can be described as either transverse or longitudinal.**
Describe the difference between transverse and longitudinal waves. [2 marks]

- 6 (d) Students study the motion of water waves in the laboratory, investigating how the speed of water waves is affected by the depth of the water.**

They time how long waves take to travel 120 cm, which is THREE LENGTHS of a tray.

- (i) Explain why the students time the waves for three lengths rather than one length.
[2 marks]**

6 (d)(ii)

GRAPH 6.3 in the separate diagram booklet shows their results.

- I. Use **GRAPH 6.3** and an equation from the separate data booklet to determine the time taken for the waves to travel **ONE LENGTH** of the tray at a depth of 2.5 cm. [4 marks]

time = _____ s

(Turn over)

6 (d)(ii)

II. It is suggested that doubling the depth from 1 cm to 2 cm increases the speed by a factor of 4.

Determine whether this suggestion is correct.

[2 marks]

Space for calculations.

6 (d)(iii)

The equation:

$$\text{speed} = \sqrt{10 \times \text{depth of water (m)}}$$

can be used to determine the true speed of the water waves.

Comment on the accuracy of the data for a depth of 2.5 cm (0.025 m). [2 marks]

Space for calculations.

- 7** **Students carry out an experiment to determine the specific heat capacity of aluminium in the form of a block as shown in DIAGRAM 7.1 in the separate diagram booklet.**

TABLE 7.2 in the separate diagram booklet shows the data they collected.

- (a)** **Only 90% of the heat energy transferred by the heater causes the block's temperature to rise.
The rest is transferred to the surroundings.**
- (i)** **Determine the heat energy transferred to the aluminium block. [1 mark]**

heat energy transferred = _____ J

7 (a)(ii)

Use an equation from the separate data booklet to calculate the specific heat capacity, c , of aluminium. [3 marks]

specific heat capacity, c = _____ J/kg°C

7 (b) The students repeat their experiment with a steel block.

Gwilym states that if the block has the same mass as the aluminium block, it must have the same volume.

Explain whether you agree. [2 marks]

6

8 **DIAGRAM 8.1** in the separate diagram booklet shows a simple a.c. generator. When the coil is in the position shown, the current produced by the generator is a maximum.

(a)(i) Explain why a current is produced in the coil as it rotates. [2 marks]

(ii) I. Determine the direction of the current in side AB of the coil when it is in the position shown in the diagram. [1 mark]

8 (a)(ii)

II. Explain how you did this. [1 mark]

(Turn over)

8 (b)(i)

The coil rotates **FROM THE POSITION SHOWN** in **DIAGRAM 8.1**.

Each complete rotation takes **0.20 s**.

The maximum current is **0.75 A**.

SKETCH A GRAPH of current against time on the axes on **GRAPH 8.2**. [3 marks]

(ii) Describe the effect on the output current from the generator if the magnetic field strength is increased **AND** the coil spins more slowly. [3 marks]

- 9** **A radiosonde is a small package of instruments which is carried into the atmosphere by a helium-filled balloon. The instruments are used to collect data for weather forecasting. The balloon moves up through the atmosphere until the helium has such a large volume that the balloon bursts. The instruments then return to Earth with a parachute.**
- (a)** **On a winter day, the balloon is filled with helium inside a warm room. It is then taken outside, where it is much colder and the volume decreases. Explain, in terms of particles, why this happens. [3 marks]**

- 9 (b) The atmospheric pressure is not constant and decreases as the height above the sea level (altitude) increases as shown by GRAPH 9.1 in the separate diagram booklet.

The temperature at sea level is 278 K.

The balloon has an initial volume of 1.8 m^3 at sea level.

The balloon bursts when its volume reaches 133 m^3 when the temperature is 212 K.

- (i) Use GRAPH 9.1 and the equation:

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

to determine the pressure at which the balloon bursts. [2 marks]

pressure = _____ kPa

(Turn over)

9 (b)(ii)

Use **GRAPH 9.1** to determine at what altitude the balloon bursts. [1 mark]

altitude = _____ km

6

END OF PAPER

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

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1 hour 45 minutes plus your additional time allowance

DIAGRAM BOOKLET

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

Surname _____

First name(s) _____

Centre Number _____

Candidate Number 0 _____

TABLE 1.1

	Kettle X	Kettle Y
Power	2200 W	2.4 kW
Time to boil (s)	90	90
Mass of water (kg)	0.6	0.6
Heat energy transferred to the water (J)	188 100	

DIAGRAM 2.1

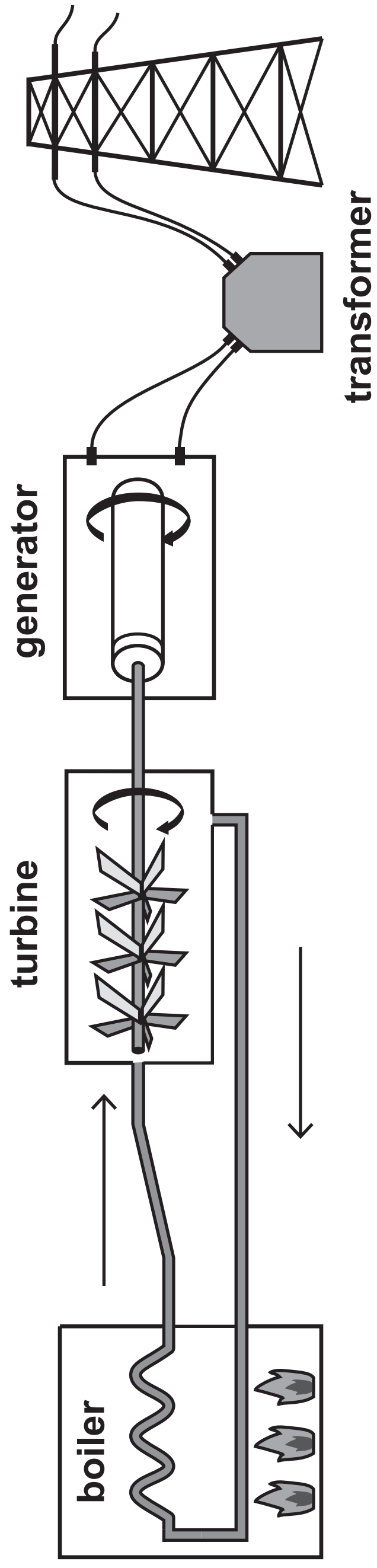


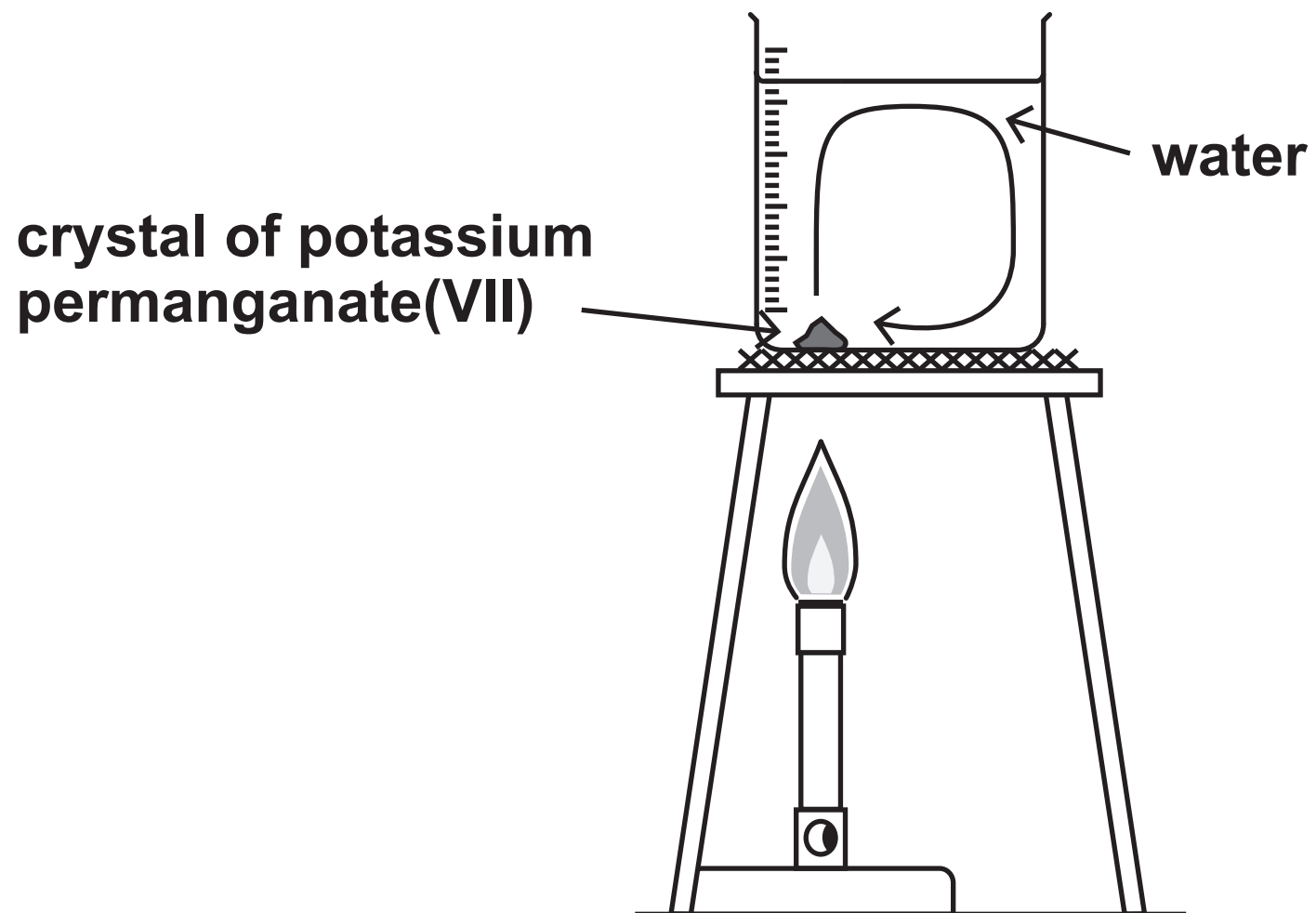
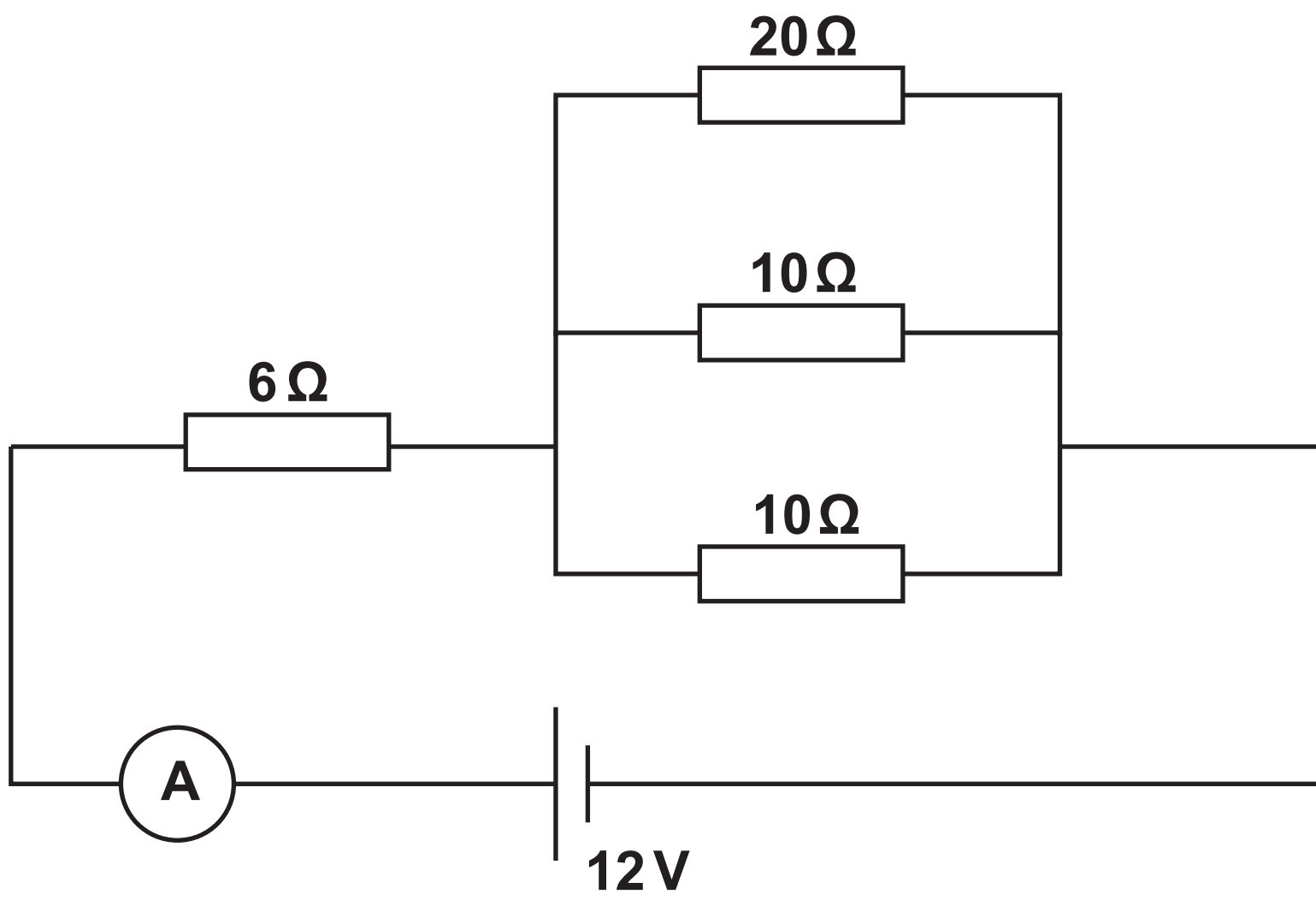
DIAGRAM 3.1

DIAGRAM 5.1



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DIAGRAM 6.1

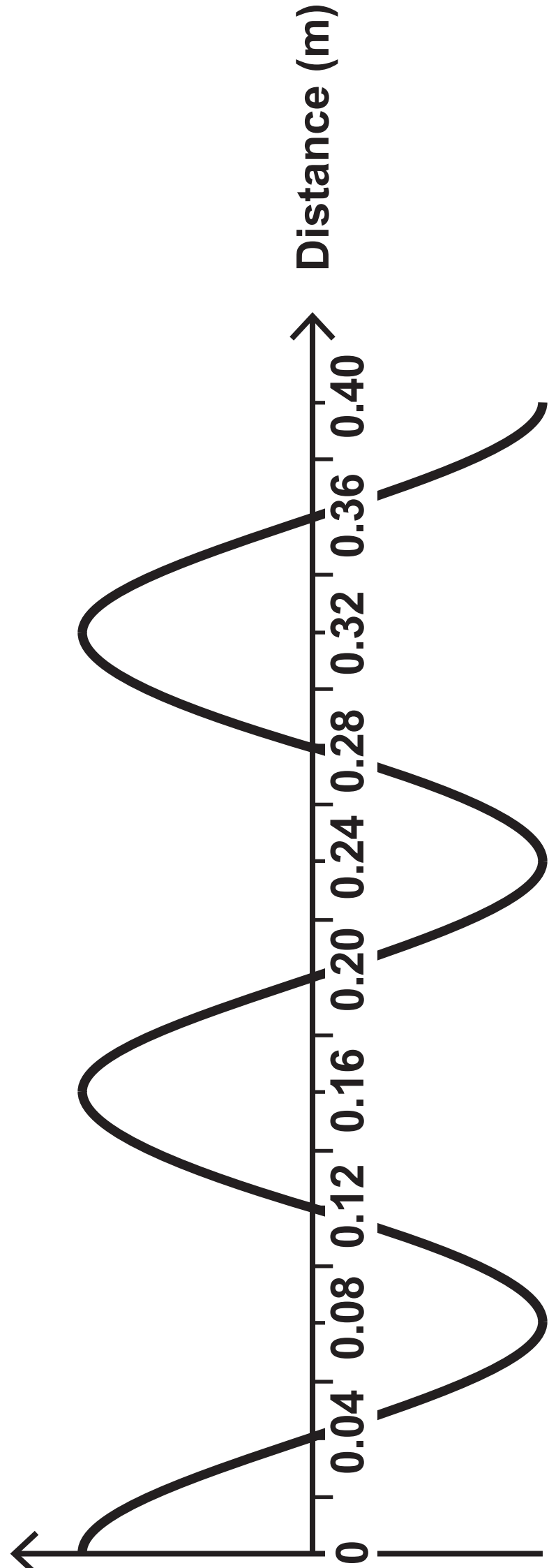
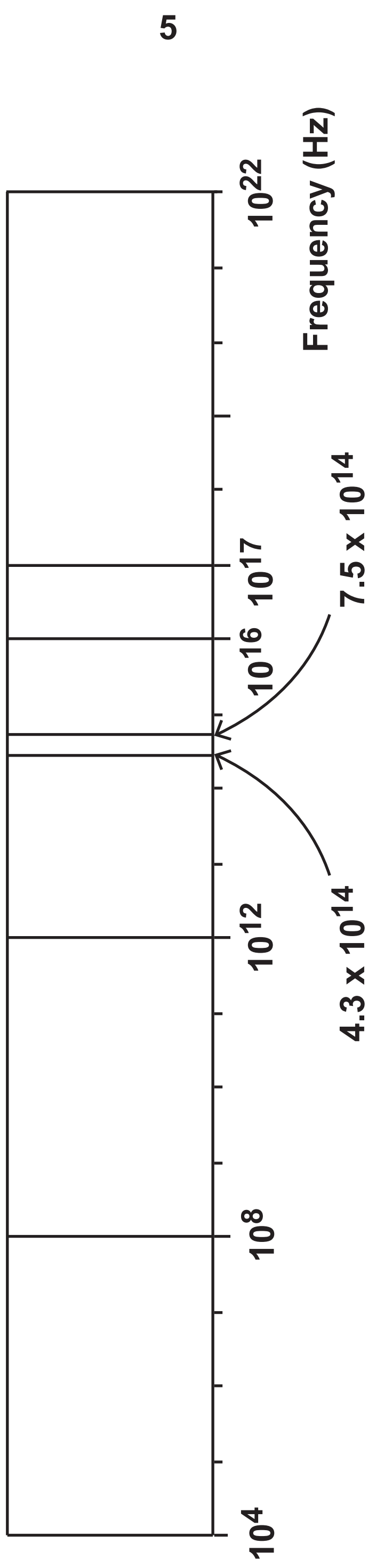
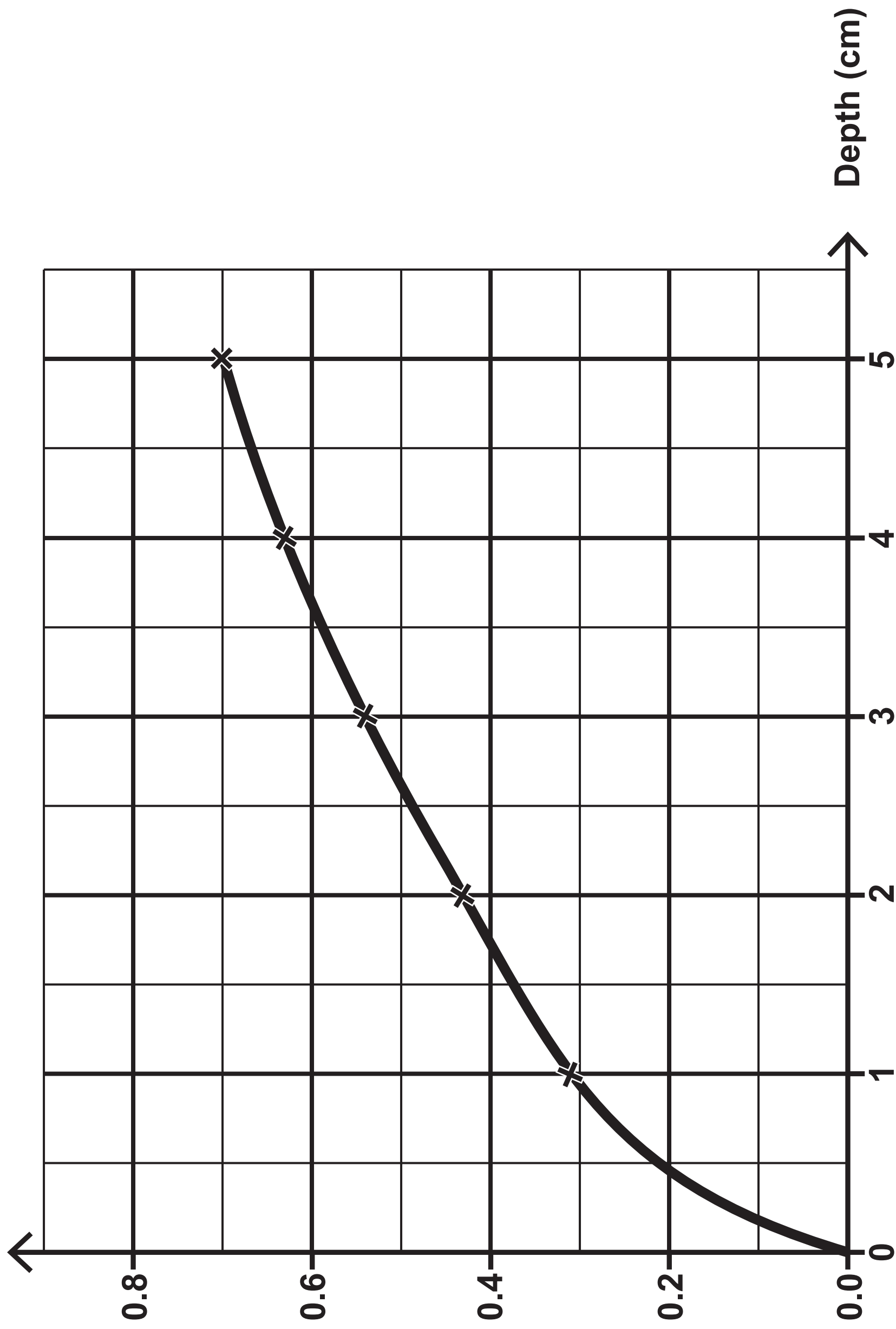


DIAGRAM 6.2



GRAPH 6.3

Speed (m/s)



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DIAGRAM 7.1

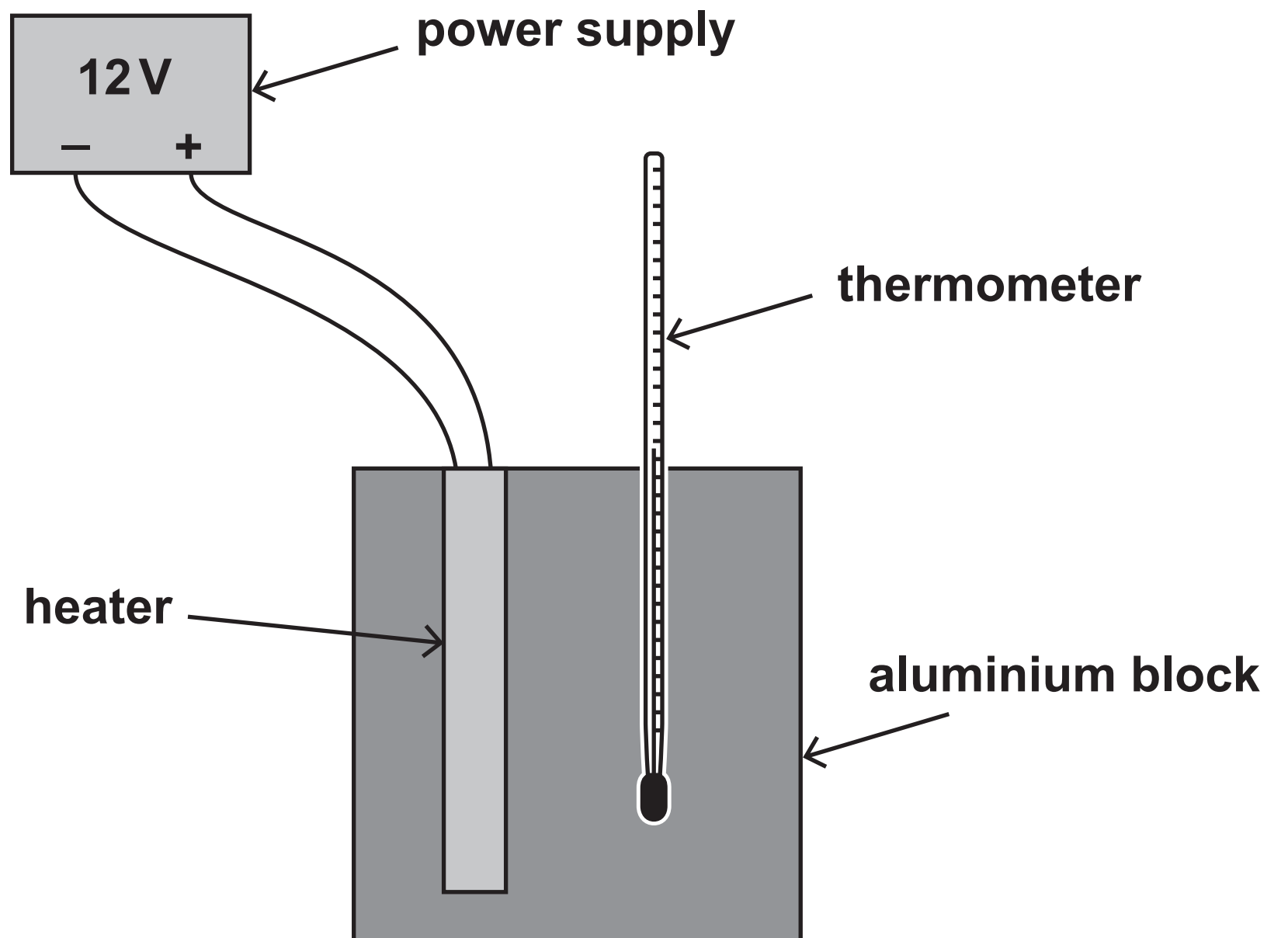
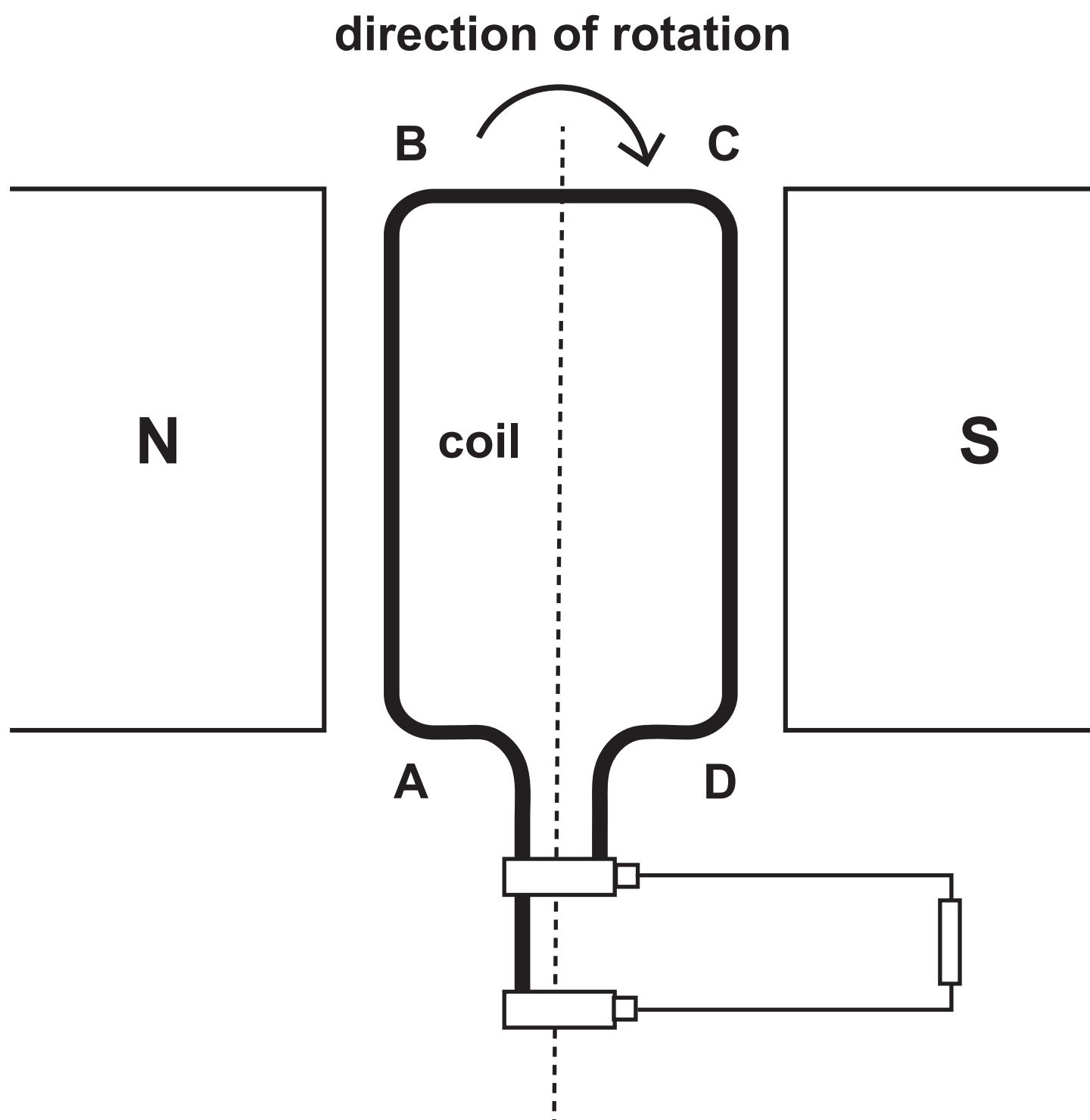
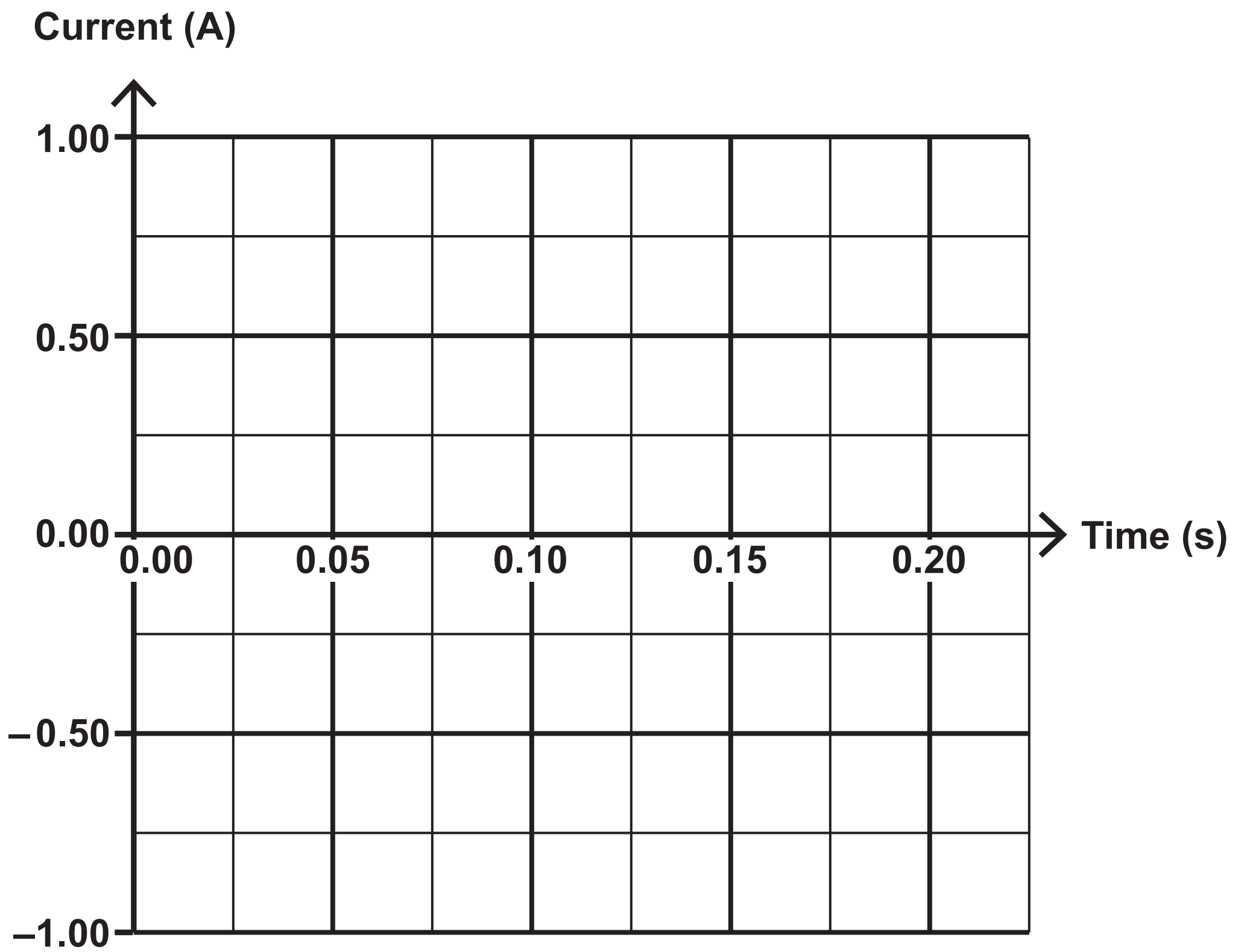


TABLE 7.2

Initial temperature of block (°C)	21
Final temperature of block (°C)	36
Mass of aluminium block (g)	980
Density of aluminium (kg/m³)	2700
Heat energy transferred by the heater (J)	14 650

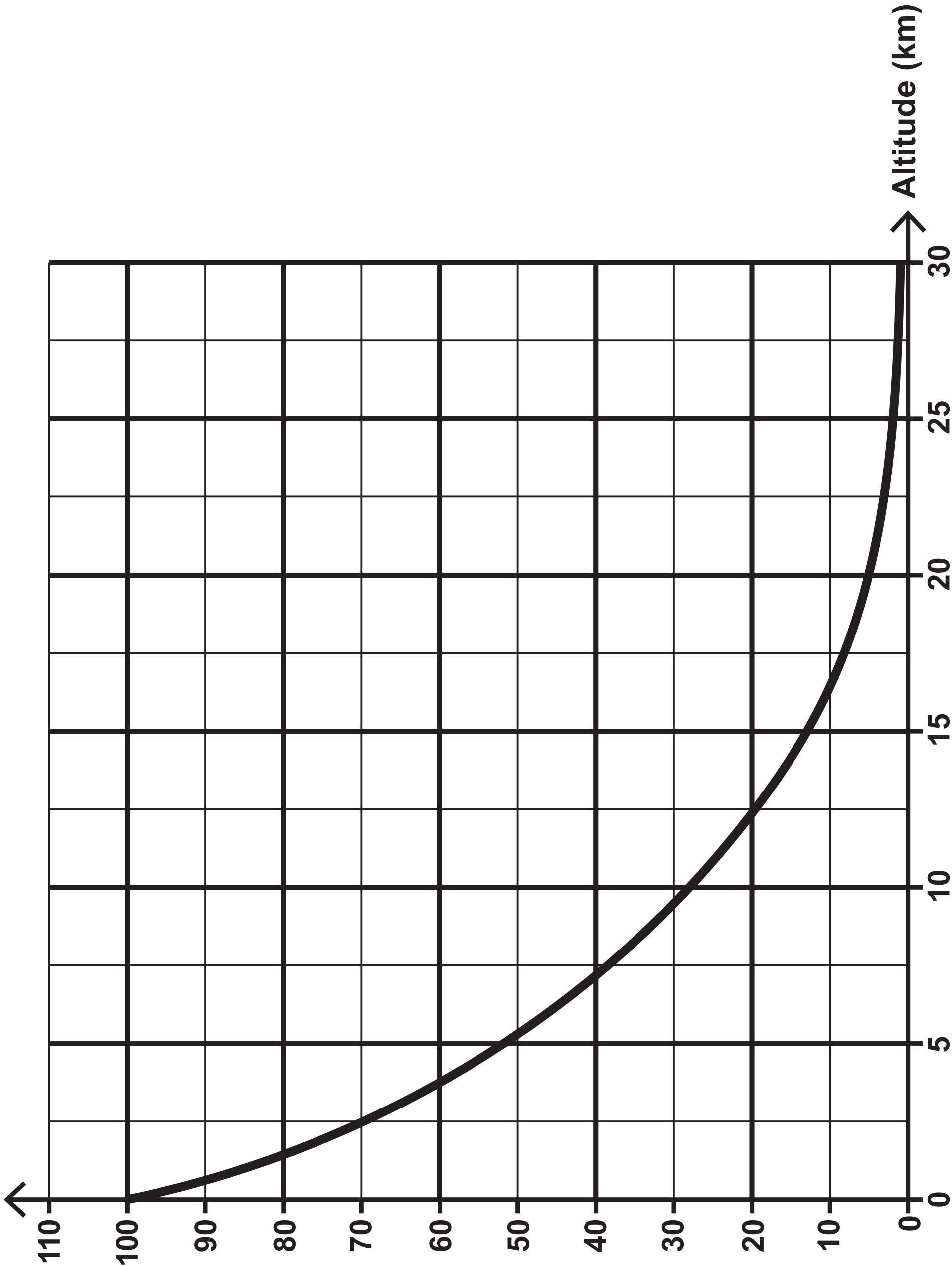
DIAGRAM 8.1



GRAPH 8.2

GRAPH 9.1

Atmospheric pressure (kPa)





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HIGHER TIER

1 hour 45 minutes plus your additional time allowance

Data Booklet

Equations and SI multipliers

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EQUATIONS

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

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

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

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

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

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

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

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

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

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

$$\text{wave speed} = \text{wavelength} \times \text{frequency} \quad v = \lambda f$$

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

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

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

p = pressure

V = volume

T = kelvin temperature

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

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

$$\begin{array}{l} \text{change in} \\ \text{thermal} \\ \text{energy} \end{array} = \text{mass} \times \begin{array}{l} \text{specific} \\ \text{heat} \\ \text{capacity} \end{array} \times \begin{array}{l} \text{change in} \\ \text{temperature} \end{array} \quad \Delta Q = mc\Delta\theta$$

$$\begin{array}{l} \text{thermal energy for} \\ \text{a change of state} \end{array} = \text{mass} \times \begin{array}{l} \text{specific} \\ \text{latent heat} \end{array} \quad Q = mL$$

$$\begin{array}{l} \text{force on a} \\ \text{conductor} \\ \text{(at right angles} \\ \text{to a magnetic} \\ \text{field) carrying a} \\ \text{current} \end{array} = \begin{array}{l} \text{magnetic} \\ \text{field} \\ \text{strength} \end{array} \times \text{current} \times \text{length} \quad F = BIl$$

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	Symbol	Conversion factor	Multiplier
pico	p	divide by 1 000 000 000 000	1×10^{-12}
nano	n	divide by 1 000 000 000	1×10^{-9}
micro	μ	divide by 1 000 000	1×10^{-6}
milli	m	divide by 1000	1×10^{-3}
centi	c	divide by 100	1×10^{-2}

kilo	k	multiply by 1000	1×10^3
mega	M	multiply by 1 000 000	1×10^6
giga	G	multiply by 1 000 000 000	1×10^9
tera	T	multiply by 1 000 000 000 000	1×10^{12}