

Please write clearly in block capitals.

Centre number

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Candidate number

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Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

INTERNATIONAL A-LEVEL PHYSICS

Unit 5 Physics in practice

Tuesday 20 January 2026

07:00 UK Time

Time allowed: 2 hours

Materials

For this paper you must have:

- a Data and Formulae Booklet as a loose insert
- a ruler with millimetre measurements
- a scientific calculator, which you are expected to use where appropriate
- a protractor.

Instructions

- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each question or on blank pages.
- All working must be shown.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 80.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
TOTAL	



Section A

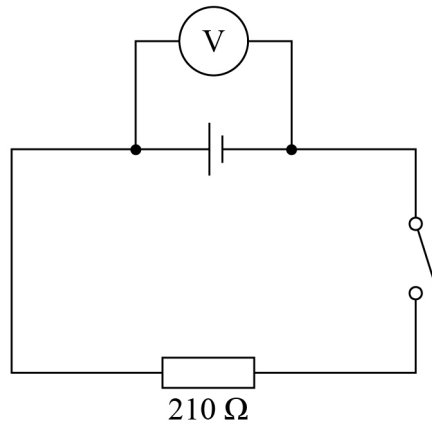
Answer **all** questions in this section.

0	1
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This question is about determining the internal resistance r of a cell of emf $\mathcal{E}$ using three different methods.

Figure 1 shows a circuit that can be used to determine r .

Figure 1



The reading on the voltmeter is V .

The resistance of the fixed resistor in the circuit is 210Ω .

0	1	.	1
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Describe how this circuit can be used to determine r .

In your answer:

- state the measurements required
- explain how to calculate r .

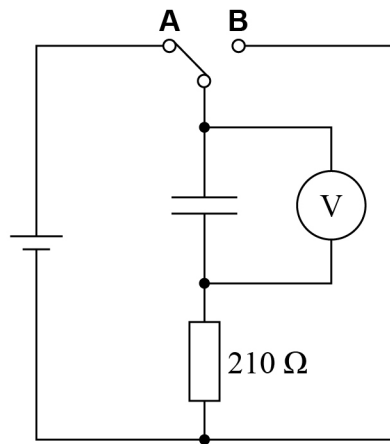
You should not add any other components to the circuit.

[3 marks]



Figure 2 shows another circuit that uses the same cell, resistor and voltmeter. A student uses the circuit to charge and discharge a capacitor to determine r .

Figure 2



When the switch is in position **A** the capacitor charges.

0 1 . 2

Explain why the value of r does not affect the voltage across the fully charged capacitor.

[2 marks]

Question 1 continues on the next page

Turn over ►

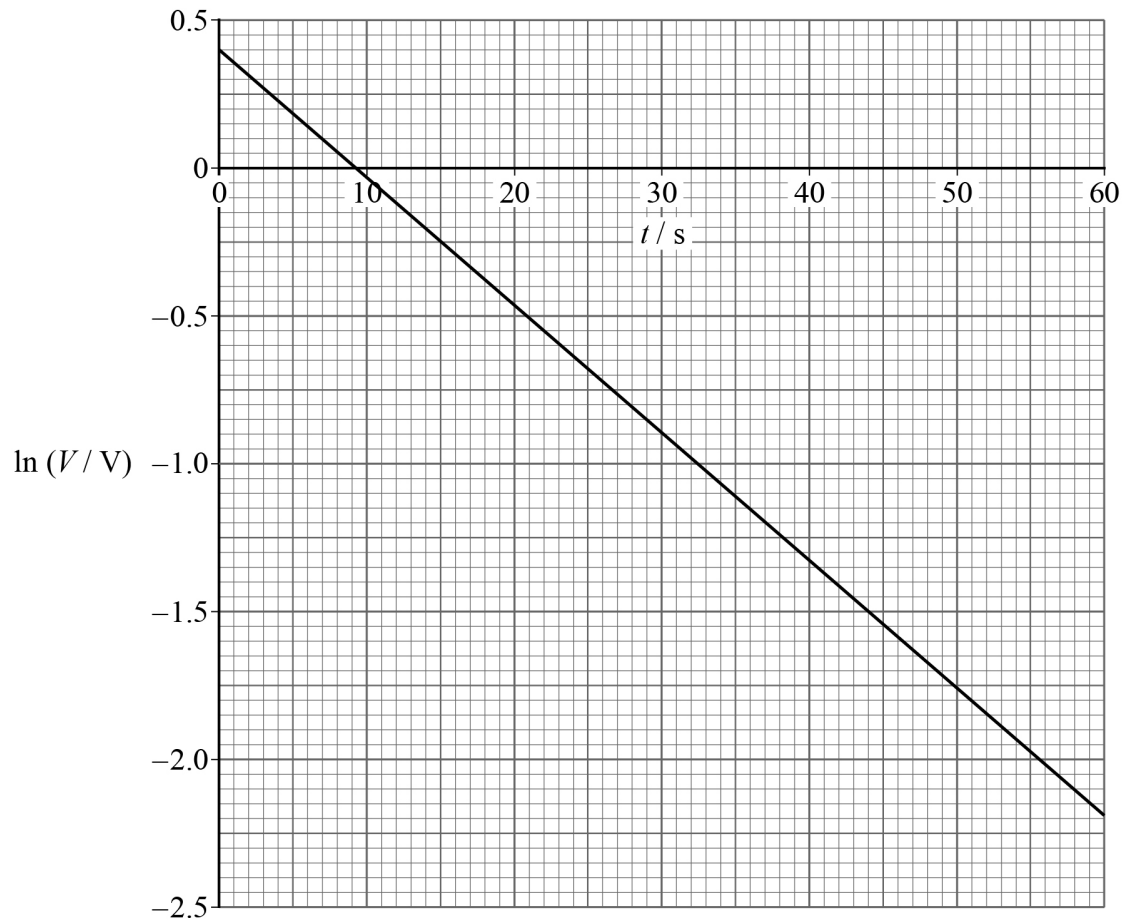


The student moves the switch to position **B** and starts a stopwatch at time $t = 0$

The student measures the variation of V with time as the capacitor discharges.

Figure 3 shows the variation of $\ln(V/V_0)$ with t .

Figure 3



0 1 . 3 Determine the gradient of the line.

[2 marks]

gradient = _____



0	1	.	4
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Show that the capacitance of the capacitor is approximately 0.1 F.

[1 mark]

Question 1 continues on the next page

Turn over ►



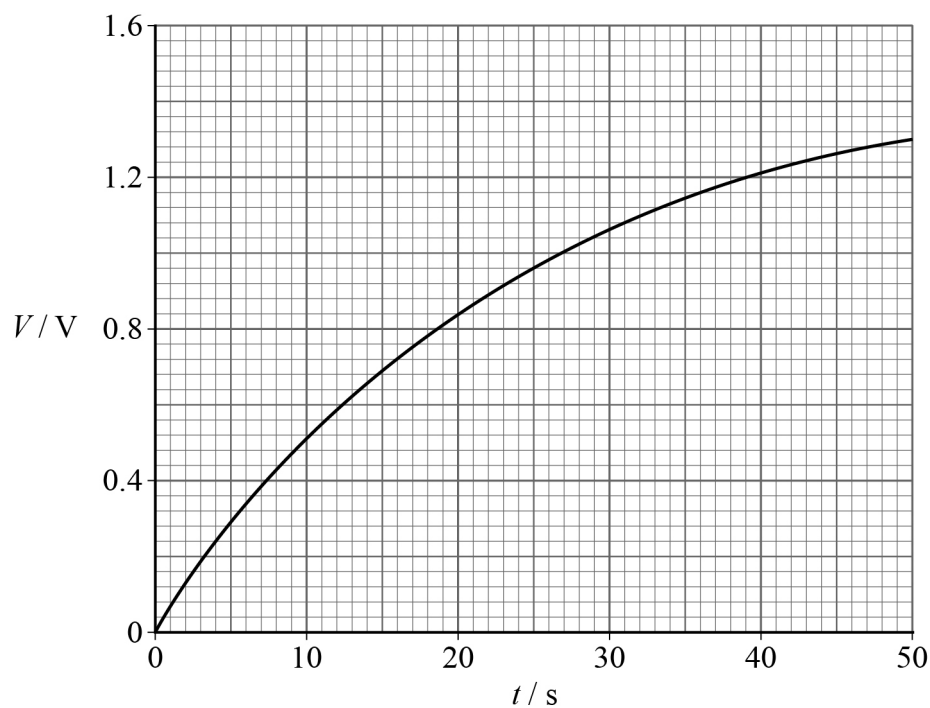
0 1 . 5

The capacitor is fully discharged. The stopwatch is reset.

The student moves the switch back to position **A** in **Figure 2** and starts the stopwatch at time $t = 0$

Figure 4 shows the variation of V with t for the charging capacitor.

Figure 4



For a charging capacitor, the time constant is the time taken for the voltage to reach $\mathcal{E}(1 - e^{-1})$.

Determine r .

$$\mathcal{E} = 1.5 \text{ V}$$

[3 marks]

$r =$ _____ Ω



Another student uses the same capacitor and resistor to determine r .

The voltage sensor has a much lower resistance than the voltmeter.

Evaluate the use of the voltage sensor and datalogger, instead of the voltmeter and stopwatch, in the determination of r .

[3 marks]

[illegible]

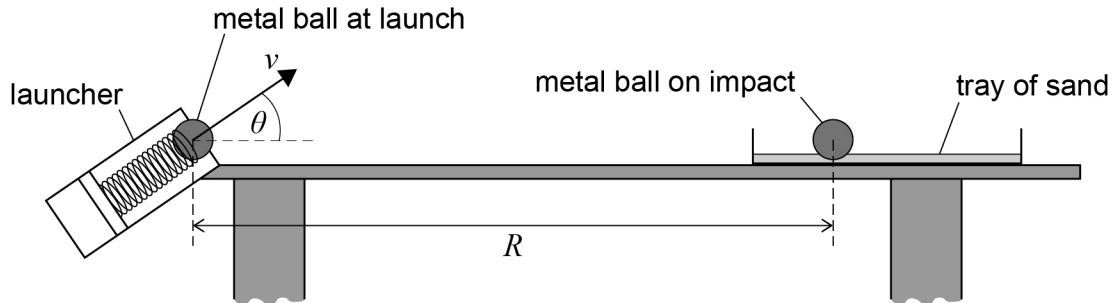
14

Turn over ►



0 2

Figure 5 shows an arrangement for measuring the horizontal distance R travelled by a metal ball launched into the air. The launch angle θ to the horizontal can be varied. The launch speed v of the ball is constant.

Figure 5

The ball lands in a tray of sand and leaves a mark in the sand. R is measured, with a metre ruler, from the end of the launcher to the middle of the mark in the sand.

Figure 6 shows part of the ruler and the marks left by the ball for five launches when $\theta = 20^\circ$.

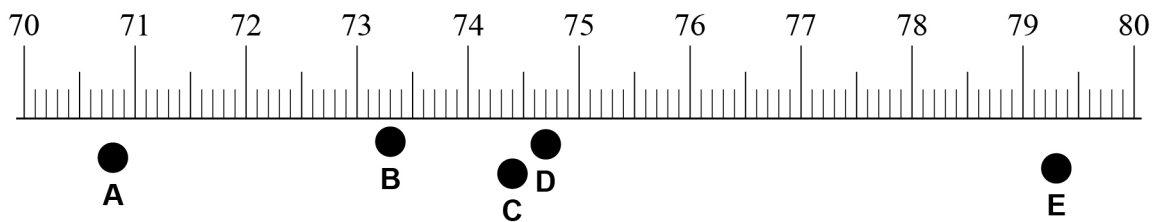
Figure 6

Table 1 shows the values of R for two of the marks.

Table 1

	A	B	C	D	E
R / m			0.744	0.747	

0 2 . 1

Complete **Table 1**.

[1 mark]



0 2 . 2

Determine the mean value of R and the uncertainty in R for $\theta = 20^\circ$.
All the data are valid.

[2 marks]mean value of $R =$ _____ muncertainty in $R = \pm$ _____ m**Question 2 continues on the next page****Turn over ►**

The ball is now launched at a range of values of θ . The mean value of R is determined for each value of θ .

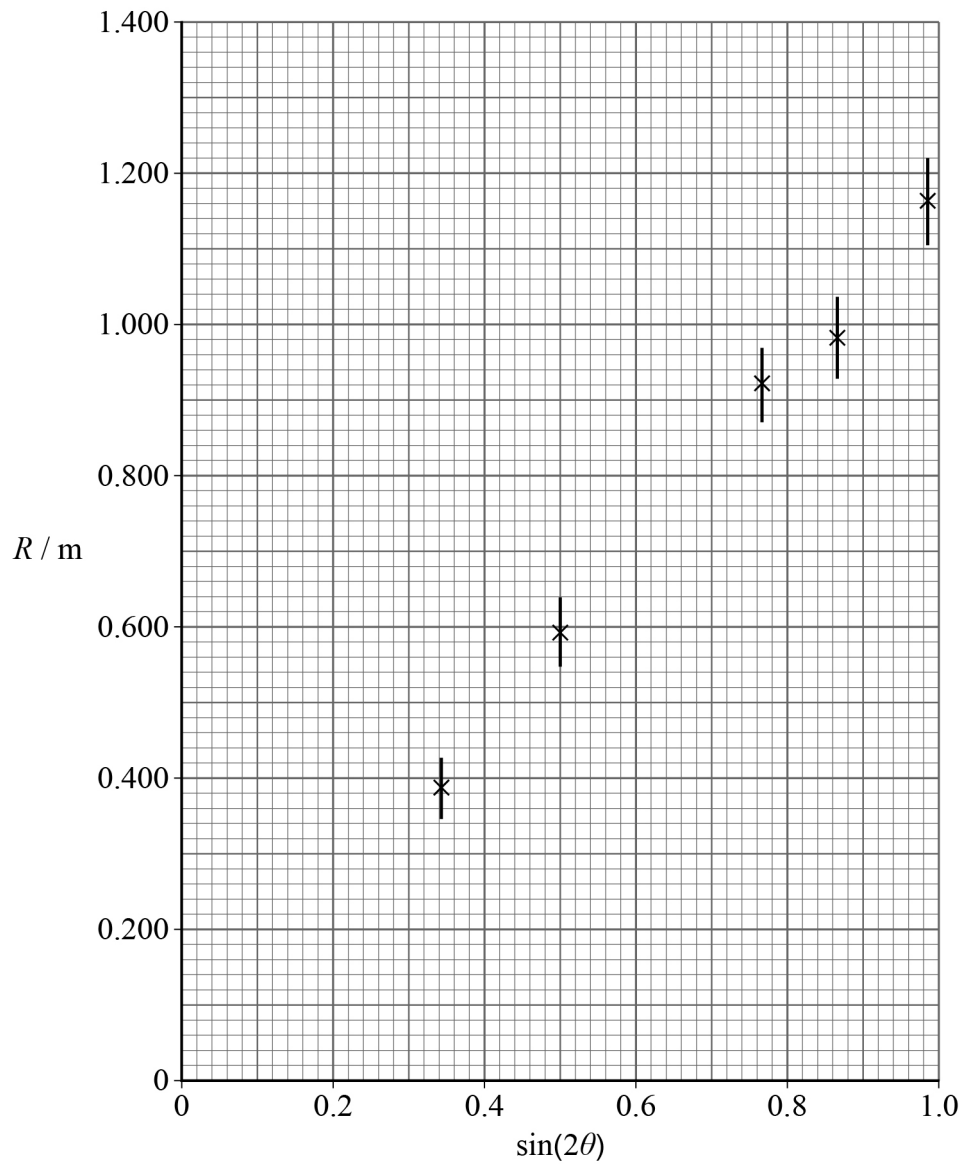
Figure 7 shows the variation of R with $\sin(2\theta)$.

0 2 . 3

Draw a point and an error bar on **Figure 7** using the data in **Table 1** on page 8.

[2 marks]

Figure 7



0 2 . 4

Determine the maximum and minimum gradients consistent with the error bars on **Figure 7**.

[3 marks]

maximum gradient = _____

minimum gradient = _____

R is given by

$$R = \frac{v^2 \sin(2\theta)}{g}$$

where v is the launch speed and g is the gravitational field strength.

0 2 . 5

Determine v using your answers to Question **02.4**.

[3 marks]

$v =$ _____ m s^{-1}

Question 2 continues on the next page

Turn over ►



0 2 . 6 The percentage uncertainty in g is $\pm 0.4\%$.

Determine the percentage uncertainty in v .

[3 marks]

percentage uncertainty = $\pm$ _____ %

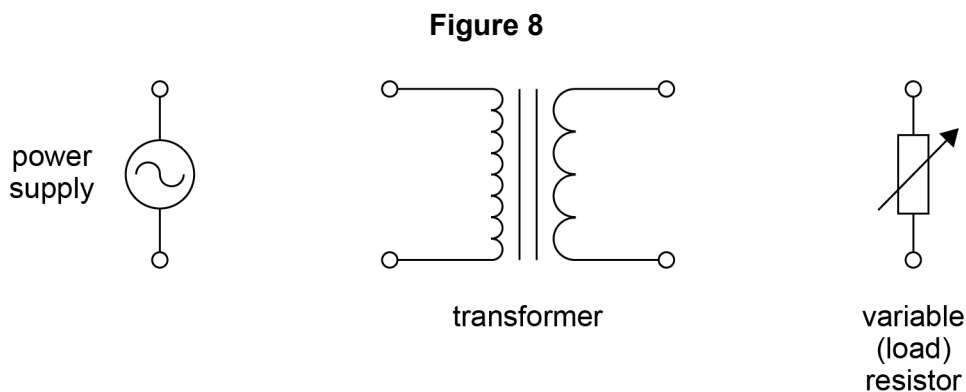
14



0 3

This question is about an experiment to determine how the efficiency of a transformer varies with the load resistance.

Figure 8 shows an incomplete circuit diagram for this experiment that includes a variable ac power supply, a transformer and a variable (load) resistor.



0 3 . 1

Complete **Figure 8** to show the circuit that is used to take measurements in this experiment.

You should include the necessary measuring devices in the circuit.

[1 mark]

0 3 . 2

A student wants to plot a graph showing how the efficiency varies with the load resistance.

Describe how to use the equipment in your completed **Figure 8** to obtain the data for this graph.

[3 marks]

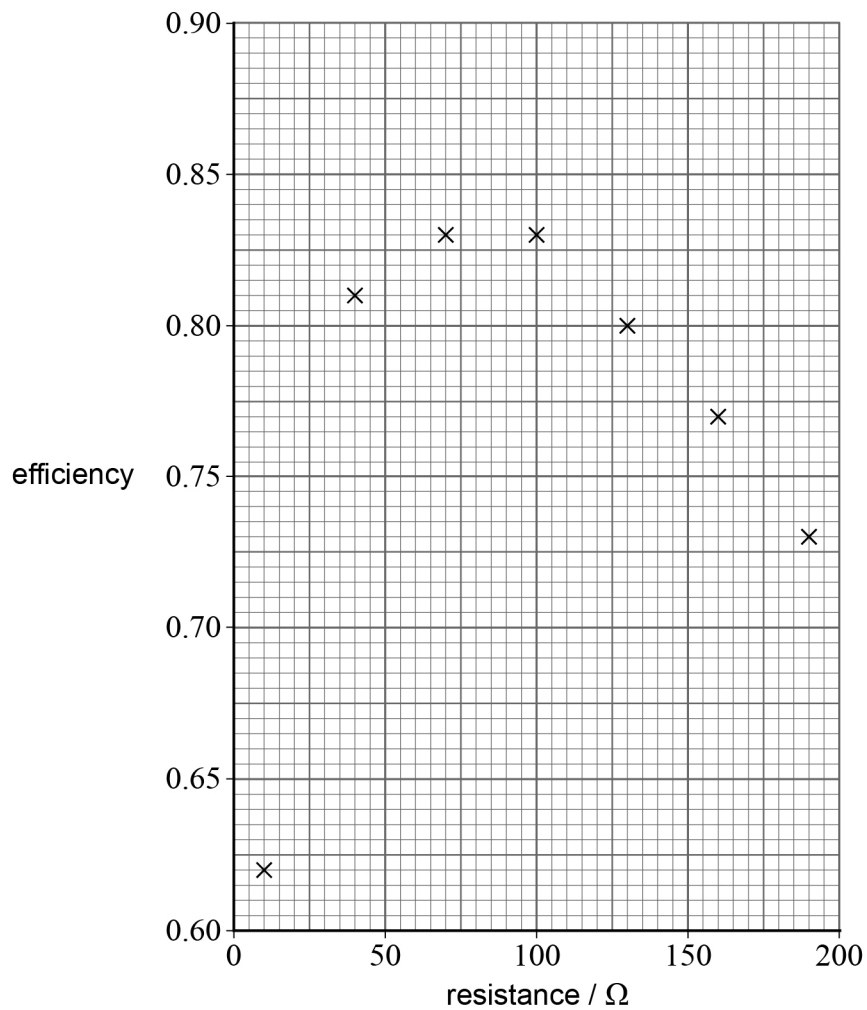
Question 3 continues on the next page

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Figure 9 shows an incomplete graph of the variation of efficiency with load resistance.

Figure 9



0 3 . 3 Draw a line of best fit on **Figure 9**.

[1 mark]

R_M is the load resistance for which the transformer has maximum efficiency.

0 3 . 4 Determine R_M .

[1 mark]

$R_M =$ _____ Ω



0	3	.	5
---	---	---	---

Suggest how the data collection could be improved to find a more accurate value for R_M .

[2 marks]

8

END OF SECTION A

Turn over ►



Section BAnswer **all** questions in this section.**0 4**

When a filament lamp is operating normally, it has a power of 19 W and a voltage of 12 V across it.

The filament in the lamp is a thin metal wire made of tungsten. The wire has:

- a length of 16 mm
- a cross-sectional area of $1.66 \times 10^{-9} \text{ m}^2$.

0 4 . 1

Determine the resistivity of tungsten when the lamp is operating normally.

[2 marks]

resistivity = _____ $\Omega \text{ m}$



The temperature of the filament is 2700 K when the lamp is operating normally.

Before the lamp is connected across a battery, the filament is initially at a temperature of 300 K.

The lamp is now connected across a battery of negligible internal resistance and emf 12 V.

The temperature of the filament increases from 300 K to 2700 K in a time t .

0 4 . 2

The specific heat capacity of tungsten is $133 \text{ J kg}^{-1} \text{ K}^{-1}$.

The density of tungsten is $1.9 \times 10^4 \text{ kg m}^{-3}$.

Estimate t .

Assume that while the temperature of the filament increases to 2700 K:

- the resistance of the filament remains constant
- the energy transferred to the surroundings is negligible.

[4 marks]

$t =$ _____ s

0 4 . 3

The energy transferred to the surroundings is negligible due to the small value of t . However, the resistance of the filament does **not** remain constant.

Discuss how the actual value of t will be different from your answer to Question 04.2.

[2 marks]

Question 4 continues on the next page

Turn over ►



0 4 . 4

The lamp is now connected across an ac voltage supply and is operating normally.

Calculate the peak voltage across the lamp.

[1 mark]

peak voltage = _____ V

Modern lamps often contain a light-emitting diode (LED) rather than a filament.
Figure 10 shows part of the current–voltage characteristic for an LED.

Figure 10

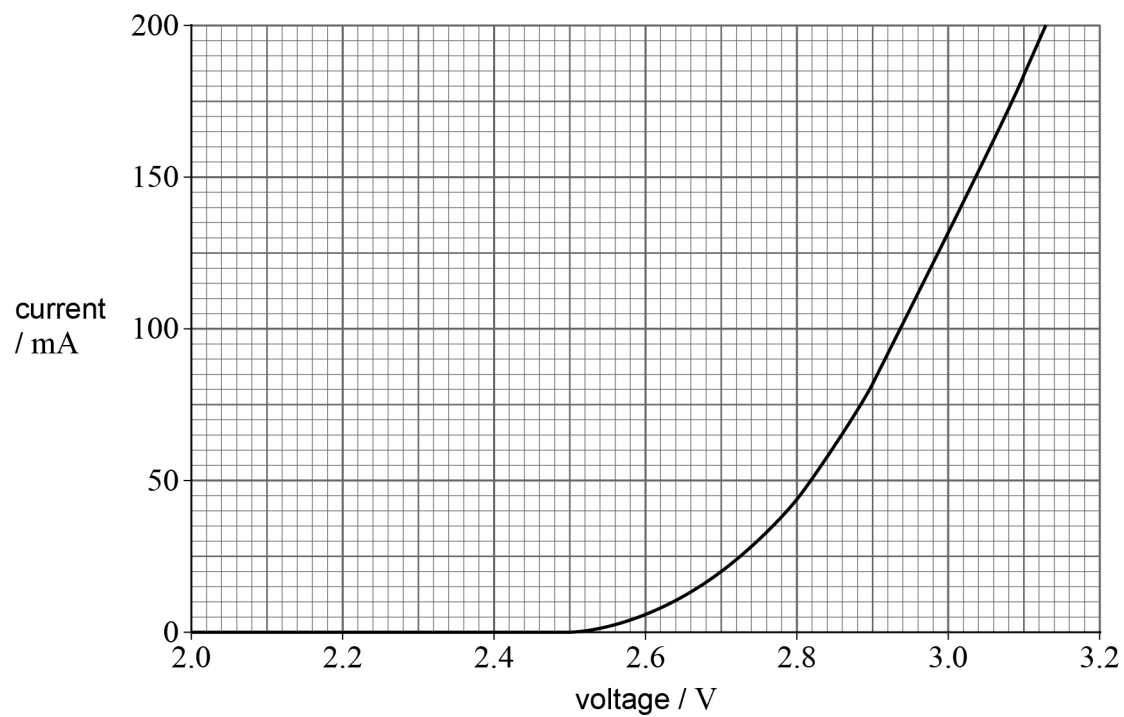
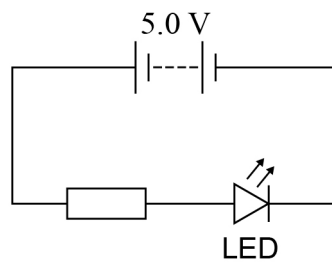


Figure 11 shows the LED in a circuit. The battery has an emf of 5.0 V and negligible internal resistance.

Figure 11



0 4 . 5 The voltage across the LED in **Figure 11** is 2.8 V.

Determine the resistance of the resistor in **Figure 11**.

[2 marks]

resistance = _____ Ω

Question 4 continues on the next page

Turn over ►

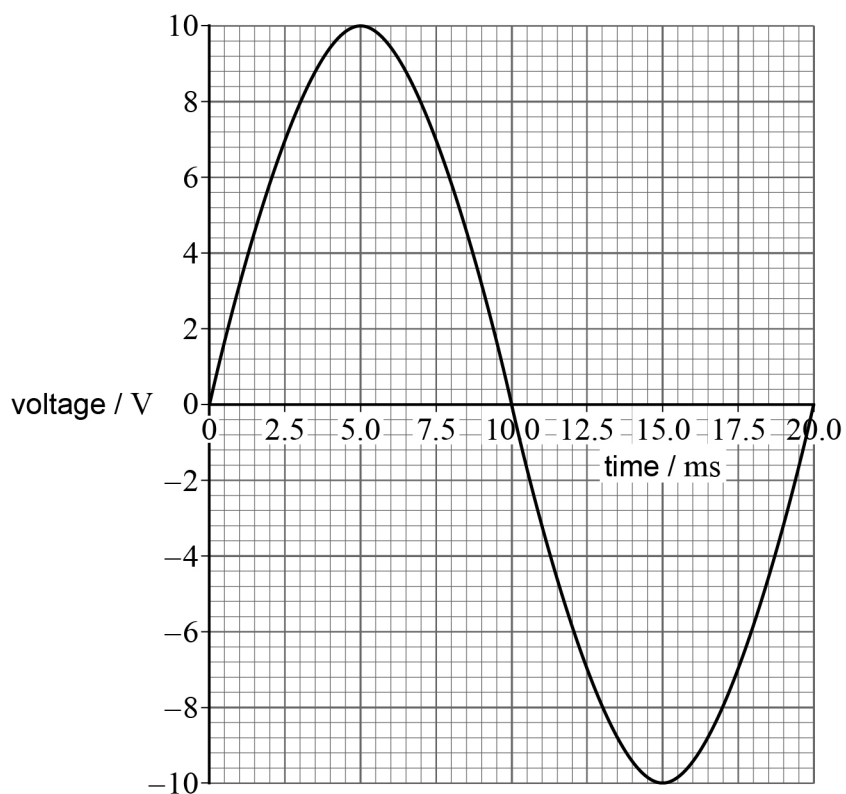


0 4 . 6

The 5.0 V battery in **Figure 11** is replaced with an ac supply. The supply has negligible internal resistance.

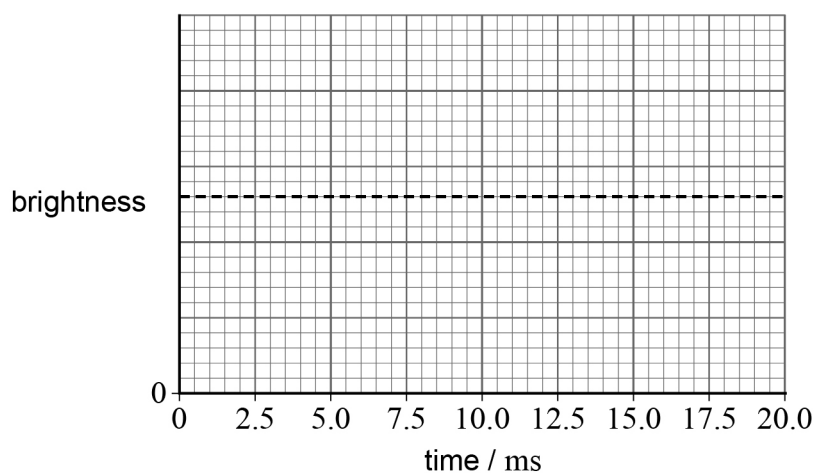
Figure 12 shows the variation of voltage with time for this ac supply.

Figure 12



The dashed line in **Figure 13** shows the variation of the brightness of the LED with time when connected to the 5.0 V battery and resistor as shown in **Figure 11**.

Figure 13



Sketch on **Figure 13** the variation of the brightness of the LED with time when connected to the ac power supply.

Do **not** add a scale to the brightness axis.

[4 marks]

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15

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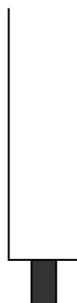


0	5
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Air springs are used in some car suspension systems. A syringe consisting of a plunger inside a cylindrical barrel can be used to model an air spring.

Figure 14 shows the barrel of the syringe.

Figure 14



The internal diameter of the barrel is measured as 42.0 mm.

0	5	.	1
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Suggest a suitable measuring instrument to measure the internal diameter of the barrel.

[1 mark]

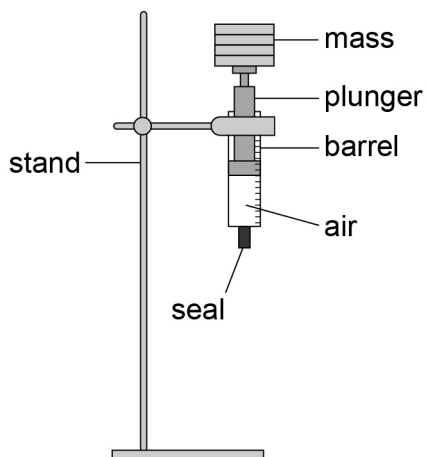
Question 5 continues on the next page

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Figure 15 shows a model of an air spring using the syringe.

Figure 15



A pressure sensor is placed inside the syringe. The syringe is filled with air and sealed at the bottom.

Initially the mass on top of the plunger is 0.100 kg.

The absolute pressure inside the syringe is 1.007×10^5 Pa.

The volume of air in the syringe is 8.94×10^{-5} m³.

The mass is then increased to 0.200 kg and the pressure increases to 1.014×10^5 Pa.

For the masses used in this experiment,

$$W = k \Delta L$$

where:

W is the weight of the mass on top of the plunger

ΔL is the change in length of the column of air in the syringe due to W

k is the spring constant of the model air spring.

0 5 . 2Determine k .

State any assumptions that you make.

[4 marks] $k =$ _____ N m^{-1}

0 5 . 3

The experiment is repeated but with a smaller amount of air inside the syringe.

Atmospheric pressure remains the same.

Explain how this change affects the spring constant.

[2 marks]

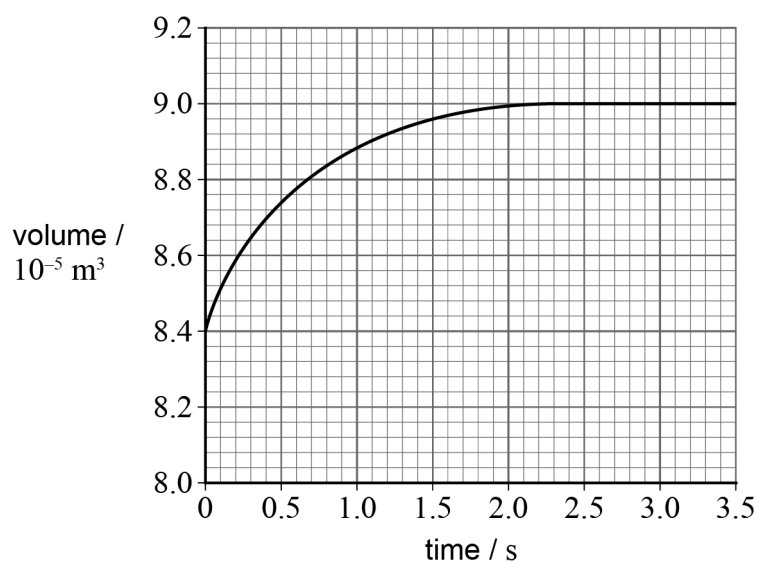
Question 5 continues on the next page**Turn over ►**

0 5 . 4

The mass on the plunger is now increased to 1.000 kg.

All of the mass is then removed quickly from the top of the plunger. **Figure 16** shows the variation of the volume of air with time after the mass is removed.

Figure 16



Explain why the plunger does not oscillate when the 1.000 kg mass is removed.

[2 marks]



A real air spring contains a fixed mass of trapped air.

When no force is applied to the air spring, the pressure of this air is 1.01×10^5 Pa and its volume is $5.00 \times 10^{-4} \text{ m}^3$.

The temperature of this air is 21°C .

0	5	.	5
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Determine, in mol, the amount of trapped air.

[2 marks]

amount of trapped air = _____ mol

Question 5 continues on the next page

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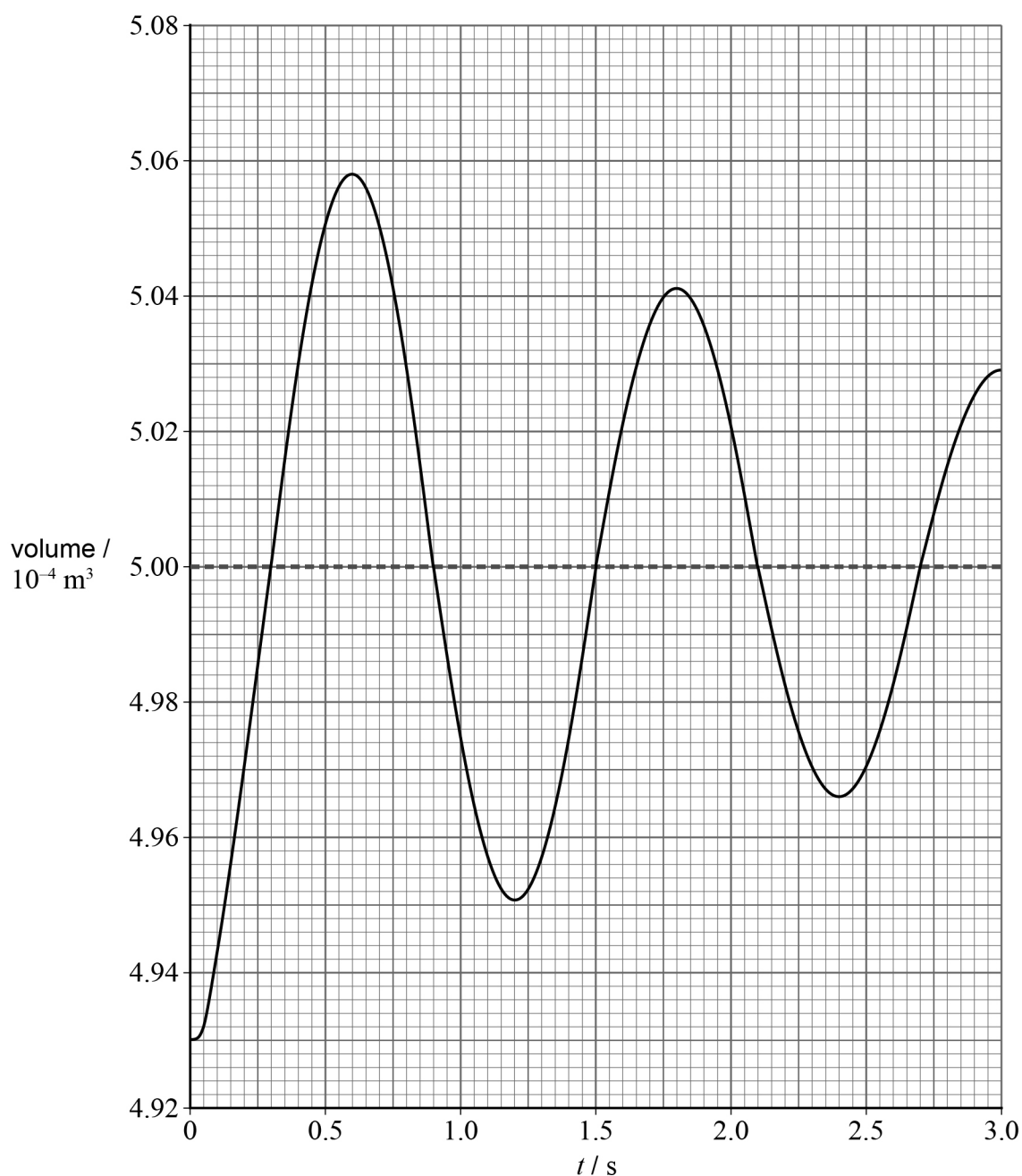
0 5 . 6

The trapped air is compressed by applying a force. The force is then removed at time $t = 0$

The air spring oscillates about its equilibrium volume of $5.00 \times 10^{-4} \text{ m}^3$.

Figure 17 shows the variation of the volume of air in the air spring with t as the air spring oscillates. The dashed line shows the equilibrium volume.

Figure 17



Determine whether this variation of amplitude with time is exponential.

[3 marks]

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14

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0 6

Figure 18 shows a system used to safely lower a lifeboat into the sea from the side of a ship. The brake in this system limits the speed at which the lifeboat can be lowered.

Figure 18

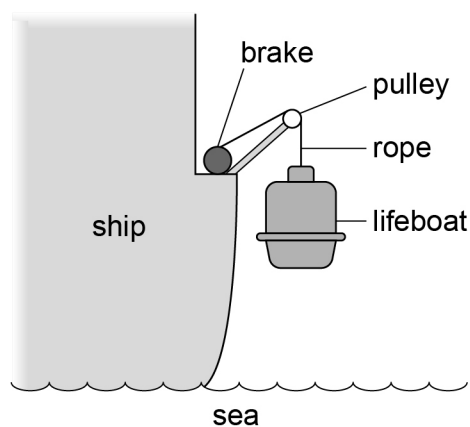
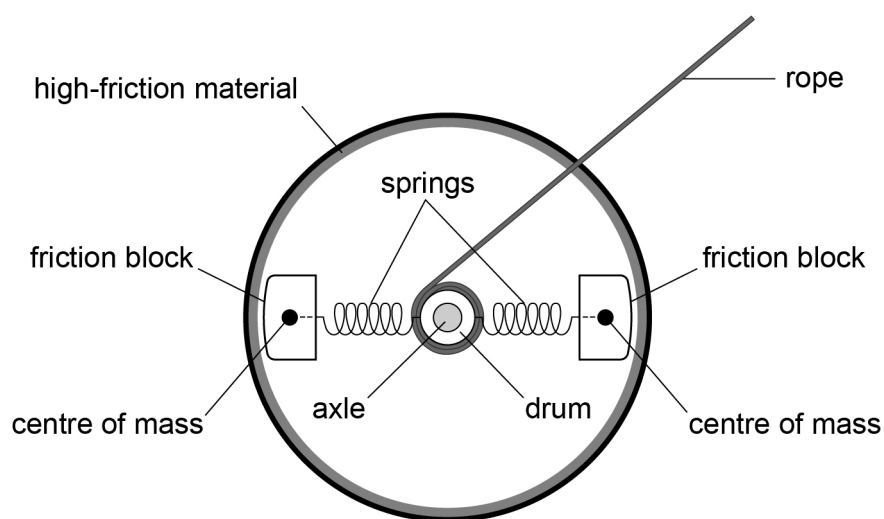


Figure 19 shows the design of the brake. A drum rotates freely around an axle. The rope is wrapped around the drum and does not slip.

Figure 19



A spring is attached to each friction block at its centre of mass. This pulls each friction block inwards towards the centre of the axle.

As the drum rotates, the friction blocks also rotate and move outwards.

When the drum reaches a certain angular speed, the friction blocks press against the high-friction material. This slows down the drum.

The high-friction material does not rotate.

0 6 . 1

Explain why the friction blocks move outwards as the drum increases in speed.

[3 marks]

Question 6 continues on the next page

Turn over ►



0 6 . 2 Each friction block has a mass of 125 g.

Each spring has a spring constant of 210 N m^{-1} .

When the lifeboat is being lowered at its maximum speed, the friction blocks are just in contact with the high-friction material but there is negligible frictional force applied. The extension of each spring is 5.5 cm.

The distance from the centre of mass of each friction block to the centre of the axle is 10.3 cm.

The radius of the drum is 2.1 cm and the rope is of negligible thickness.

Determine the maximum speed of the rope.

[4 marks]

maximum speed = _____ m s^{-1}



0	6	.	3
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The acceleration of the lifeboat is always less than 9.81 m s^{-2} , even when the friction blocks are not in contact with the high-friction material.

Explain why.

[3 marks]

Question 6 continues on the next page

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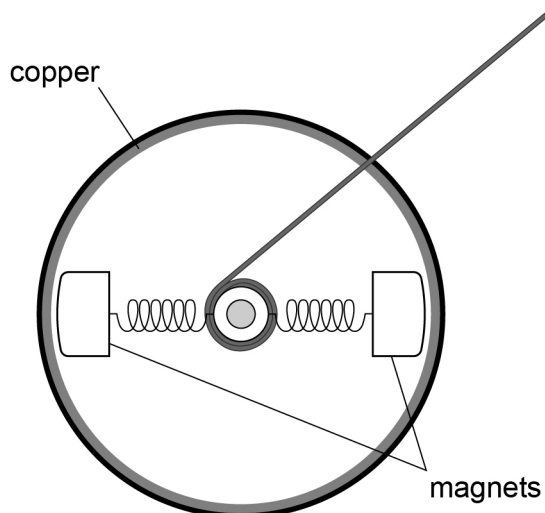


0 6 . 4

Figure 20 shows another design for the brake where:

- the friction blocks have been replaced by magnets
- the high-friction material has been replaced by a thick layer of copper.

Figure 20



Refer to **two** laws of induction in your answer.

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END OF QUESTIONS



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