OXFORD
INTERNATIONAL
AQA EXAMINATIONS

Please write clearly in block capitals.

Centre number | | | | | |

Candidate number | | | | |

Surname ____________________

Forename(s) ____________________

Candidate signature ____________________

INTERNATIONAL A-LEVEL
PHYSICS

Unit 5 Physics in practice

Wednesday 26 June 2019 07:00 GMT 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.

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 page or on blank pages.
- 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).
- All working must be shown.
- 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	
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TOTAL	

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ANSWER IN THE SPACES PROVIDED

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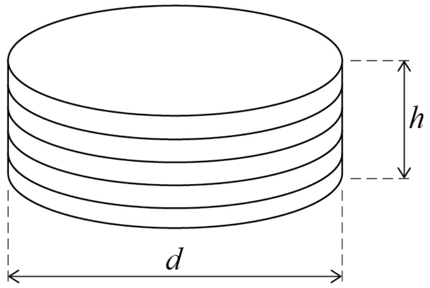
Section A

Answer **all** questions in this section.

0 1 A student was asked to determine the density of the metal in five similar coins. **Figure 1** shows the coins stacked together in a pile.

Figure 1



0 1 . 1 The student measured the diameter d of each coin using a ruler with 0.5 mm divisions. Her results are shown in **Table 1**.

Table 1

Coin number	1	2	3	4	5
d **/ mm**	26.0	25.5	26.5	26.0	25.5

Calculate the mean diameter D of the coins and the absolute uncertainty ΔD of this value.

[1 mark]

$D =$ ____________________ mm

$\Delta D = \pm$ ____________________ mm

Question 1 continues on the next page

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0 1 . 2 The student measured the height h of the pile of coins and found it to be $10.0\ \text{mm} \pm 0.5\ \text{mm}$.

She calculated the total volume V of the coins using the formula $V = \dfrac{\pi D^2 h}{4}$ and found it to be $5.27\ \text{cm}^3$.

Calculate the percentage uncertainty of this value for V.

[2 marks]

percentage uncertainty of $V =$ ____________________

0 1 . 3 The student then found the total mass of the coins to be $35.5\ \text{g} \pm 0.5\ \text{g}$.

Calculate the density ρ of the metal in the coins.

[1 mark]

$\rho =$ ____________________ g cm^{-3}

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01.4 Calculate the absolute uncertainty of the value of ρ in question **01.3**.

[2 marks]

absolute uncertainty of the value of ρ = ______________________ $\mathrm{g\ cm^{-3}}$

01.5 Another student measured V for the same set of coins by displacing water in a measuring cylinder.
His measurements were

volume of water $= 42.0\ \mathrm{cm^3} \pm 0.5\ \mathrm{cm^3}$
volume of water and coins $= 47.0\ \mathrm{cm^3} \pm 0.5\ \mathrm{cm^3}$

Calculate the percentage uncertainty of V in this experiment.

[1 mark]

percentage uncertainty of V = ______________________

01.6 State and explain which of these two methods is better for finding the volume of five coins.

[1 mark]

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8

Turn over ►

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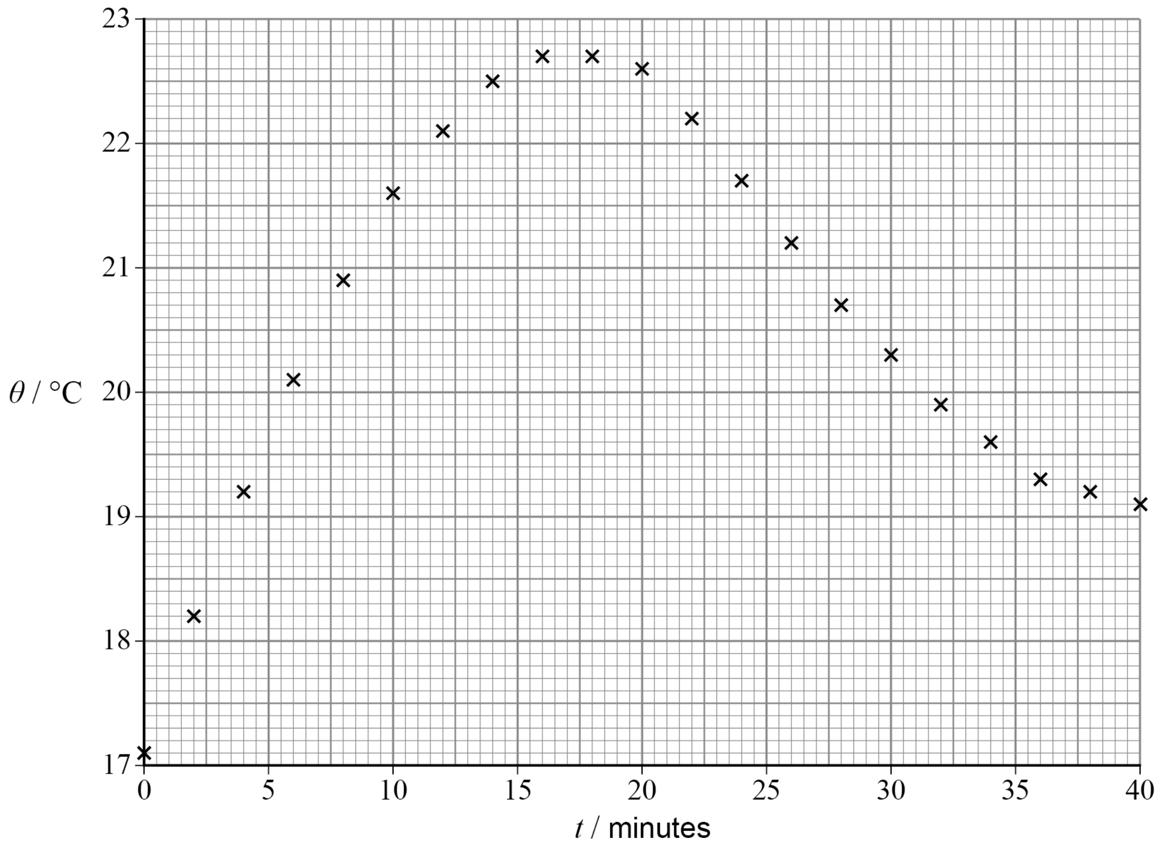
0 2 This question is about how to correct for energy transfer to the surroundings in an experiment to measure the specific heat capacity of rubber.
The rubber was heated to $100\ °C$ and then put quickly into a container of water. The water was initially at a room temperature of $17.1\ °C$.
There was energy transfer from the rubber to the water and from the water to the surroundings.
The temperature of the water was measured every 2 minutes for 40 minutes after the rubber was put into the water.

Figure 2 shows the variation in water temperature θ with time t after the rubber was put into the water.

Figure 2



0 2 . 1 Draw a line of best fit.

[1 mark]

0 2 . 2 State the maximum temperature θ_{max} reached by the water.

[1 mark]

θ_{max} = ________________________ °C

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The rate of temperature decrease was determined at $\theta_{½}$ where $\theta_{½}$ is the temperature halfway between room temperature and θ_{max}. To do this the gradient of the **cooling part of the curve** at $\theta_{½}$ was found.
The rate of temperature decrease is the gradient of the cooling part of the curve.

0 2 . 3 Determine $\theta_{½}$.

[1 mark]

$\theta_{½}$ = ________________________ °C

0 2 . 4 Draw a tangent to the cooling part of the curve at $\theta_{½}$.

[1 mark]

0 2 . 5 Show that the rate of temperature decrease at $\theta_{½}$ is approximately $0.20\ \mathrm{K\ min^{-1}}$.

[2 marks]

Question 2 continues on the next page

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0 2 . 6 When there is no energy transfer to the surroundings, θ_{max} will be higher by a temperature difference $\Delta\theta$.
$\Delta\theta$ is found by multiplying the rate of temperature decrease at $\theta_{½}$ by the time taken for the water to reach θ_{max}.

Calculate $\Delta\theta$.

[2 marks]

$\Delta\theta =$ ______________________ K

8

0 3 . 1 A filament lamp is marked $6\ \mathrm{V}$.

Draw a diagram of a circuit that you would use to investigate how the potential difference V across this lamp varies with the current I in the lamp.

Your circuit should include the lamp, a battery, an ammeter, a voltmeter and a way of varying the pd across the lamp from zero to $6\ \mathrm{V}$.

[1 mark]

Question 3 continues on the next page

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0 3 . 2 It is suggested that the relationship between the electrical power P transferred by the lamp and I is

$$P \propto I^3$$

Describe how you would use your circuit to test this suggestion.

Your answer should include

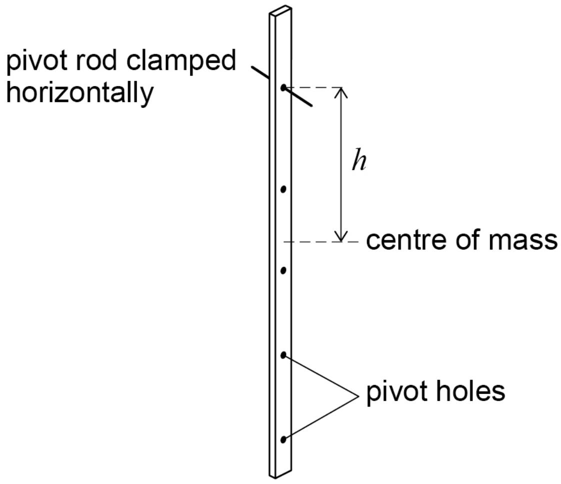
- the method you would follow
- how you would present your results
- an explanation of what you would expect your results to show if the given relationship is correct.

[5 marks]

6

0 4 A strip of wood was suspended from one of the five pivot holes along its length as shown in **Figure 3**.
The distance h between the point of suspension and the centre of mass was varied by using the different holes in turn.
The ruler oscillated with period T.
The variation of T with h was investigated.

Figure 3



0 4 . 1 The relationship between T and h is

$$T = 2\pi\sqrt{\frac{k^2 + h^2}{gh}}$$

where k is a constant and g is the gravitational field strength.

Show that, on a graph of T^2h against h^2, the gradient will be $\frac{4\pi^2}{g}$ and the intercept on the T^2h axis will be $\frac{4\pi^2k^2}{g}$.

[3 marks]

Question 4 continues on the next page

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0 4 . 2 **Table 2** shows a summary of results from this experiment.

Complete **Table 2**.

[2 marks]

Table 2

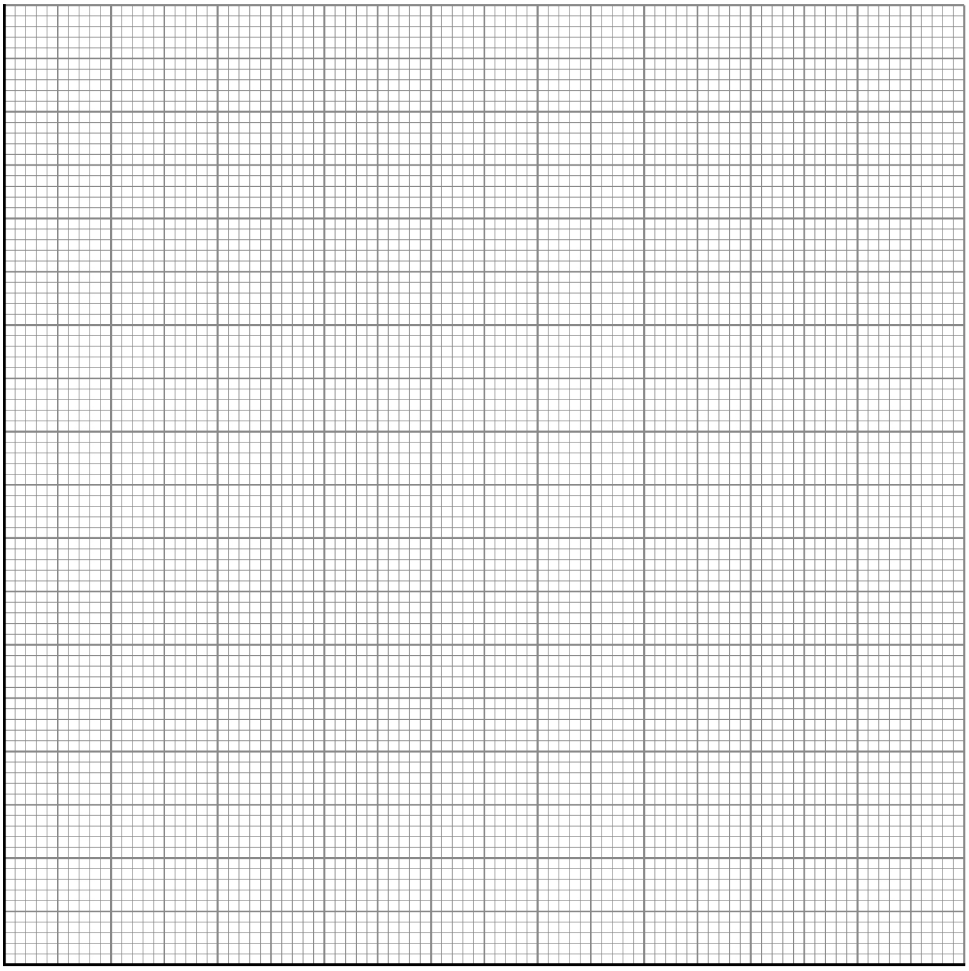
h / m	T / s	h^2 / m^2	T^2h / s^2 m
0.100	3.20		
0.300	2.11		
0.500	2.03		
0.700	2.09		
0.900	2.19		

0 4 . 3 Plot on **Figure 4** a graph of T^2h against h^2.

[3 marks]

Figure 4

T^2h / s^2 m



h^2 / m^2

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0 4 . 4 Deduce g using the gradient of your graph.

[4 marks]

$g =$ ______________________

0 4 . 5 Determine a value for k.

[2 marks]

$k =$ ______________________ m

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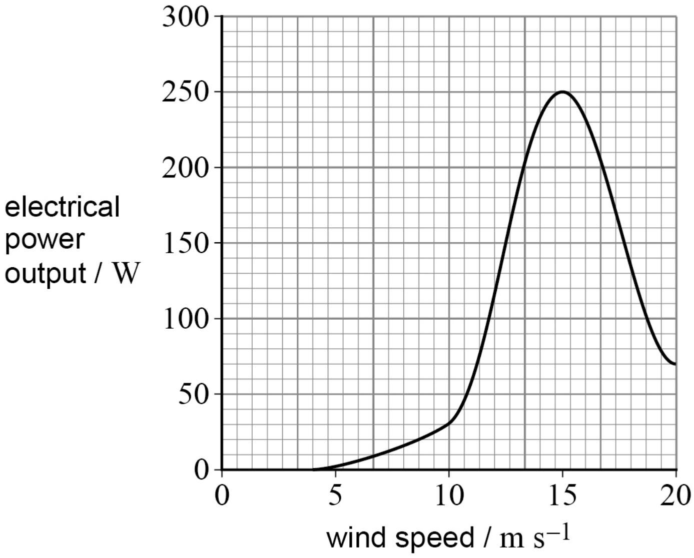
END OF SECTION A

Section B

Answer **all** questions in this section.

0 5 A small wind turbine generator (WTG) has a rotor diameter of 92 cm.
When the wind speed becomes greater than $15\ \text{m s}^{-1}$, the WTG's control system causes it to turn away from the wind, resulting in a reduced power output, as shown in **Figure 5**.

Figure 5



0 5 . 1 Explain why the angular velocity of the rotor is reduced when the WTG is not pointing directly into the wind.

[1 mark]

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0 5 . 2 Suggest **one** reason why it is necessary to reduce the angular velocity of the WTG rotor in this way.

[1 mark]

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0 5 . 3 Show that, at peak electrical power output, the WTG is extracting approximately 20% of the power available from the wind.

density of air = 1.2 kg m^{-3}

[4 marks]

Question 5 continues on the next page

0 5 . 4 The WTG generates alternating current. The peak value of the output voltage from the WTG is $17\ \text{V}$ when the wind speed is $15\ \text{m s}^{-1}$.

Calculate the rms output current from the WTG when the wind speed is $15\ \text{m s}^{-1}$.

[3 marks]

rms output current = ______________________ A

0 5 . 5 Most generators use electrical contacts called brushes to extract current from rotating coils. The brushes do this by rubbing on contacts at the ends of the coils.

The generator in the WTG is a **brushless** generator. It uses a contactless method to transfer energy from a rotating coil to the stationary output circuit.

Suggest **two** advantages of a brushless generator compared with a generator with brushes.

[2 marks]

1 ____

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2 ____

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0 5 . 6 The rotor of the brushless generator carries electromagnets that are supplied with steady dc current. As the rotor turns, electromagnets move past stationary coils.

Explain why an alternating emf is induced in the stationary coils when the rotor turns.
[2 marks]

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0 5 . 7 A stationary coil has 150 turns and an area of 2.5×10^{-3} m^2.

Calculate the rate of change of magnetic flux density in the coil when the emf induced in it is 6.0 V.
State an appropriate unit for your answer.
[3 marks]

rate of change of magnetic flux density = ____________________

unit = ____________________

16

Turn over ►

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0 6 On average, the thermal fission of a uranium−235 nucleus releases 203 MeV.
In a nuclear fission reactor, approximately 180 MeV per fission heats the coolant.

0 6 . 1 Explain, in terms of nuclear binding energy, why the fission of uranium−235 results in the release of energy.

[3 marks]

0 6 . 2 Describe, in terms of the products of fission, how energy from fissions heats the coolant.

[2 marks]

0 6 . 3 Suggest why not all of the 203 MeV per fission is available to heat the coolant.

[1 mark]

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0 6 . 4 In one type of nuclear fission reactor, the uranium–235 fuel rods heat the coolant at a rate of 1500 MW.

Calculate the number of fissions occurring per second in the reactor.

[2 marks]

number of fissions per second = ____________________

0 6 . 5 Some of the output electrical energy of a power station is used to drive pumps that circulate gas coolant through the core of the reactor.

Explain how some of the electrical energy used to drive the pumps will be retrieved as an output of electrical energy from the power station.

[2 marks]

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Question 6 continues on the next page

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0 6 . 6 The coolant pumps move gas through the reactor at the rate of 4.0×10^3 kg s^{-1}, keeping the core of the reactor at a constant temperature.
The gas enters the reactor at a temperature of 290 °C and leaves the reactor at 620 °C.

Calculate the specific heat capacity of the gas in these conditions.

[2 marks]

specific heat capacity = ______________________ J kg^{-1} K^{-1}

0 6 . 7 The containment vessel has a surface area of 2700 m^2. The average temperature of the inside surface is kept at 300 °C while the temperature of the outside surface is 20 °C.
The U-value of the containment vessel is 0.29 W m^{-2} K^{-1}.

Show that the rate of loss of energy through the walls of the containment vessel is **not** significant to the operation of the power station.

[3 marks]

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15

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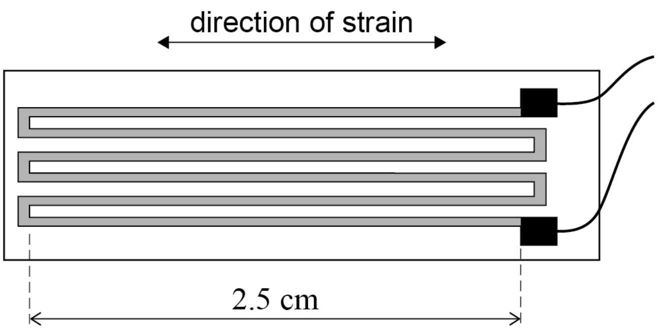
0 7 A strain gauge is made of six lengths of thin wire connected in series.
The gauge is glued to an object that is expected to stretch. When the object stretches, the gauge also stretches. The changes to the length and cross-sectional area of the strain gauge cause its electrical resistance to change. The resistance of the gauge is due to the resistance of the six lengths of thin wire. By measuring the change of resistance the strain of the object can be found.

Figure 6 shows a strain gauge with wires of length 2.5 cm.

Figure 6



0 7 . 1 The cross-sectional area of the wires in the gauge is 1.2×10^{-10} m^2. When unstretched and at room temperature, the resistance of the strain gauge is 95 Ω.

Calculate the resistivity of the metal used for the wires in the strain gauge.

[3 marks]

resistivity = ____________________ Ω m

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0 7 . 2 The strain gauge is now stretched, increasing its length by 2% and decreasing its cross-sectional area by 2%.

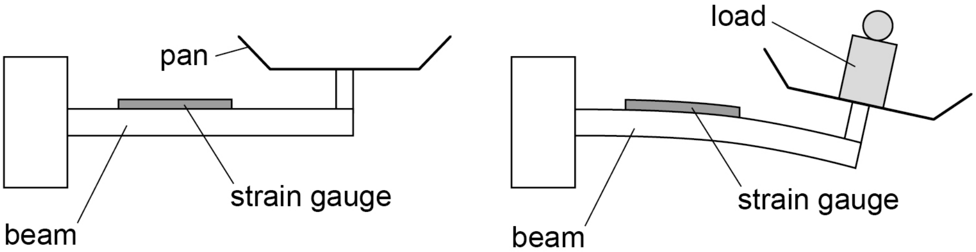
Calculate the new resistance of the gauge.

[2 marks]

resistance = ________________________ Ω

0 7 . 3 A strain gauge is used in an electronic balance. The gauge is glued to a beam that bends when a load is added to the pan as shown in **Figure 7**. The length of the strain gauge increases as the beam bends. The change in electrical resistance of the gauge is measured and converted electronically into a value for the mass of the load. The principle is shown in **Figure 7**.

Figure 7



The room temperature increases.

State and explain the effect on the measured value of mass when the room temperature increases.

[2 marks]

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Question 7 continues on the next page

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0 7 . 4 **Figure 8** shows a magnetic force restoration balance.

When an object is placed on the balance, the beam turns clockwise about the pivot. A position sensor detects this movement and produces a current in the coil that is attached to the beam.
The coil carries current with a direction that is always at 90 degrees to the magnetic field produced by the permanent magnet. The coil experiences a force that moves the coil and beam back to their original positions.

Figure 9 shows a plan view of the coil in the radial magnetic field provided by the permanent magnet.

Figure 8

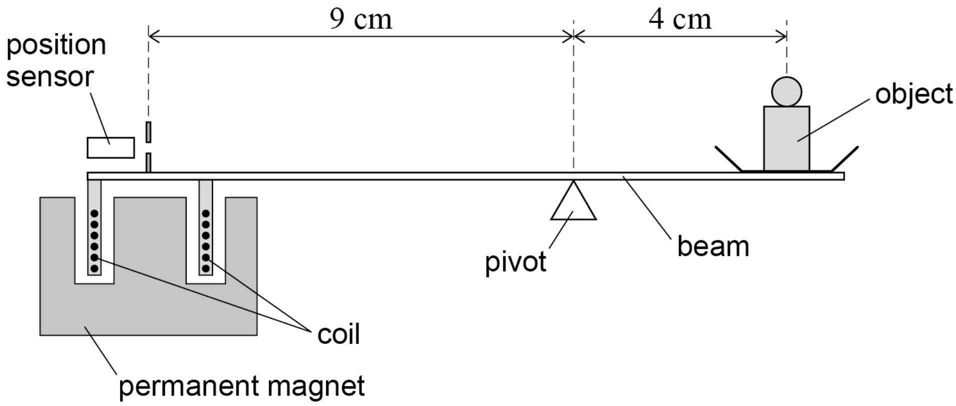
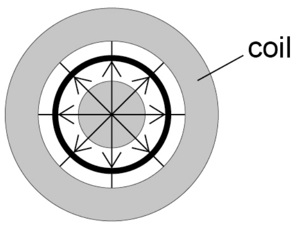


Figure 9



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The magnitude of the current I needed to restore the beam to its original position is proportional to the mass of the object.

Show that the current I is given by:

$$I = \frac{2mg}{9BN\pi r}$$

where r is the radius of the coil, B is the magnetic flux density of the permanent magnet, N is the number of turns of the coil and m is the mass of the object.

[3 marks]

Question 7 continues on the next page

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0 7 . 5 A magnetic force restoration balance has a coil with 20 turns and a radius of $1.2\ \text{cm}$. With a magnetic field of flux density $400\ \text{mT}$, the current in the balance can be measured to $\pm\ 0.1\ \mu\text{A}$.

Deduce whether or not the balance can measure mass to within $1\ \mu\text{g}$.

[3 marks]

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