Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname ______________________________

Forename(s) ______________________________

Candidate signature ______________________________

A-level
PHYSICS A

Unit 4 Fields and Further Mechanics
Section B

Monday 20 June 2016 Morning

Time allowed: The total time for both sections of this paper is 1 hour 45 minutes. You are advised to spend approximately one hour on this section.

Materials

For this paper you must have:
- a calculator
- a ruler
- a Data and Formulae Booklet (enclosed).

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 space provided. Answers written in margins or on blank pages will not be marked.
- Do all rough work in this book. Cross through any work you do not want to be marked.
- Show all your working.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 50.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information clearly
  – use specialist vocabulary where appropriate.

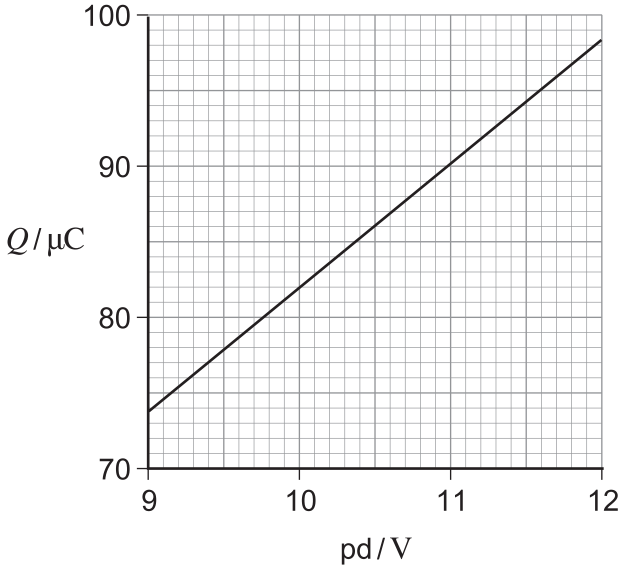
Section B

Answer **all** questions.

You are advised to spend approximately **one hour** on this section.

1 (a) **Figure 1** shows how the charge Q stored by a capacitor varies with the potential difference (pd) V across it as V is increased from $9.0\ \text{V}$ to $12.0\ \text{V}$.

Figure 1



1 (a) (i) Use **Figure 1** to determine an accurate value for the capacitance of the capacitor.

[2 marks]

capacitance = ____________________ μF

1 (a) (ii) Calculate the additional energy stored by the capacitor when V is increased from $9.0\ \text{V}$ to $12.0\ \text{V}$.

[3 marks]

additional energy = ____________________ J

1 (b) When a $470\ \mu F$ capacitor is discharged through a fixed resistor R, the pd across it decreases by 80% in $45\ s$.

1 (b) (i) Calculate the time constant of the capacitor–resistor circuit.

[3 marks]

time constant = ____________________________ s

1 (b) (ii) Determine the resistance of R.

[2 marks]

resistance = ____________________________ Ω

1 (b) (iii) At which point during the discharging process is the capacitor losing charge at the smallest rate? Tick (✓) the correct answer.

[1 mark]

	✓ if correct
when the charge on the capacitor is greatest	
when energy is dissipated at the greatest rate	
when the current in the resistor is greatest	
when the pd across R is least	

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2 The planet Venus may be considered to be a sphere of uniform density $5.24 \times 10^3\ \mathrm{kg\ m^{-3}}$.
The gravitational field strength at the surface of Venus is $8.87\ \mathrm{N\ kg^{-1}}$.

2 (a) (i) Show that the gravitational field strength g_s at the surface of a planet is related to the the density ρ and the radius R of the planet by the expression

$$g_s = \frac{4}{3}\pi G R \rho$$

where G is the gravitational constant.

[2 marks]

2 (a) (ii) Calculate the radius of Venus.
Give your answer to an appropriate number of significant figures.

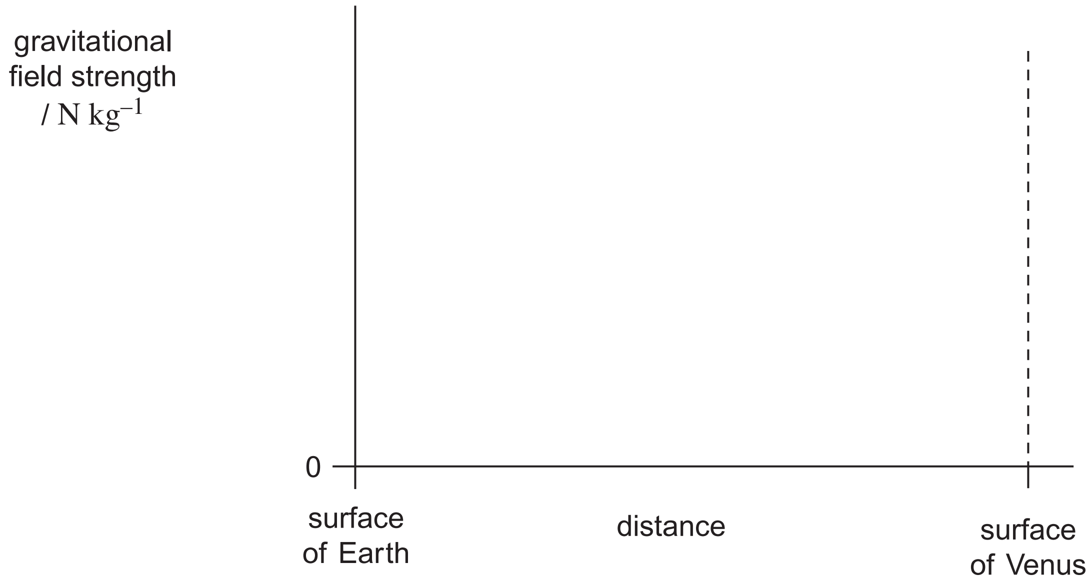
[3 marks]

radius = ____________________________ m

Do not write outside the box

2 (b) At a certain time, the positions of Earth and Venus are aligned so that the distance between them is a minimum.
Sketch a graph on the axes below to show how the magnitude of the gravitational field strength g varies with distance along the shortest straight line between their surfaces.
Consider only the contributions to the field produced by Earth and Venus.
Mark values on the vertical axis of your graph.

[3 marks]



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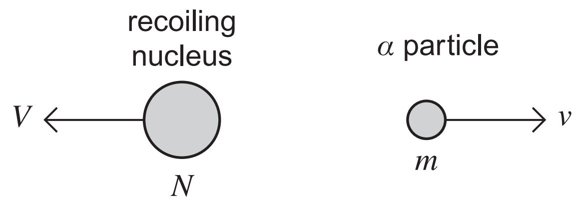
Turn over for the next question

3 (a) State the condition for momentum to be conserved in a system.

[1 mark]

3 (b) When a stationary unstable nucleus emits an α particle with velocity v the resulting nucleus recoils with velocity V, as shown in **Figure 2**.

Figure 2



The mass of the α particle is m and the mass of the recoiling nucleus is N.

3 (b) (i) Show how the principle of conservation of momentum may be used to derive an expression for V in terms of N, m and v.

[2 marks]

3 (b) (ii) Assume that all of the energy released in the emission process is transferred as kinetic energy to the α particle and the recoiling nucleus. The total energy released is E.
Use your result from part **(b)(i)** to show that the kinetic energy of the α particle is given by

$$E_\alpha = \left(\frac{N}{N + m}\right)E$$

[4 marks]

3 (c) (i) The isotope of radon $^{220}_{86}\mathrm{Rn}$ decays by emitting an α particle.

State the nucleon number of the recoiling nucleus.

[1 mark]

nucleon number = ____________________

Question 3 continues on the next page

Turn over ▶

Do not write outside the box

3 (c) (ii) The total energy released when a nucleus of $^{220}_{86}\mathrm{Rn}$ decays is 1.02×10^{-12} J.

Calculate the magnitude of the momentum of the α particle.
State an appropriate unit for your answer.

Mass of a nucleon = 1.66×10^{-27} kg

[4 marks]

momentum = ____________ unit ____________

3 (d) Explain why the expressions in parts **(b)(i)** and **(b)(ii)** could **not** be applied when an unstable nucleus decays by emitting a β^{-} particle.

[1 mark]

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Turn over for the next question

Turn over ▶

4 Within certain limits, the bob of a simple pendulum of length l may be considered to move with simple harmonic motion of period T, where

$$T = 2\pi\sqrt{\frac{l}{g}}$$

4 (a) State **one** limitation that applies to the pendulum when this equation is used.

[1 mark]

4 (b) Describe an experiment to determine the value of the Earth's gravitational field strength g using a simple pendulum and any other appropriate apparatus.

In your answer you should:

- describe how you would arrange the apparatus
- indicate how you would make the measurements
- explain how you would calculate the value of g by a graphical method
- state the experimental procedures you would use to ensure that your result was accurate.

You may draw a diagram to help you with your answer.

The quality of your written communication will be assessed in your answer.

[6 marks]

Question 4 continues on the next page

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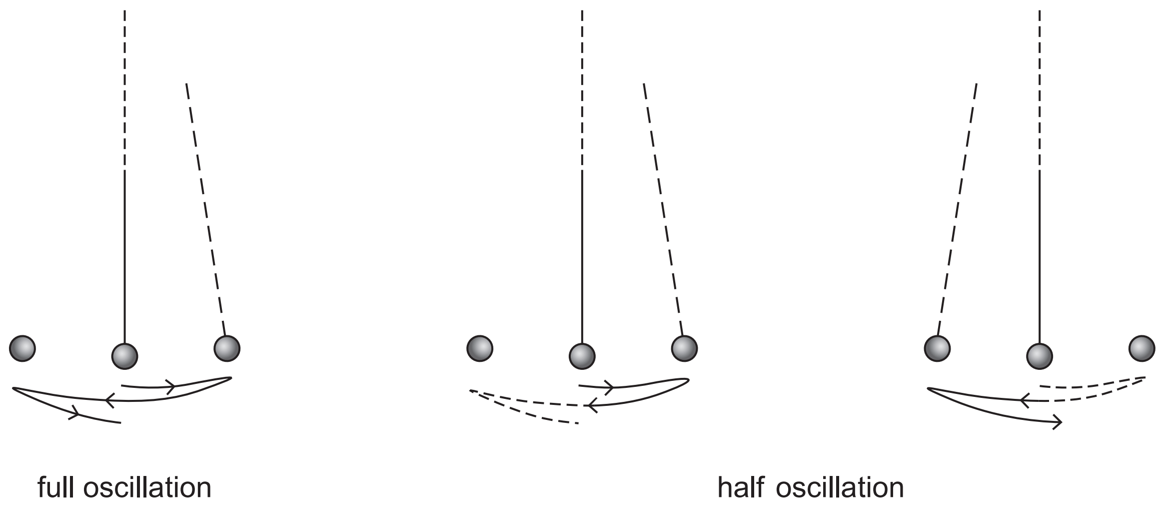
4 (c) When carrying out the experiment in part **(b)**, a student measures the time period incorrectly. Mistakenly, the student thinks that the time period is the time taken for half of an oscillation instead of a full oscillation, as illustrated in **Figure 3**.

Figure 3



Deduce the effect this will have on the value of g obtained from the experiment, explaining how you arrive at your answer.

[3 marks]

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Turn over for the next question

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5 (a) State, in words, the two laws of electromagnetic induction.

[3 marks]

Law 1 ____

____

____

____

Law 2 ____

____

____

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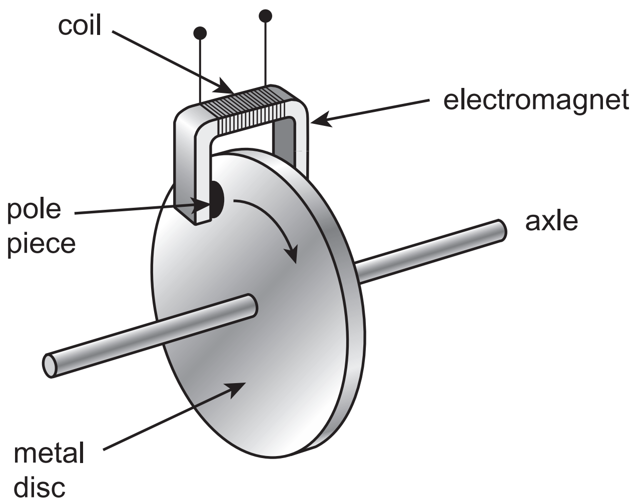
5 (b) **Figure 4** illustrates the main components of one type of electromagnetic braking system. A metal disc is attached to the rotating axle of a vehicle. An electromagnet is mounted with its pole pieces placed either side of the rotating disc, but not touching it. When the brakes are applied, a direct current is passed through the coil of the electromagnet and the disc slows down.

Figure 4



5 (b) (i) Explain, using the laws of electromagnetic induction, how the device in **Figure 4** acts as an electromagnetic brake.

[3 marks]

5 (b) (ii) A conventional braking system has friction pads that are brought into contact with a moving metal surface when the vehicle is to be slowed down.
State **one** advantage and **one** disadvantage of an electromagnetic brake compared to a conventional brake.

[2 marks]

Advantage

Disadvantage

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END OF QUESTIONS

There are no questions printed on this page

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