Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
June 2010

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Friday 18 June 2010 9.00 am to 10.45 am

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

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.

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. 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.

Information
- The marks for questions are shown in brackets.
- The maximum mark for this section 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.

Do not write outside the box

Answer **all** questions.

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

1 (a) State Newton's law of gravitation.

....

....

....

....

(2 marks)

1 (b) In 1798 Cavendish investigated Newton's law by measuring the gravitational force between two unequal uniform lead spheres. The radius of the larger sphere was 100 mm and that of the smaller sphere was 25 mm.

1 (b) (i) The mass of the smaller sphere was 0.74 kg. Show that the mass of the larger sphere was about 47 kg.

density of lead = 11.3×10^3 kg m^{-3}

(2 marks)

1 (b) (ii) Calculate the gravitational force between the spheres when their surfaces were in contact.

answer = ... N

(2 marks)

Do not write outside the box

1 (c) Modifications, such as increasing the size of each sphere to produce a greater force between them, were considered in order to improve the accuracy of Cavendish's experiment. Describe and explain the effect on the calculations in part (b) of doubling the radius of both spheres.

....

....

....

....

....

....

....

....

....

....

(4 marks)

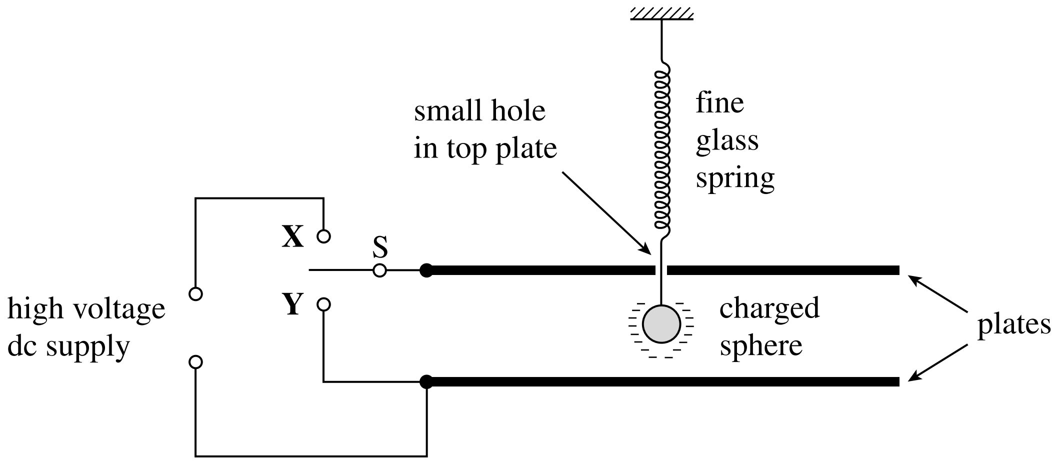
10

Turn over for the next question

Do not write outside the box

2 A small negatively charged sphere is suspended from a fine glass spring between parallel horizontal metal plates, as shown in **Figure 1**.

Figure 1



2 (a) Initially the plates are uncharged. When switch S is set to position **X**, a high voltage dc supply is connected across the plates. This causes the sphere to move vertically upwards so that eventually it comes to rest 18 mm higher than its original position.

2 (a) (i) State the direction of the electric field between the plates.

....

(1 mark)

2 (a) (ii) The spring constant of the glass spring is $0.24\,\mathrm{N\,m^{-1}}$. Show that the force exerted on the sphere by the electric field is $4.3 \times 10^{-3}\,\mathrm{N}$.

(1 mark)

Do not write outside the box

2 (a) (iii) The pd applied across the plates is 5.0 kV. If the charge on the sphere is -4.1×10^{-8} C, determine the separation of the plates.

answer = ... m

(3 marks)

2 (b) Switch S is now moved to position **Y**.

2 (b) (i) State and explain the effect of this on the electric field between the plates.

....

....

....

....

(2 marks)

2 (b) (ii) With reference to the forces acting on the sphere, explain why it starts to move with simple harmonic motion.

....

....

....

....

....

....

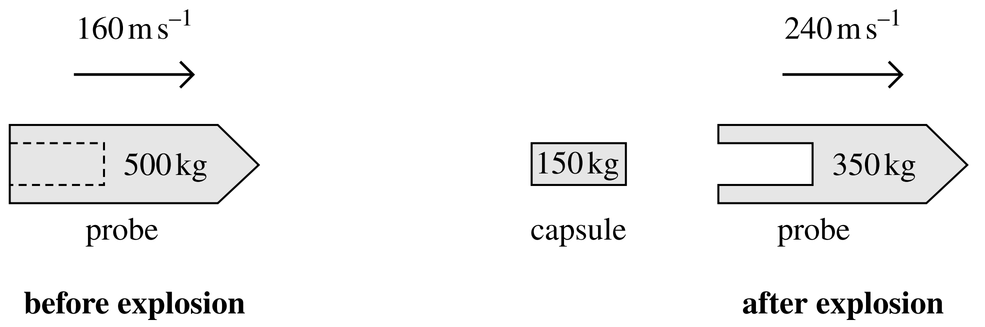
(3 marks)

10

Do not write outside the box

3 Deep space probes often carry modules which may be ejected from them by an explosion. A space probe of total mass 500 kg is travelling in a straight line through free space at 160 m s^{-1} when it ejects a capsule of mass 150 kg explosively, releasing energy. Immediately after the explosion the probe, now of mass 350 kg, continues to travel in the original straight line but travels at 240 m s^{-1}, as shown in **Figure 2**.

Figure 2



3 (a) Discuss how the principles of conservation of momentum and conservation of energy apply in this instance.

The quality of your written communication will be assessed in this question.

....

....

....

....

....

....

....

....

....

....

....

....

....

(6 marks)

Do not write outside the box

3 (b) (i) Calculate the magnitude of the velocity of the capsule immediately after the explosion and state its direction of movement.

magnitude of velocity = ... $m\,s^{-1}$

direction of movement ....

(3 marks)

3 (b) (ii) Determine the total amount of energy given to the probe and capsule by the explosion.

answer = ... J

(4 marks)

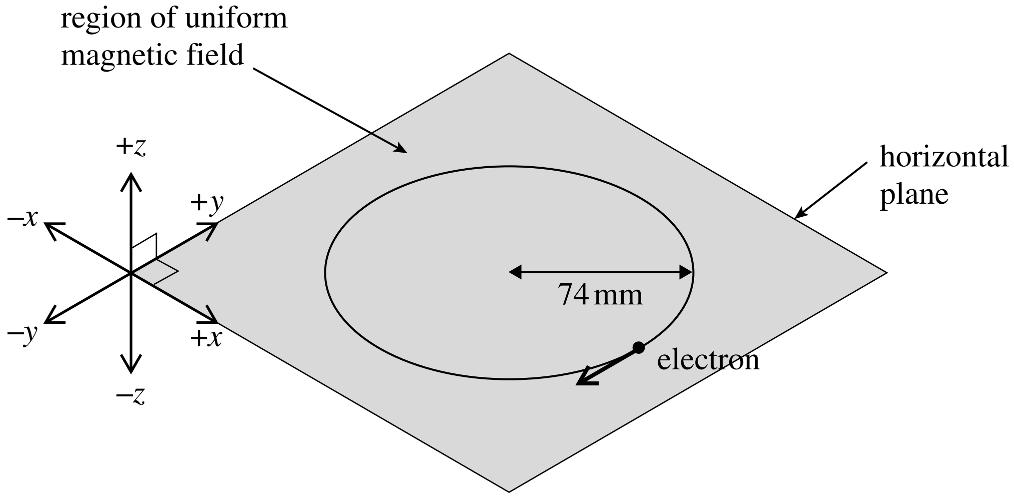
13

Turn over for the next question

Do not write outside the box

4 When travelling in a vacuum through a uniform magnetic field of flux density 0.43 mT, an electron moves at constant speed in a horizontal circle of radius 74 mm, as shown in **Figure 3**.

Figure 3



4 (a) When viewed from vertically above, the electron moves clockwise around the horizontal circle. In which one of the six directions shown on **Figure 3**, $+x$, $-x$, $+y$, $-y$, $+z$ or $-z$, is the magnetic field directed?

direction of magnetic field ....

(1 mark)

4 (b) Explain why the electron is accelerating even though it is travelling at constant speed.

....

....

....

....

....

....

(2 marks)

Do not write outside the box

4 (c) (i) By considering the centripetal force acting on the electron, show that its speed is $5.6 \times 10^6\,\mathrm{m\,s^{-1}}$.

(2 marks)

4 (c) (ii) Calculate the angular speed of the electron, giving an appropriate unit.

answer = ...

(2 marks)

4 (c) (iii) How many times does the electron travel around the circle in one minute?

answer = ...

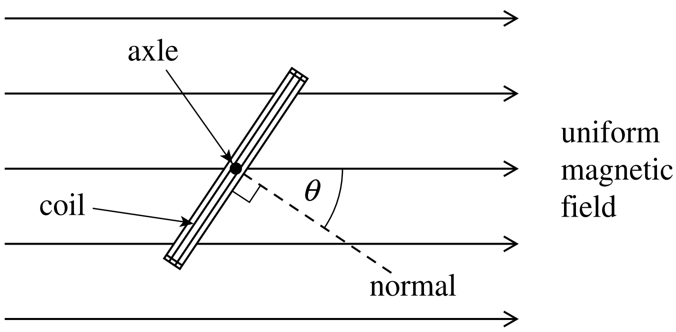
(2 marks)

9

Do not write outside the box

5 **Figure 4** shows an end view of a simple electrical generator. A rectangular coil is rotated in a uniform magnetic field with the axle at right angles to the field direction. When in the position shown in **Figure 4** the angle between the direction of the magnetic field and the normal to the plane of the coil is θ.

Figure 4



5 (a) The coil has 50 turns and an area of $1.9 \times 10^{-3}\,m^2$. The flux density of the magnetic field is $2.8 \times 10^{-2}\,T$. Calculate the flux linkage for the coil when θ is 35°, expressing your answer to an appropriate number of significant figures.

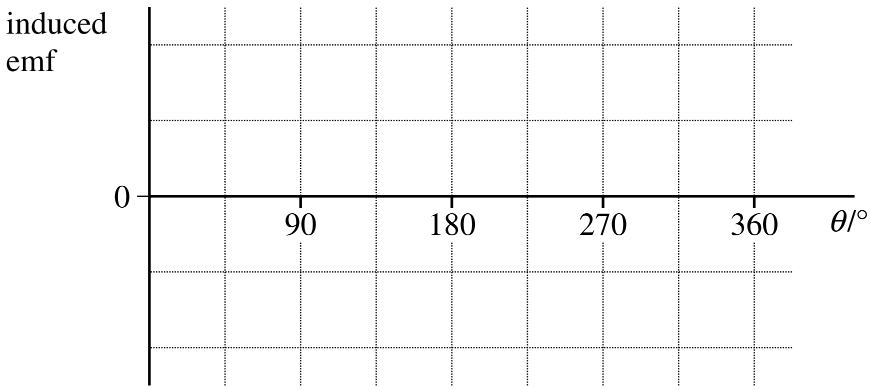
answer = ... Wb turns
(3 marks)

Do not write outside the box

5 (b) The coil is rotated at constant speed, causing an emf to be induced.

5 (b) (i) Sketch a graph on the outline axes to show how the induced emf varies with angle θ during one complete rotation of the coil, starting when $\theta = 0$. Values are not required on the emf axis of the graph.

(1 mark)



5 (b) (ii) Give the value of the flux linkage for the coil at the positions where the emf has its greatest values.

answer = ... Wb turns
(1 mark)

5 (b) (iii) Explain why the magnitude of the emf is greatest at the values of θ shown in your answer to part (b)(i).

....

....

....

....

....

....

....

....

(3 marks)

8

END OF QUESTIONS

Do not write outside the box

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright © 2010 AQA and its licensors. All rights reserved.