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
January 2013

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Wednesday 16 January 2013 1.30 pm to 3.15 pm

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

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
- Show all your working.

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 in the spaces provided.
You are advised to spend approximately **one hour** on this section.

1 (a) State **one** similarity and **one** difference between an elastic collision and an inelastic collision.

similarity ....

....

difference ....

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(2 marks)

1 (b) An unstable isotope of neodymium, ${}^{144}_{60}\text{Nd}$, decays into an isotope of cerium, Ce, by emitting an α particle.

1 (b) (i) Complete the following decay equation.

$$ {}^{144}_{60}\text{Nd} \rightarrow {}^{\cdots\cdots}_{\cdots\cdots}\text{Ce} \quad + {}^{\cdots\cdots}_{\cdots\cdots}\alpha $$

(1 mark)

1 (b) (ii) The α particle is emitted from a stationary ${}^{144}_{60}\text{Nd}$ nucleus at a speed of $9.3 \times 10^{6}\,\text{m s}^{-1}$. Calculate the recoil speed of the daughter nucleus.

recoil speed .... m s^{-1}

(2 marks)

Do not write outside the box

1 (b) (iii) Show that, when a stationary $^{144}_{60}$Nd nucleus decays, the kinetic energy of the recoiling cerium nucleus is only about 3% of the kinetic energy of the emitted α particle.

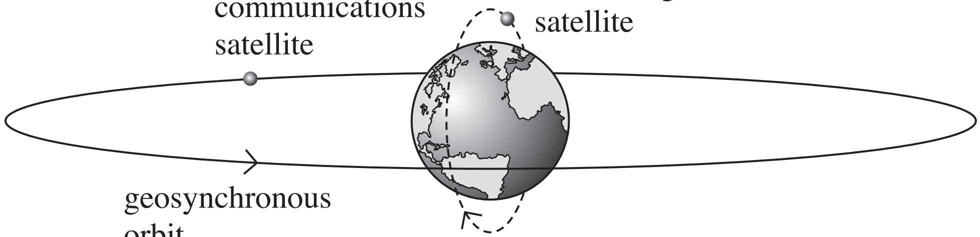
(3 marks)

8

Turn over for the next question

2 **Figure 1** shows the orbits of two Earth satellites, a communications satellite in a geosynchronous orbit and a monitoring satellite in a low orbit that passes over the poles.

Figure 1



2 (a) The time period, T, of any satellite in a circular orbit around a planet is proportional to $r^{3/2}$, where r is the radius of its orbit measured from the centre of the planet.
For a satellite in a low orbit that passes over the poles of the Earth, T is 105 minutes when r is 7370 km.

2 (a) (i) Calculate the height above the surface of the Earth, in km, of a satellite in a geosynchronous circular orbit.
Give your answer to an appropriate number of significant figures.

height above surface .... km
(4 marks)

2 (a) (ii) Calculate the centripetal force acting on the polar orbiting satellite if its mass is 650 kg.

centripetal force .... N

(2 marks)

2 (b) These geosynchronous and polar satellites have different applications because of their different orbits in relation to the rotation of the Earth.

Compare the principal features of the geosynchronous and polar orbits and explain the consequences for possible uses of satellites in these orbits.

In your answer you should explain why:

- a low polar orbit is suitable for a satellite used to monitor conditions on the Earth.
- a geosynchronous circular orbit above the Equator is especially suitable for a satellite used in communications.

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

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Turn over ▶

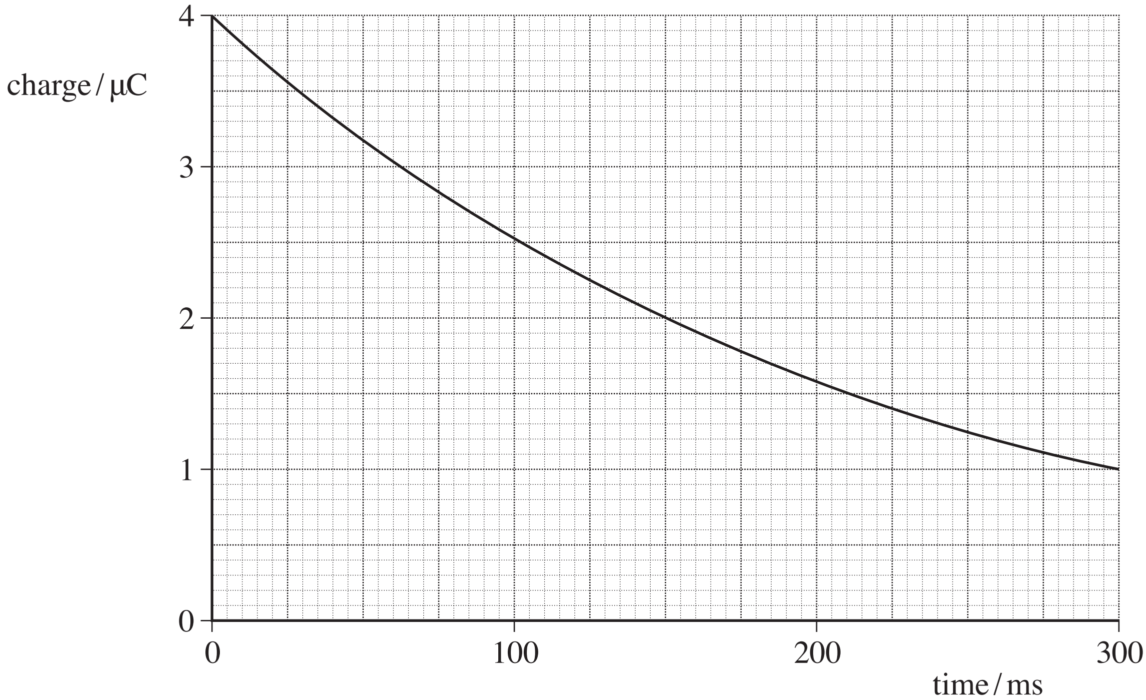
(6 marks)

12

Do not write outside the box

3 **Figure 2** shows how the charge stored by a capacitor varies with time when it is discharged through a fixed resistor.

Figure 2



3 (a) Determine the time constant, in ms, of the discharge circuit.

time constant .... ms

(3 marks)

3 (b) Explain why the rate of discharge will be greater if the fixed resistor has a smaller resistance.

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(2 marks)

5

Turn over ▶

4 (a) State, in words, Coulomb's law.

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(2 marks)

4 (b) **Figure 3** shows two point charges of +4.0 nC and +6.0 nC which are 68 mm apart.

Figure 3

4 (b) (i) Sketch on **Figure 3** the pattern of the electric field surrounding the charges.

(3 marks)

4 (b) (ii) Calculate the magnitude of the electrostatic force acting on the +4.0 nC charge.

magnitude of force .... N

(2 marks)

Do not write outside the box

4 (c) (i) Calculate the magnitude of the resultant electric field strength at the mid-point of the line joining the two charges in **Figure 3**.
State an appropriate unit for your answer.

electric field strength .... unit ....

(4 marks)

4 (c) (ii) State the direction of the resultant electric field at the mid-point of the line joining the charges.

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(1 mark)

12

Turn over for the next question

5 (a) State Lenz's law.

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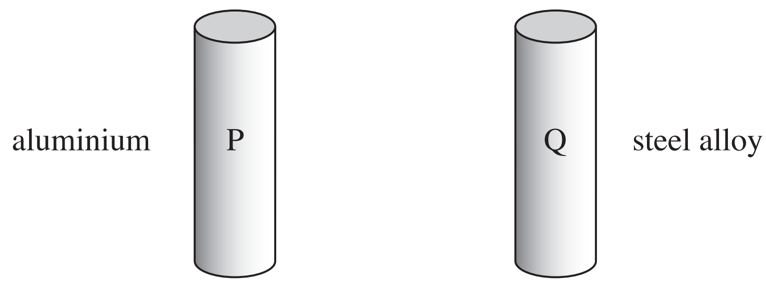
(2 marks)

5 (b) **Figure 4** shows two small, solid metal cylinders, **P** and **Q**.
P is made from aluminium. **Q** is made from a steel alloy.

Figure 4



5 (b) (i) The dimensions of **P** and **Q** are identical but **Q** has a greater mass than **P**. Explain what material property is responsible for this difference.

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(1 mark)

Do not write outside the box

5 (b) (ii) When **P** and **Q** are released from rest and allowed to fall freely through a vertical distance of 1.0 m, they each take 0.45 s to do so. Justify this time value and explain why the times are the same.

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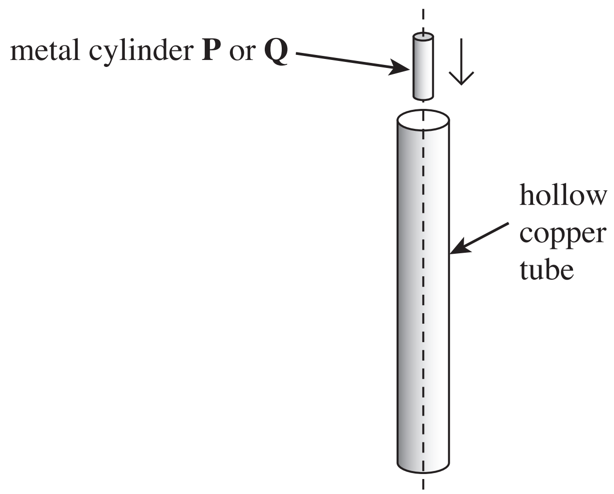
(2 marks)

5 (c) The steel cylinder **Q** is a strong permanent magnet. **P** and **Q** are released separately from the top of a long, vertical copper tube so that they pass down the centre of the tube, as shown in **Figure 5**.

Figure 5



The time taken for **Q** to pass through the tube is much longer than that taken by **P**.

5 (c) (i) Explain why you would expect an emf to be induced in the tube as **Q** passes through it.

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(2 marks)

Turn over ▶

5 (c) (ii) State the consequences of this induced emf, and hence explain why **Q** takes longer than **P** to pass through the tube.

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(3 marks)

5 (d) The copper tube is replaced by a tube of the same dimensions made from brass. The resistivity of brass is much greater than that of copper. Describe and explain how, if at all, the times taken by **P** and **Q** to pass through the tube would be affected.

P: ....

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Q: ....

....

....

....

(3 marks)

13

END OF QUESTIONS