Centre Number						Candidate Number				
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Other Names										
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
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TOTAL	

General Certificate of Education
Advanced Level Examination
June 2014

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Wednesday 11 June 2014 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 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.

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Section B

Answer **all** questions in the spaces provided.

1 (a) (i) Define gravitational field strength and state whether it is a scalar or vector quantity.

[2 marks]

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1 (a) (ii) A mass m is at a height h above the surface of a planet of mass M and radius R. The gravitational field strength at height h is g. By considering the gravitational force acting on mass m, derive an equation from Newton's law of gravitation to express g in terms of M, R, h and the gravitational constant G.

[2 marks]

1 (b) (i) A satellite of mass $2520\,\text{kg}$ is at a height of $1.39 \times 10^7\,\text{m}$ above the surface of the Earth. Calculate the gravitational force of the Earth attracting the satellite. Give your answer to an appropriate number of significant figures.

[3 marks]

force attracting satellite ..... N

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1 (b) (ii) The satellite in part (b)(i) is in a circular polar orbit. Show that the satellite would travel around the Earth three times every 24 hours.

[5 marks]

1 (c) State and explain **one** possible use for the satellite travelling in the orbit in part (b)(ii).

[2 marks]

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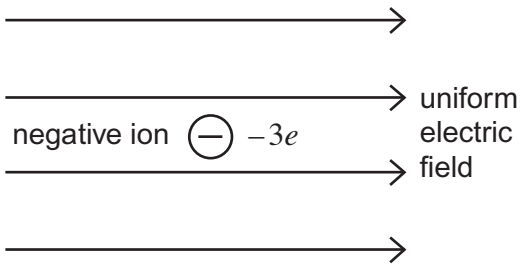
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2 (a) **Figure 1** shows a negative ion which has a charge of $-3e$ and is free to move in a uniform electric field. When the ion is accelerated by the field through a distance of $63\,\text{mm}$ parallel to the field lines its kinetic energy increases by $4.0 \times 10^{-16}\,\text{J}$.

Figure 1



2 (a) (i) State and explain the direction of the electrostatic force on the ion.

[2 marks]

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2 (a) (ii) Calculate the magnitude of the electrostatic force acting on the ion.

[2 marks]

magnitude of electrostatic force ..... N

2 (a) (iii) Calculate the electric field strength.

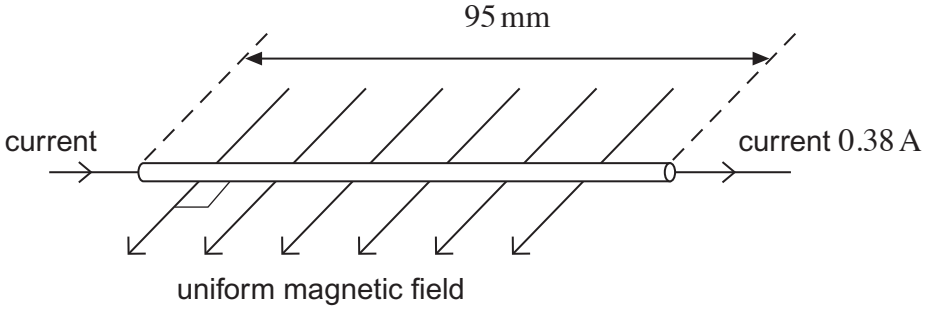
[1 mark]

electric field strength ..... N C^{-1}

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2 (b) **Figure 2** shows a section of a horizontal copper wire carrying a current of $0.38\,\text{A}$. A horizontal uniform magnetic field of flux density B is applied at right angles to the wire in the direction shown in the figure.

Figure 2



2 (b) (i) State the direction of the magnetic force that acts on the moving electrons in the wire as a consequence of the current and explain how you arrive at your answer.

[2 marks]

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2 (b) (ii) Copper contains 8.4×10^{28} free electrons per cubic metre. The section of wire in **Figure 2** is $95\,\text{mm}$ long and its cross-sectional area is $5.1 \times 10^{-6}\,\text{m}^2$. Show that there are about 4×10^{22} free electrons in this section of wire.

[1 mark]

2 (b) (iii) With a current of $0.38\,\text{A}$, the average velocity of an electron in the wire is $5.5 \times 10^{-6}\,\text{m s}^{-1}$ and the average magnetic force on one electron is $1.4 \times 10^{-25}\,\text{N}$. Calculate the flux density B of the magnetic field.

[2 marks]

flux density ..... T

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3 (a) (i) Name the **two** types of potential energy involved when a mass–spring system performs vertical simple harmonic oscillations.

[1 mark]

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3 (a) (ii) Describe the energy changes which take place during one complete oscillation of a vertical mass-spring system, starting when the mass is at its lowest point.

[2 marks]

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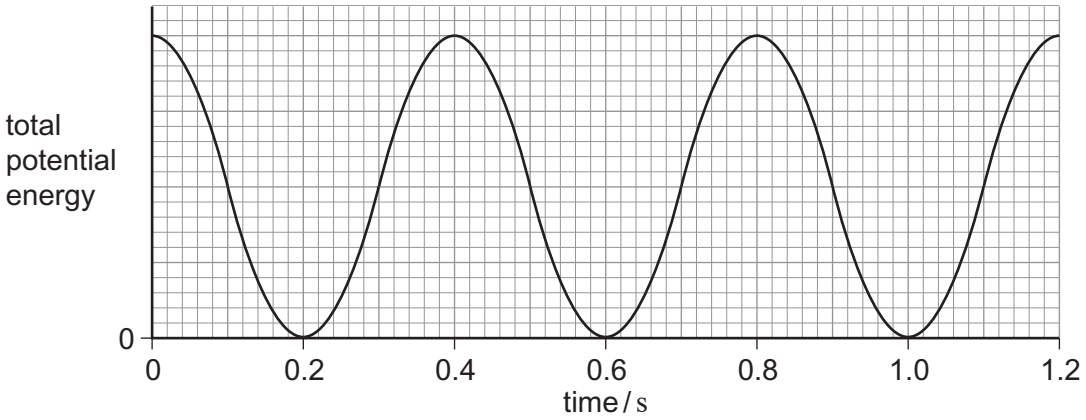
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3 (b) **Figure 3** shows how the **total** potential energy due to the simple harmonic motion varies with time when a mass-spring system oscillates vertically.

Figure 3



3 (b) (i) State the time period of the simple harmonic oscillations that produces the energy–time graph shown in **Figure 3**, explaining how you arrive at your answer.

[2 marks]

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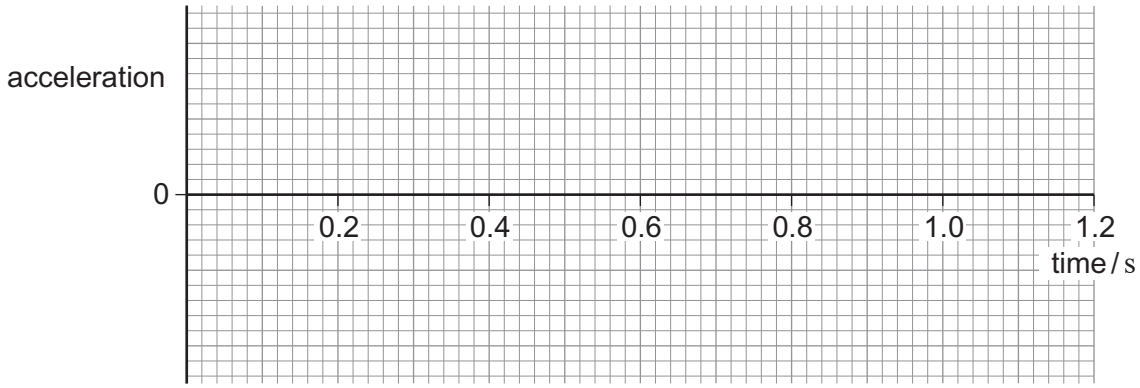
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3 (b) (ii) Sketch a graph on **Figure 4** to show how the acceleration of the mass varies with time over a period of $1.2\,\mathrm{s}$, starting with the mass at the highest point of its oscillations. On your graph, upwards acceleration should be shown as positive and downwards acceleration as negative. Values are not required on the acceleration axis.

[2 marks]

Figure 4



3 (c) (i) The mass of the object suspended from the spring in part (b) is $0.35\,\mathrm{kg}$. Calculate the spring constant of the spring used to obtain **Figure 3**. State an appropriate unit for your answer.

[3 marks]

spring constant ..... unit .....

3 (c) (ii) The maximum kinetic energy of the oscillating object is $2.0 \times 10^{-2}\,\mathrm{J}$. Show that the amplitude of the oscillations of the object is about $40\,\mathrm{mm}$.

[4 marks]

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4 (a) When an uncharged capacitor is charged by a **constant** current of $4.5\,\mu A$ for $60\,s$ the pd across it becomes $4.4\,V$.

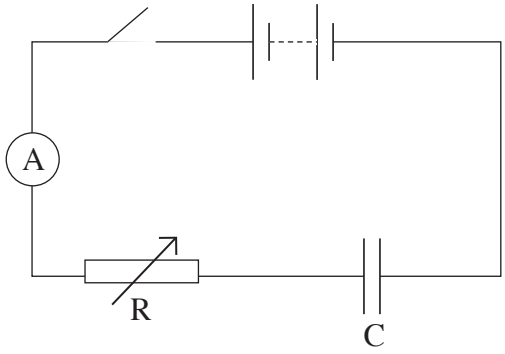
4 (a) (i) Calculate the capacitance of the capacitor.

[3 marks]

capacitance ..... F

4 (a) (ii) The capacitor is charged using the circuit shown in **Figure 5**. The battery emf is $6.0\,V$ and its internal resistance is negligible. In order to keep the current constant at $4.5\,\mu A$, the resistance of the variable resistor R is decreased steadily as the charge on the capacitor increases.

Figure 5



Calculate the resistance of R when the uncharged capacitor has been charging for $30\,s$.

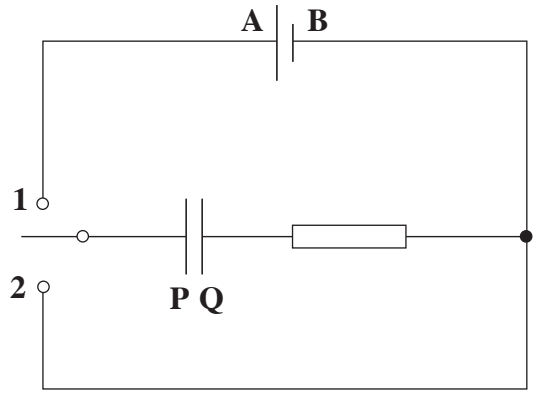
[3 marks]

resistance ..... Ω

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4 (b) The circuit in **Figure 6** contains a cell, an uncharged capacitor, a fixed resistor and a two-way switch.

Figure 6



The switch is moved to position **1** until the capacitor is fully charged. The switch is then moved to position **2**.

Describe what happens in this circuit after the switch is moved to position **1**, and after it has been moved to position **2**. In your answer you should refer to:

- the direction in which electrons flow in the circuit, and how the flow of electrons changes with time,
- how the potential differences across the resistor and the capacitor change with time,
- the energy changes which take place in the circuit.

The terminals of the cell are labelled **A** and **B** and the capacitor plates are labelled **P** and **Q** so that you can refer to them in your answer.

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

[6 marks]

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END OF QUESTIONS

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