Centre Number						Candidate Number				
Surname										
Other Names										
Candidate Signature										

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

General Certificate of Education
Advanced Level Examination
January 2012

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Tuesday 24 January 2012 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 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.

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

1 (a) Define the electric potential at a point in an electric field.

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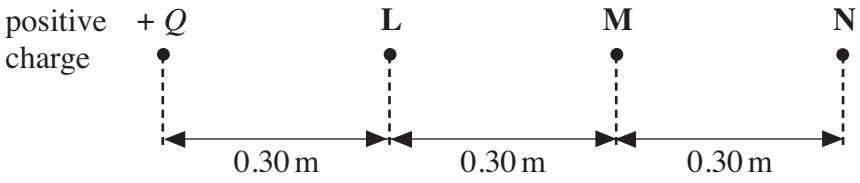
(3 marks)

1 (b) **Figure 1** shows part of the region around a small positive charge.

Figure 1



1 (b) (i) The electric potential at point **L** due to this charge is + 3.0 V. Calculate the magnitude Q of the charge. Express your answer to an appropriate number of significant figures.

answer = ... C

(3 marks)

1 (b) (ii) Show that the electric potential at point **N**, due to the charge, is +1.0 V.

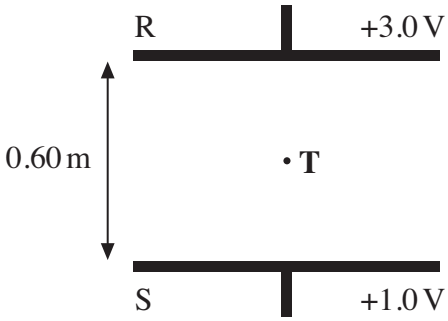
(1 mark)

1 (b) (iii) Show that the electric field strength at point **M**, which is mid-way between **L** and **N**, is 2.5 V m^{-1}.

(1 mark)

1 (c) R and S are two charged parallel plates, 0.60 m apart, as shown in **Figure 2**. They are at potentials of + 3.0 V and + 1.0 V respectively.

Figure 2



1 (c) (i) On **Figure 2**, sketch the electric field between R and S, showing its direction.

(2 marks)

1 (c) (ii) Point **T** is mid-way between R and S.
Calculate the electric field strength at **T**.

answer = ... V m^{-1}

(1 mark)

1 (c) (iii) Parts (b)(iii) and (c)(ii) both involve the electric field strength at a point mid-way between potentials of + 1.0 V and + 3.0 V. Explain why the magnitudes of these electric field strengths are different.

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(1 mark)

12

2 (a) Define the capacitance of a capacitor.

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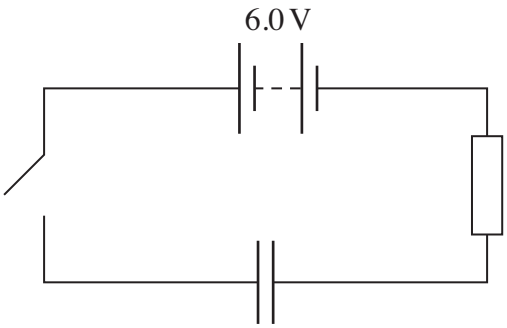
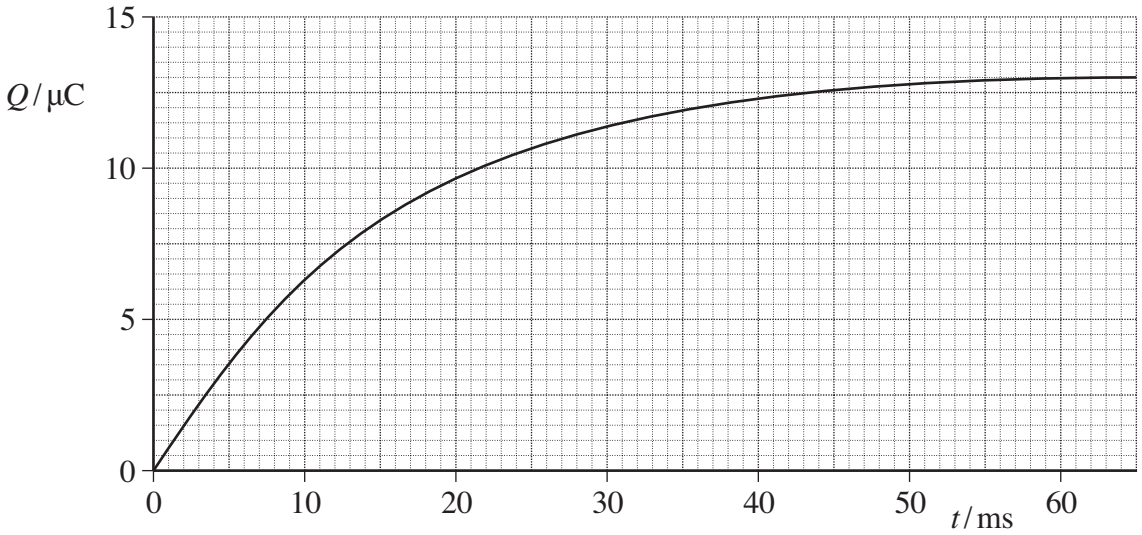
(2 marks)

2 (b) The circuit shown in **Figure 3** contains a battery, a resistor, a capacitor and a switch.

Figure 3



The switch in the circuit is closed at time $t = 0$. The graph shows how the charge Q stored by the capacitor varies with t.



2 (b) (i) When the capacitor is fully charged, the charge stored is 13.2 μC. The electromotive force (emf) of the battery is 6.0 V. Determine the capacitance of the capacitor.

answer = ... F

(2 marks)

2 (b) (ii) The time constant for this circuit is the time taken for the charge stored to increase from 0 to 63% of its final value. Use the graph to find the time constant in milliseconds.

answer = ... ms

(2 marks)

2 (b) (iii) Hence calculate the resistance of the resistor.

answer = ... Ω

(1 mark)

2 (b) (iv) What physical quantity is represented by the gradient of the graph?

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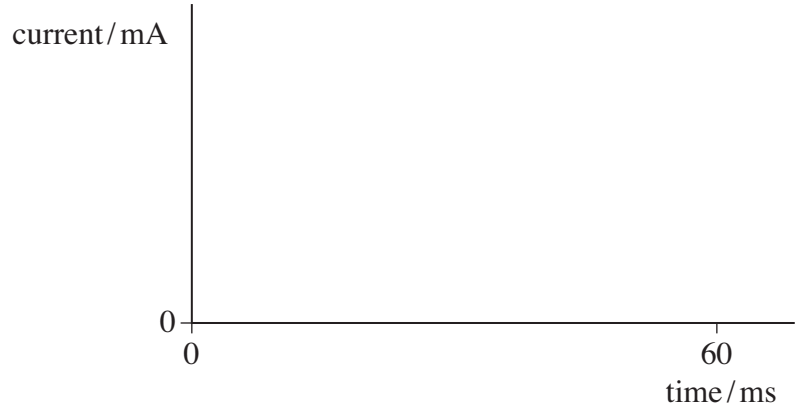
(1 mark)

2 (c) (i) Calculate the maximum value of the current, in mA, in this circuit during the charging process.

answer = ... mA

(1 mark)

2 (c) (ii) Sketch a graph on the outline axes to show how the current varies with time as the capacitor is charged. Mark the maximum value of the current on your graph.

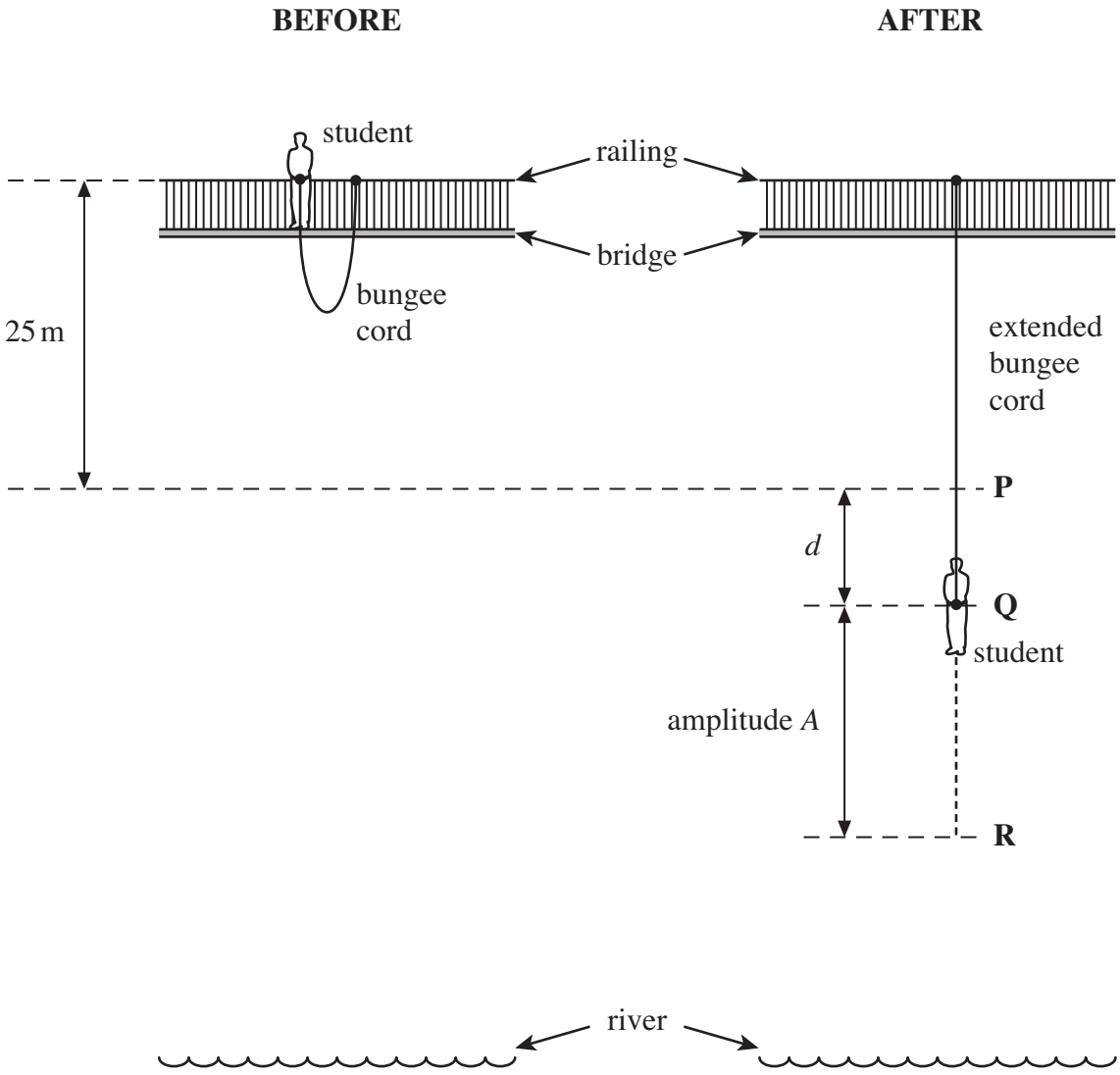


(2 marks)

11

3 The two diagrams in **Figure 4** show a student before and after she makes a bungee jump from a high bridge above a river. One end of the bungee cord, which is of unstretched length 25 m, is fixed to the top of a railing on the bridge. The other end of the cord is attached to the waist of the student, whose mass is 58 kg. After she jumps, the bungee cord goes into tension at point **P**. She comes to rest momentarily at point **R** and then oscillates about point **Q**, which is a distance *d* below **P**.

Figure 4



3 (a) (i) Assuming that the centre of mass of the student has fallen through a vertical distance of 25 m when she reaches point **P**, calculate her speed at **P**.
You may assume that air resistance is negligible.

answer = ... $m\,s^{-1}$

(2 marks)

3 (a) (ii) The bungee cord behaves like a spring of spring constant 54 $N\,m^{-1}$.
Calculate the distance d, from **P** to **Q**, assuming the cord obeys Hooke's law.

answer = ... m

(2 marks)

3 (b) As the student moves below **P**, she begins to move with simple harmonic motion for part of an oscillation.

3 (b) (i) If the arrangement can be assumed to act as a mass-spring system, calculate the time taken for one half of an oscillation.

answer = ... s

(2 marks)

3 (b) (ii) Use your answers from parts (a) and (b)(i) to show that the amplitude A, which is the distance from **Q** to **R**, is about 25 m.

(3 marks)

Turn over ▶

3 (c) Explain why, when the student rises above point **P**, her motion is no longer simple harmonic.

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(2 marks)

3 (d) (i) Where is the student when the stress in the bungee cord is a maximum?

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(1 mark)

3 (d) (ii) The bungee cord has a significant mass. Whereabouts along the bungee cord is the stress a maximum? Explain your answer.

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(2 marks)

14

4 (a) A transformer operating on a 230 V mains supply provides a 12 V output. There are 1150 turns on the primary coil.

4 (a) (i) Calculate the number of turns on the secondary coil.

answer = ... turns
(1 mark)

4 (a) (ii) A number of identical lamps rated at 12 V, 24 W are connected in parallel across the secondary coil. The primary circuit of the transformer includes a 630 mA fuse. Calculate the maximum number of lamps that can be supplied by the transformer if its efficiency is 85%.

answer = ... lamps
(2 marks)

4 (a) (iii) The transformer circuit includes a fuse. Explain why this is necessary.

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(1 mark)

4 (a) (iv) Why is the fuse placed in the primary circuit rather than in the secondary circuit?

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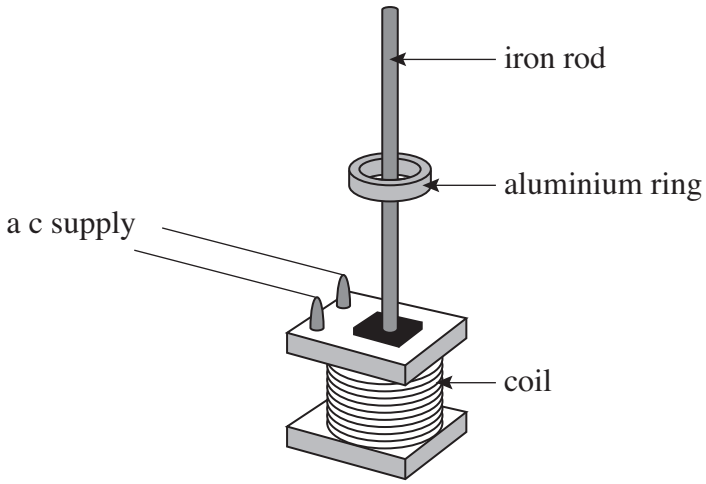
(1 mark)

Question 4 continues on the next page

4 (b) **Figure 5** shows an experimental arrangement that can be used to demonstrate magnetic levitation. The iron rod is fixed vertically inside a large coil of wire. When the alternating current supply to the coil is switched on, the aluminium ring moves up the rod until it reaches a stable position 'floating' above the coil.

Figure 5



4 (b) (i) By reference to the laws of electromagnetic induction explain

- why a current will be induced in the ring,
- why the ring experiences a force that moves it upwards,
- why the ring reaches a stable position.

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

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(6 marks)

4 (b) (ii) What would happen to the ring if the alternating current in the coil was increased without changing the frequency? Explain your answer.

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(2 marks)

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END OF QUESTIONS

There are no questions printed on this page

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