Centre Number						Candidate Number				
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For Examiner's Use	
Examiner's Initials	
Question	Mark
1	
2	
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5	
TOTAL	

General Certificate of Education
Advanced Level Examination
June 2011

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Tuesday 21 June 2011 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 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

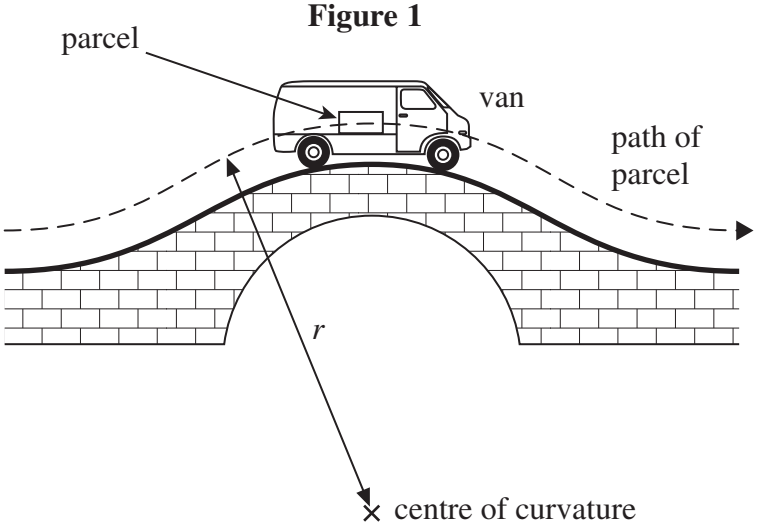
Information
- The marks for questions are shown in brackets.
- The maximum mark for this paper is 50.
- You are expected to use a calculator where appropriate.
- A *Data and Formulae Booklet* is provided as a loose insert.
- You will be marked on your ability to:
  – use good English
  – organise information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

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

1 **Figure 1** shows a parcel on the floor of a delivery van that is passing over a hump-backed bridge on a straight section of road. The radius of curvature of the path of the parcel is r and the van is travelling at a constant speed v. The mass of the parcel is m.

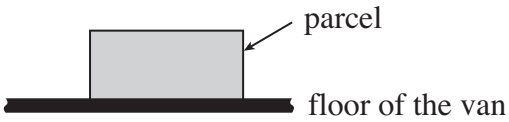
Figure 1



1 (a) (i) Draw arrows on **Figure 2** below to show the forces that act on the parcel as it passes over the highest point of the bridge. Label these forces.

(1 mark)

Figure 2



1 (a) (ii) Write down an equation that relates the contact force, R, between the parcel and the floor of the van to m, v, r and the gravitational field strength, g.

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(1 mark)

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1 (a) (iii) Calculate R if $m = 12\,\text{kg}$, $r = 23\,\text{m}$, and $v = 11\,\text{m s}^{-1}$.

answer = ...N

(2 marks)

1 (b) Explain what would happen to the magnitude of R if the van passed over the bridge at a higher speed. What would be the significance of any van speed greater than $15\,\text{m s}^{-1}$? Support your answer with a calculation.

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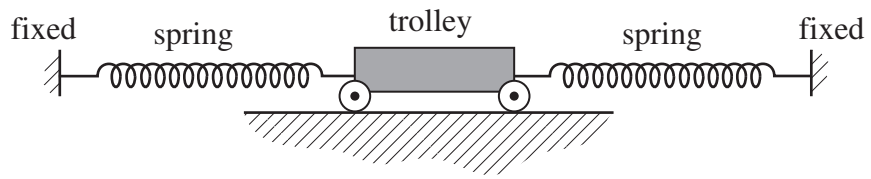
(3 marks)

7

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2 A trolley of mass 0.80 kg rests on a horizontal surface attached to two identical stretched springs, as shown in **Figure 3**. Each spring has a spring constant of 30 N m^{-1}, can be assumed to obey Hooke's law, and to remain in tension as the trolley moves.

Figure 3



2 (a) (i) The trolley is displaced to the left by 60 mm and then released. Show that the magnitude of the resultant force on it at the moment of release is 3.6 N.

(2 marks)

2 (a) (ii) Calculate the acceleration of the trolley at the moment of release and state its direction.

answer = ...m s^{-2}

direction .....

(2 marks)

Do not write outside the box

2 (b) (i) The oscillating trolley performs simple harmonic motion. State the **two** conditions which have to be satisfied to show that a body performs simple harmonic motion.

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(2 marks)

2 (b) (ii) The frequency f of oscillation of the trolley is given by

$$f = \frac{1}{2\pi}\sqrt{\frac{2k}{m}}$$

where m = mass of the trolley
k = spring constant of one spring.

Calculate the period of oscillation of the trolley, stating an appropriate unit.

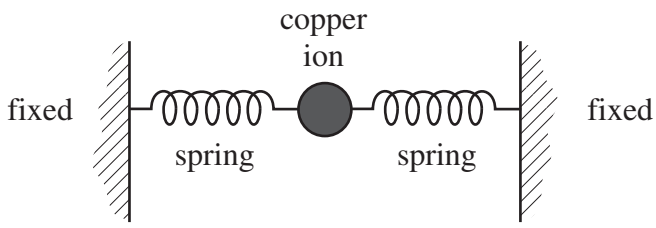
answer = ...

(3 marks)

Do not write outside the box

2 (c) Copper ions in a crystal lattice vibrate in a similar way to the trolley, because the inter-atomic forces act in a similar way to the forces exerted by the springs. **Figure 4** shows how this model of a vibrating ion can be represented.

Figure 4



2 (c) (i) The spring constant of each inter-atomic 'spring' is about $200\,N\,m^{-1}$. The mass of the copper ion is $1.0 \times 10^{-25}\,kg$. Show that the frequency of vibration of the copper ion is about $10^{13}\,Hz$.

(1 mark)

2 (c) (ii) If the amplitude of vibration of the copper ion is $10^{-11}m$, estimate its maximum speed.

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

(1 mark)

2 (c) (iii) Estimate the maximum kinetic energy of the copper ion.

answer = ...J

(1 mark)

12

Do not write outside the box

3 Capacitors and rechargeable batteries are examples of electrical devices that can be used repeatedly to store energy.

3 (a) (i) A capacitor of capacitance 70 F is used to provide the emergency back-up in a low voltage power supply.
Calculate the energy stored by this capacitor when fully charged to its maximum operating voltage of 1.2 V. Express your answer to an appropriate number of significant figures.

answer = ...J
(3 marks)

3 (a) (ii) A rechargeable 1.2 V cell used in a cordless telephone can supply a steady current of 55 mA for 10 hours. Show that this cell, when fully charged, stores almost 50 times more energy than the capacitor in part (a)(i).

(2 marks)

3 (b) Give **two** reasons why a capacitor is **not** a suitable source for powering a cordless telephone.

Reason 1.....

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Reason 2.....

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(2 marks)

7

Do not write outside the box

4 (a) The equation $F = BQv$ may be used to calculate magnetic forces.

4 (a) (i) State the condition under which this equation applies.

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(1 mark)

4 (a) (ii) Identify the physical quantities that are represented by the four symbols in the equation.

F .....

B .....

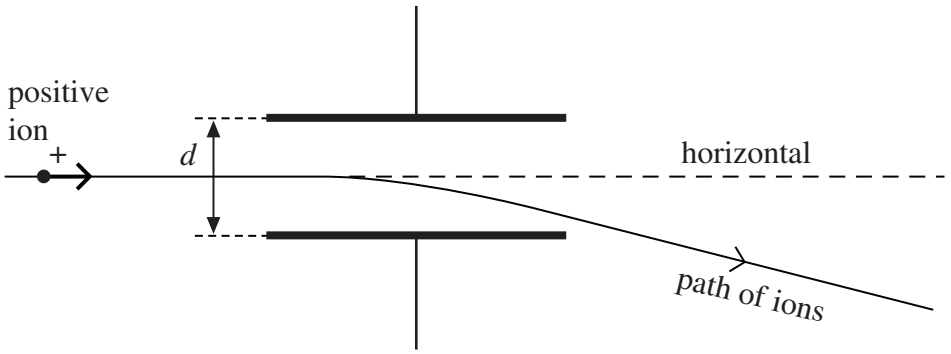
Q.....

v.....

(1 mark)

4 (b) **Figure 5** shows the path followed by a stream of identical positively-charged ions, of the same kinetic energy, as they pass through the region between two charged plates. Initially the ions are travelling horizontally and they are then deflected downwards by the electric field between the plates.

Figure 5



Whilst the electric field is still applied, the path of the ions may be restored to the horizontal, so that they have no overall deflection, by applying a magnetic field over the same region as the electric field. The magnetic field must be of suitable strength and has to be applied in a particular direction.

4 (b) (i) State the direction in which the magnetic field should be applied.

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(1 mark)

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4 (b) (ii) Explain why the ions have no overall deflection when a magnetic field of the required strength has been applied.

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(2 marks)

4 (b) (iii) A stream of ions passes between the plates at a velocity of $1.7 \times 10^5\ m\,s^{-1}$. The separation d of the plates is 65 mm and the pd across them is 48 V. Calculate the value of B required so that there is no overall deflection of the ions, stating an appropriate unit.

answer = ...

(4 marks)

4 (c) Explain what would happen to ions with a velocity higher than $1.7 \times 10^5\ m\,s^{-1}$ when they pass between the plates at a time when the conditions in part (b)(iii) have been established.

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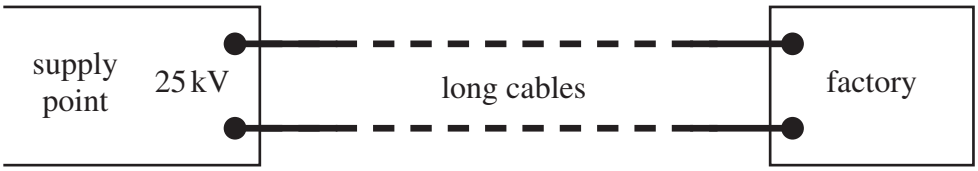
(2 marks)

11

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5 (a) Long cables are used to send electrical power from a supply point to a factory some distance away, as shown in **Figure 6**. An input power of 500 kW at 25 kV is supplied to the cables.

Figure 6



5 (a) (i) Calculate the current in the cables.

answer = ...A
(1 mark)

5 (a) (ii) The total resistance of the cables is 30 Ω. Calculate the power supplied to the factory by the cables.

answer = ...kW
(2 marks)

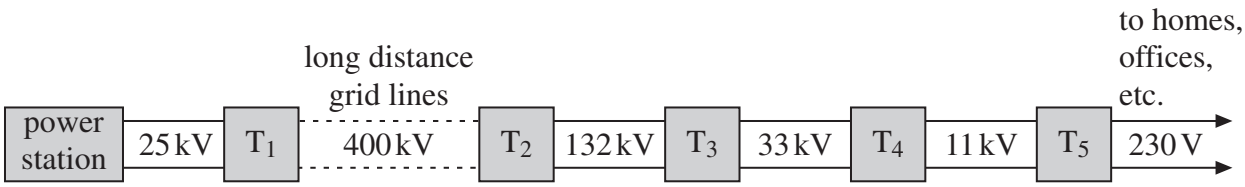
5 (a) (iii) Calculate the efficiency with which power is transmitted by the cables from the input at the supply point to the factory.

answer = ...%
(1 mark)

Do not write outside the box

5 (b) In Great Britain, the electrical generators at power stations provide an output at 25 kV. Most homes, offices and shops are supplied with electricity at 230 V. Power is transmitted from the power stations to the consumers by the grid system, the main principles of which are shown in **Figure 7**. In this network, T_1, T_2, T_3, etc, are transformers.

Figure 7



5 (b) (i) Explain how a step-down transformer differs in construction from a step-up transformer.

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(1 mark)

5 (b) (ii) Explain why the secondary windings of a step-down transformer should be made from thicker copper wire than the primary windings.

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(2 marks)

Question 5 continues on the next page

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5 (c) Discuss the principles involved in high voltage transmission systems, explaining why a.c. is used in preference to d.c. and how the energy losses are minimised.

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

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(6 marks)

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END OF QUESTIONS

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