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
June 2012

Physics A PHYA4/2

Unit 4 Fields and Further Mechanics
Section B

Monday 11 June 2012 1.30 pm to 3.15 pm

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.
- 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.

Do not write outside the box

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

1 (a) State, in words, the relationship between the force acting on a body and the momentum of the body.

.....

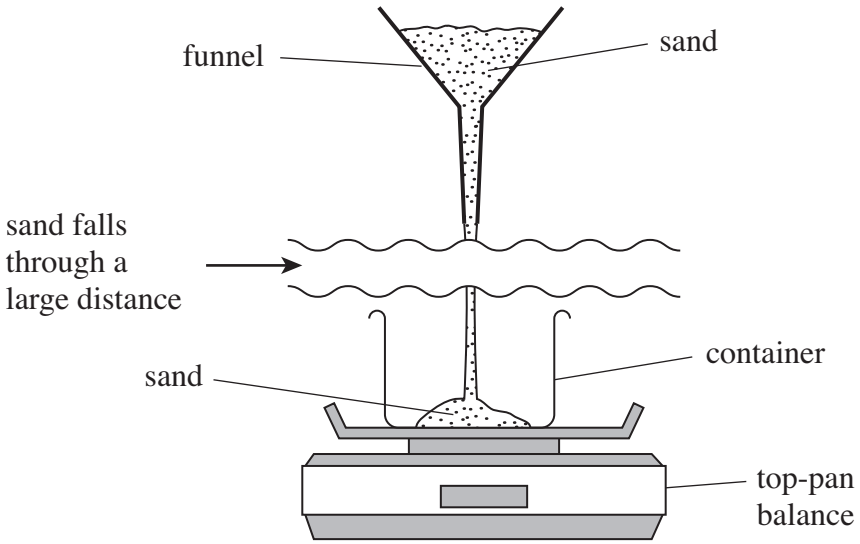
.....

.....

(1 mark)

1 (b) A container rests on a top-pan balance, which measures mass in kg. A funnel above the container holds some sand. The sand falls at a constant rate of $0.300\,\text{kg}\,\text{s}^{-1}$ into the container, having fallen through an average vertical height of 1.60 m.
This arrangement is shown in **Figure 1**.

Figure 1



1 (b) (i) Show that the velocity of the sand as it lands in the container is $5.6\,\text{m}\,\text{s}^{-1}$.

(1 mark)

1 (b) (ii) Calculate the magnitude of the momentum of the sand that lands in the container in each second.

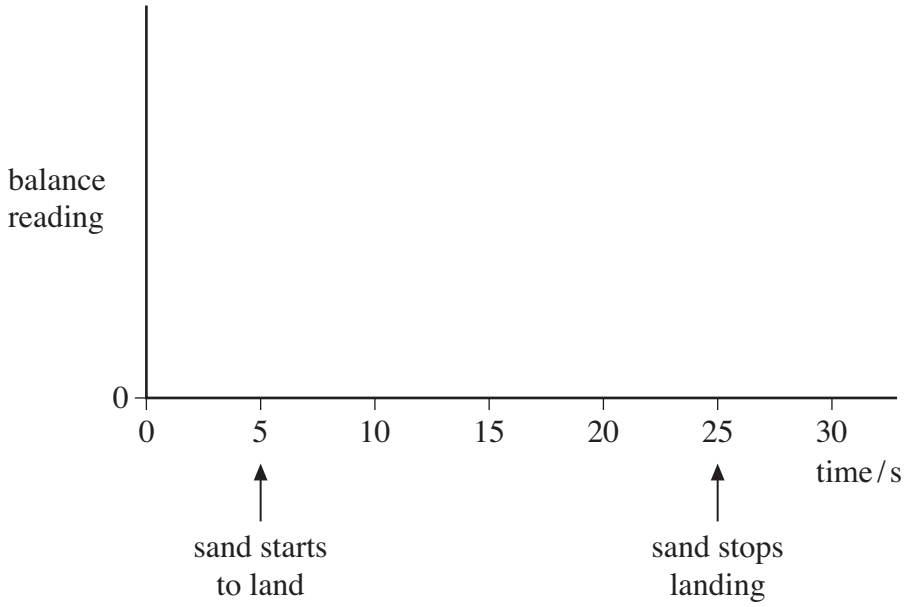
answer = ... N s
(1 mark)

Do not write outside the box

1 (b) (iii) The mass of the container is 0.650 kg. Show that the reading of the balance, 10.0 s after the sand starts landing continuously in the container, will be 3.82 kg. You may assume that the sand comes to rest without rebounding when it lands in the container.

(3 marks)

1 (c) It takes 20.0 s for all of the sand to fall into the container.
On the axes below, sketch a graph to show how the reading of the balance will change over a 30.0 s period, where t = 5.0 s is the time at which the sand starts to land in the container. No further calculations are required and values need not be shown on the vertical axis of the graph.



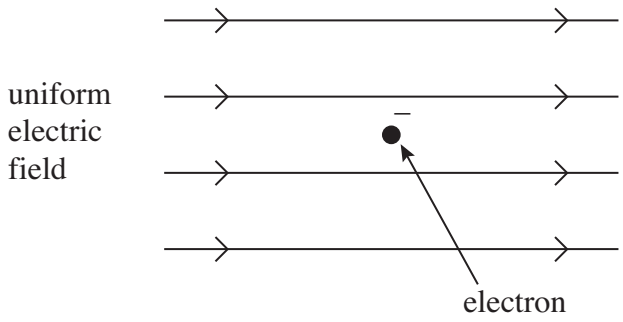
(3 marks)

9

Do not write outside the box

2 (a) **Figure 2** shows an electron at a point in a uniform electric field at an instant when it is stationary.

Figure 2



2 (a) (i) Draw an arrow on **Figure 2** to show the direction of the electrostatic force that acts on the stationary electron.

(1 mark)

2 (a) (ii) State and explain what, if anything, will happen to the magnitude of the electrostatic force acting on the electron as it starts to move in this field.

.....

.....

.....

.....

.....

(2 marks)

2 (b) **Figure 3a** shows a stationary electron in a non-uniform electric field. **Figure 3b** shows a stationary proton, placed in exactly the same position in the same electric field as the electron in **Figure 3a**.

Figure 3a

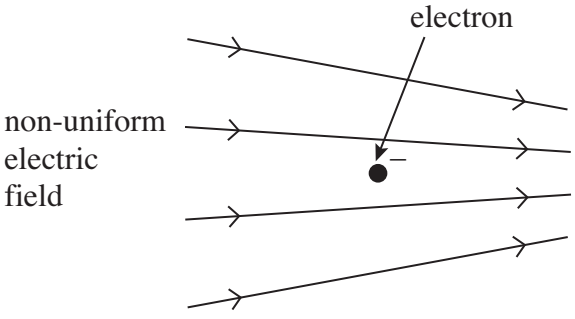
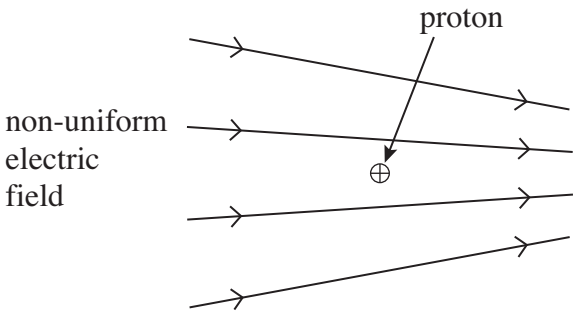


Figure 3b



Do not write outside the box

2 (b) (i) State and explain how the electrostatic force on the proton in **Figure 3b** compares with that on the electron in **Figure 3a**.

.....

.....

.....

.....

.....

(2 marks)

2 (b) (ii) Each of the particles starts to move from the positions shown in **Figure 3a** and **Figure 3b**. State and explain how the magnitude of the **initial** acceleration of the proton compares with that of the electron.

.....

.....

.....

.....

.....

.....

(2 marks)

2 (b) (iii) Describe and explain what will happen to the acceleration of each of these particles as they continue to move in the electric field.

.....

.....

.....

.....

.....

.....

(2 marks)

Do not write outside the box

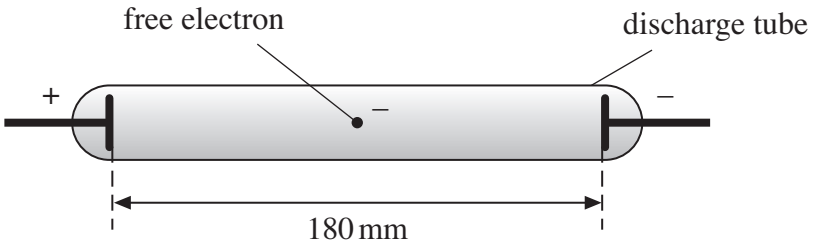
2 (c) The line spectrum of neon gas contains a prominent red line of wavelength 650 nm.

2 (c) (i) Show that the energy required to excite neon atoms so that they emit light of this wavelength is about 2 eV.

(3 marks)

2 (c) (ii) An illuminated shop sign includes a neon discharge tube, as shown in **Figure 4**. A pd of 4500 V is applied across the electrodes, which are 180 mm apart.

Figure 4



Assuming that the electric field inside the tube is uniform, calculate the minimum distance that a free electron would have to move from rest in order to excite the red spectral line in part (c).

answer = ... m

(3 marks)

15

Do not write outside the box

3 The Large Hadron Collider (LHC) uses magnetic fields to confine fast-moving charged particles travelling repeatedly around a circular path. The LHC is installed in an underground circular tunnel of circumference 27 km.

3 (a) In the presence of a suitably directed uniform magnetic field, charged particles move at constant speed in a circular path of constant radius. By reference to the force acting on the particles, explain how this is achieved and why it happens.

.....

.....

.....

.....

.....

.....

.....

.....

.....

(4 marks)

3 (b) (i) The charged particles travelling around the LHC may be protons. Calculate the centripetal force acting on a proton when travelling in a circular path of circumference 27 km at one-tenth of the speed of light. Ignore relativistic effects.

answer = ... N

(3 marks)

Turn over ▶

Do not write outside the box

3 (b) (ii) Calculate the flux density of the uniform magnetic field that would be required to produce this force. State an appropriate unit.

answer = ... unit .....

(3 marks)

3 (c) The speed of the protons gradually increases as their energy is increased by the LHC. State and explain how the magnetic field in the LHC must change as the speed of the protons is increased.

.....

.....

.....

.....

.....

(2 marks)

12

Do not write outside the box

4 (a) Define the gravitational potential at a point in a gravitational field.

.....

.....

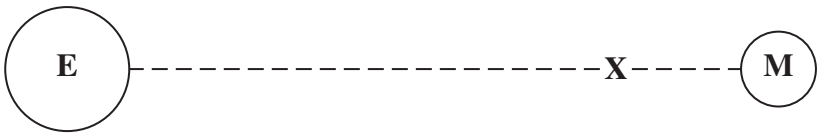
.....

.....

(2 marks)

4 (b) **Figure 5**, which is not drawn to scale, shows the region between the Earth (**E**) and the Moon (**M**).

Figure 5



4 (b) (i) The gravitational potential at the Earth's surface is $-62.6\,\text{MJ kg}^{-1}$. Point **X** shown in **Figure 5** is on the line of centres between the Earth and the Moon At **X** the resultant gravitational field is zero, and the gravitational potential is $-1.3\,\text{MJ kg}^{-1}$.

Calculate the minimum amount of energy that would be required to move a Moon probe of mass $1.2 \times 10^4\,\text{kg}$ from the surface of the Earth to point **X**. Express your answer to an appropriate number of significant figures.

answer = ... J

(3 marks)

4 (b) (ii) Explain why, once the probe is beyond **X**, no further energy would have to be supplied in order for it to reach the surface of the Moon.

.....

.....

.....

(1 mark)

Turn over ▶

Do not write outside the box

4 (b) (iii) In the vicinity of the Earth's orbit the gravitational potential due to the Sun's mass is $-885\,\text{MJ kg}^{-1}$. With reference to the variation in gravitational potential with distance, explain why the gravitational potential due to the Sun's mass need not be considered when carrying out the calculation in part (b)(i).

.....

.....

.....

.....

.....

(2 marks)

4 (c) The amount of energy required to move a manned spacecraft from the Earth to the Moon is much greater than that required to return it to the Earth. By reference to the forces involved, to gravitational field strength and gravitational potential, and to the point **X**, explain why this is so.

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Do not write outside the box

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(6 marks)

END OF QUESTIONS

14

There are no questions printed on this page

DO NOT WRITE ON THIS PAGE
ANSWER IN THE SPACES PROVIDED

Copyright © 2012 AQA and its licensors. All rights reserved.