Surname		Other Names	
Centre Number		Candidate Number	
Candidate Signature			

For Examiner's Use

General Certificate of Education
January 2007
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) **PA04**
Unit 4 Waves, Fields and Nuclear Energy

Section B

Monday 22 January 2007 9.00 am to 10.30 am

For this paper you must have:
- a calculator
- a pencil and a ruler.

Time allowed: The total time for Section A and Section B of this paper is 1 hour 30 minutes

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- Answer the questions in the spaces provided.
- Show all your working.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The maximum mark for this Section is 45.
- Two of these marks will be awarded for using good English, organising information clearly and using specialist vocabulary where appropriate.
- The marks for questions are shown in brackets.
- You are expected to use a calculator where appropriate.
- A *Data Sheet* is provided on pages 3 and 4 of Section A. You may wish to detach this perforated sheet at the start of the examination.
- Questions 1(b) and 5(a)(ii) should be answered in continuous prose. In these questions you will be marked on your ability to use good English, to organise information clearly and to use specialist vocabulary where appropriate.

For Examiner's Use			
Question	Mark	Question	Mark
1			
2			
3			
4			
5			
Total (Column 1) →			
Total (Column 2) →			
Quality of Written Communication			
TOTAL			
Examiner's Initials			

Jan07PA04201

J A N 0 7 P A 0 4 2 0 1

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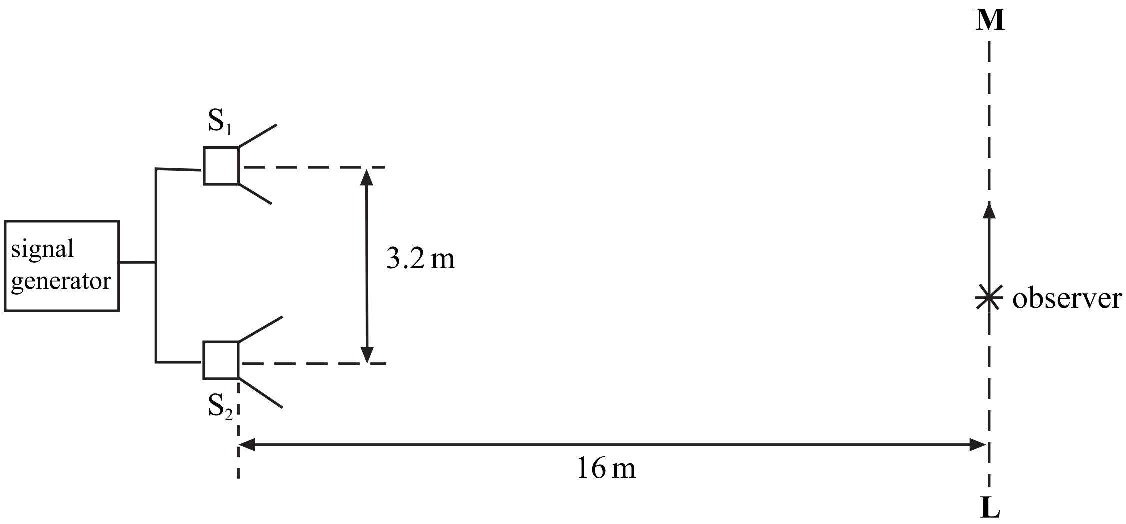
Answer **all** questions.

You are advised to spend about **one hour** on this section.

1 (a) Two identical loudspeakers, S_1 and S_2, are connected to the same signal generator so that each produces a sound wave of frequency 850 Hz. They are arranged in the open air, as shown in **Figure 1**, with their centres 3.2 m apart. An observer who walks along the line **LM**, 16 m away from the loudspeakers, notices that there are minima of sound every 2.0 m.

Figure 1



Calculate

(i) the wavelength of the sound waves,

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(ii) the speed of sound in the air.

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(2 marks)

0 1 2 /2

(b) You may be awarded additional marks to those shown in brackets for the quality of written communication in your answers.

(i) The sound waves from the loudspeakers in part (a) produce interference effects. Light waves from two separate small monochromatic light sources of the same frequency do not produce observable interference effects. Explain why the loudspeakers are able to produce interference effects but the light sources do not.

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(ii) Describe and explain how interference effects may be produced from a single monochromatic light source using appropriate additional equipment.

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(5 marks)

0 1 2 3 4 5 /5 /7

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2 (a) When a parallel beam of monochromatic light is incident normally on a diffraction grating, light leaving the grating has maxima of intensity in particular directions. Explain the parts played by *diffraction* and *interference* in the production of these maxima.

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(3 marks)

0 1 2 3 /3

(b) Light consisting of two wavelengths, the shorter of which is 420 nm, is incident normally on a grating. At a diffraction angle of 44°, the third order maximum produced by light of one wavelength coincides exactly with the second order maximum produced by light of the other wavelength.

(i) Show that the other wavelength is 630 nm.

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(ii) Calculate the number of lines per metre on the grating.

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J A N 0 7 P A 0 4 2 0 4

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(iii) Determine the highest order maximum that can be observed with the 420 nm wavelength.

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(5 marks)

0 1 2 3 4 5 /5

/8

Turn over for the next question

3 **Figure 2** shows a circuit used to determine the capacitance of a capacitor C. Switch S is held in position **X** until C is fully charged. It is then switched to position **Y**, so that C discharges through the microammeter and the variable resistor R. While discharging, R is adjusted continuously to keep the current constant until C has been fully discharged. Measurements taken during the discharge allow the initial charge stored by C to be determined.

Figure 2

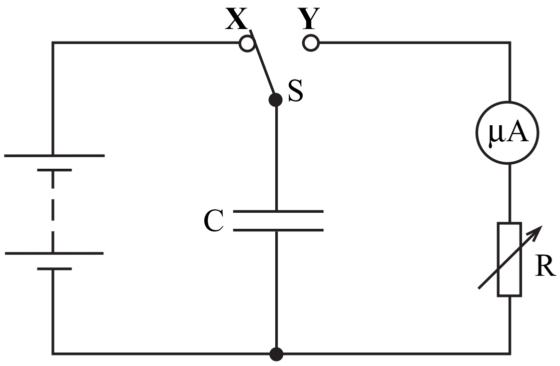
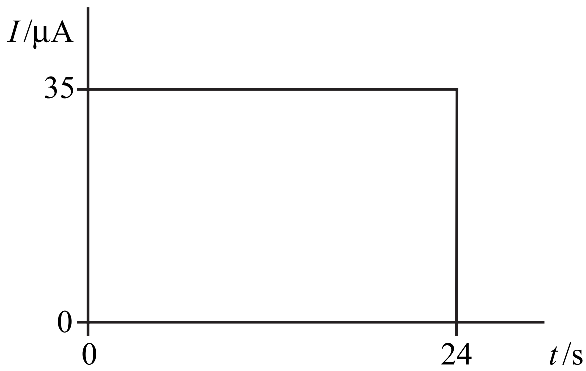


Figure 3 shows a graph of current, *I*, against time, *t*, obtained in such an experiment.

Figure 3



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(a) Calculate

(i) the initial charge stored by the capacitor,

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(ii) the capacitance of the capacitor, if the emf of the battery used was 6.0 V.

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(2 marks)

/2

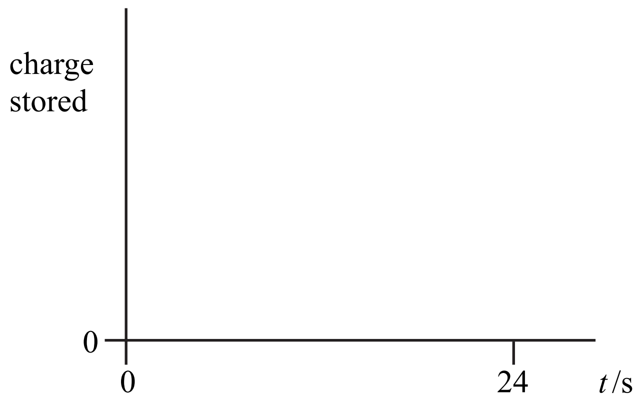
(b) Sketch graphs on the axes below to show, for the capacitor, how

(i) the charge stored
(ii) the energy stored

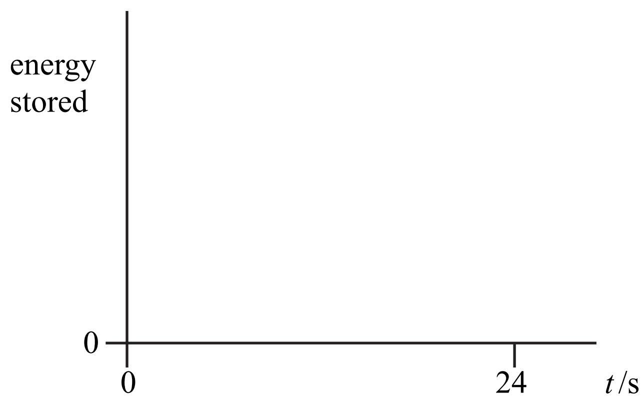
varied with time during the experiment.

You do not need to show any values on the vertical axes.

(i)



(ii)



(4 marks)

/4

/6

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4 (a) State what is meant by *gravitational field strength* at a point in a gravitational field and state whether it is a scalar or vector quantity.

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(2 marks)

0 1 2 /2

(b) A satellite of mass 2.5×10^3 kg is to be moved from the surface of the Earth to an orbit of radius 1.6×10^7 m around the Earth.

(i) Calculate the gravitational force acting on the satellite when in orbit.

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(ii) Given that the gravitational potential at the surface of the Earth (due to the Earth) is $-63\,\text{MJ}\,\text{kg}^{-1}$, calculate the increase in the gravitational potential energy of the satellite when it is placed in the orbit.

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(5 marks)

0 1 2 3 4 5 /5

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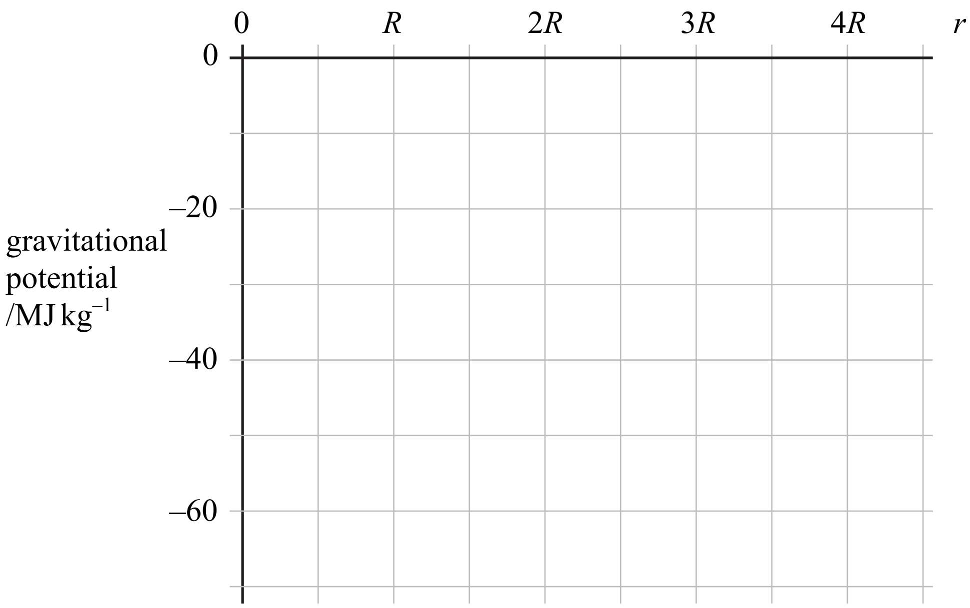
(c) Draw a graph on the axes below to show how the gravitational potential due to the Earth varies with distance, r, measured from the centre of the Earth, for points outside the Earth. On the horizontal axis, R is the radius of the Earth.



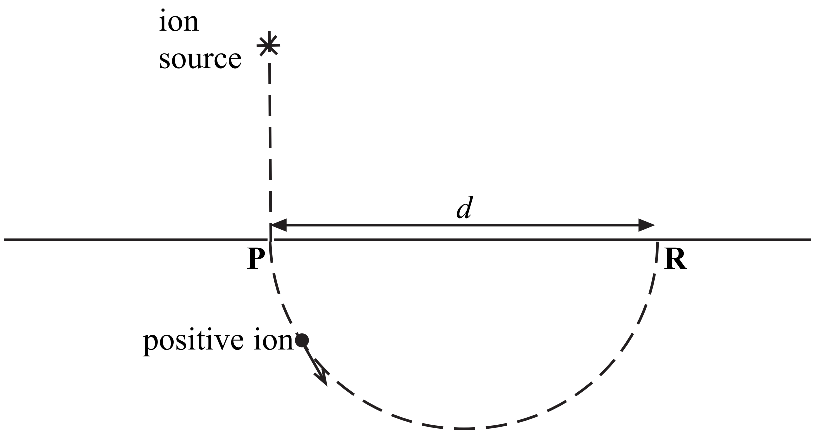
(3 marks)

0 1 2 3 /3 /10

Turn over for the next question

5 **Figure 4** shows the arrangement of an apparatus for determining the masses of ions. In an evacuated chamber, positive ions from an ion source pass through the slit at **P** with the same velocity *v*. After passing **P**, the ions enter a region over which a uniform magnetic field is applied. The ions travel in a semicircular path of diameter *d* and are detected at points such as **R**.

Figure 4



(a) (i) State the direction of the applied magnetic field.

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(ii) Explain why the ions travel in a semicircular path whilst in the magnetic field.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer.

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(iii) By considering the force that acts on an ion of mass m and charge Q, having velocity v, show that the diameter d of the path of the ions is given by

$$d = \frac{2mv}{BQ},$$

where B is the flux density of the magnetic field.

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(7 marks)

0 1 2 3 4 5 6 7 /7

(b) In an experiment using singly-ionised magnesium ions travelling at a velocity of $7.5 \times 10^4\ \mathrm{m\,s^{-1}}$, d was 110 mm when B was 0.34 T. Use this result to calculate the charge to mass ratio of these ions.

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(2 marks)

0 1 2 /2

Question 5 continues on the next page

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Turn over

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(c) (i) Some ions of the same element, whilst travelling at the same velocity as each other at **P**, may arrive at a point that is close to, but slightly different from, **R**.
Explain why this might happen.

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(ii) Other ions of the same element, also travelling at the same velocity at **P** as all of the others, may travel in a path whose diameter is half that of the others.
Explain why this might happen.

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(3 marks)

0 1 2 3 /3

/12

0 1 2

Quality of Written Communication *(2 marks)*

/2

END OF QUESTIONS