Surname		Other Names	
Centre Number			Candidate Number	
Candidate Signature			

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General Certificate of Education
June 2002
Advanced Level Examination

ASSESSMENT and QUALIFICATIONS ALLIANCE

PHYSICS (SPECIFICATION A) PA10
Unit 10 The Synoptic Unit

Thursday 27 June 2002 9.00am to 11.00am

In addition to this paper you will require:
- a calculator;
- a pencil and a ruler.

Time allowed: 2 hours

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

Information
- The maximum mark for this paper is 80.
- Mark allocations are shown in brackets.
- The paper carries 20% of the total marks for Physics Advanced.
- A *Data Sheet* is provided on pages 3 and 4. You may wish to detach this perforated sheet at the start of the examination.
- You are expected to use a calculator where appropriate.
- In questions requiring description and explanation you will be assessed on your ability to use an appropriate form and style of writing, to organise relevant information clearly and coherently, and to use specialist vocabulary where appropriate. The degree of legibility of your handwriting and the level of accuracy of your spelling, punctuation and grammar will also be taken into account.

For Examiner's Use			
Number	Mark	Number	Mark
1			
2			
3			
4			
5			
6			
7			
8			
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

Data Sheet

- A perforated Data Sheet is provided as pages 3 and 4 of this question paper.
- This sheet may be useful for answering some of the questions in the examination.
- You may wish to detach this sheet before you begin work.

THE DATA SHEET WILL REPLACE THIS PAGE

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

1 (a) When an α particle is emitted from a nucleus of the isotope $^{212}_{83}$Bi, a nucleus of thallium, Tl, is formed. Complete the equation below.

$$^{212}_{83}\text{Bi} \longrightarrow \alpha + \text{Tl}$$

(2 marks)

(b) The α particle in part (a) is emitted with 6.1 MeV of kinetic energy.

(i) The mass of the α particle is 4.0 u. Show that the speed of the α particle immediately after it has been emitted is $1.7 \times 10^7\,\text{m s}^{-1}$. Ignore relativistic effects.

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(ii) Calculate the speed of recoil of the daughter nucleus immediately after the α particle has been emitted. Assume the parent nucleus is initially at rest.

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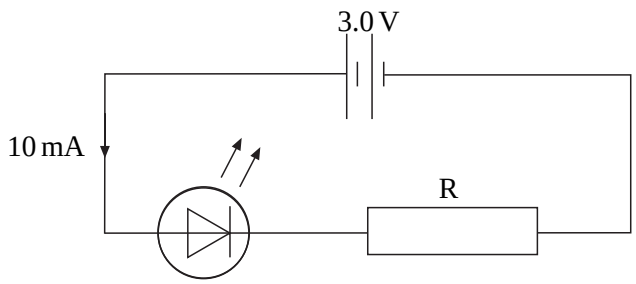
(6 marks)

8

2 The circuit diagram shows a light-emitting diode connected in series with a resistor R and a 3.0 V battery of negligible internal resistance. The potential difference across the terminals of the diode is 2.0 V and the current through it is 10 mA. The diode emits photons of wavelength 635 nm.



(i) Calculate the resistance of R.

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(ii) Calculate the electrical power supplied to the diode.

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(iii) Calculate the energy of a photon of wavelength 635 nm.

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(iv) Estimate the number of photons emitted per second by the diode.

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(v) State an assumption you made in your estimation in part (iv).

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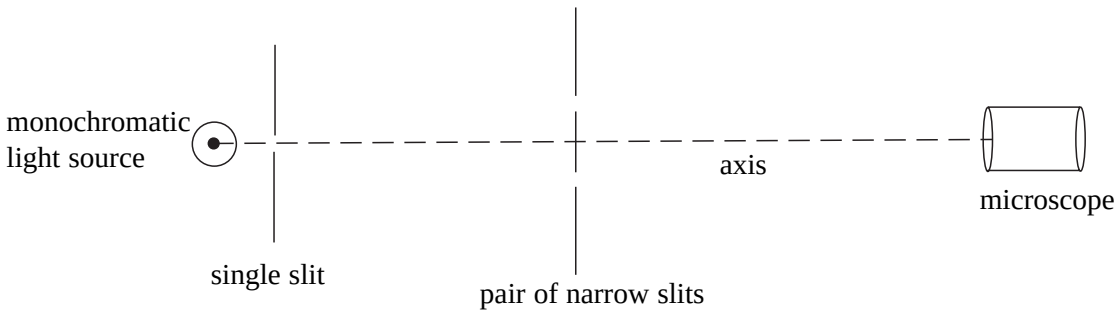
(8 marks)

8

3 The diagram shows two closely spaced narrow slits illuminated by light from a single slit in front of a monochromatic light source. A microscope is used to view the pattern of bright and dark fringes formed by light from the two slits.



(a) (i) Explain qualitatively why these fringes are formed.

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(ii) Describe what is observed if one of the narrow slits is covered by an opaque object.

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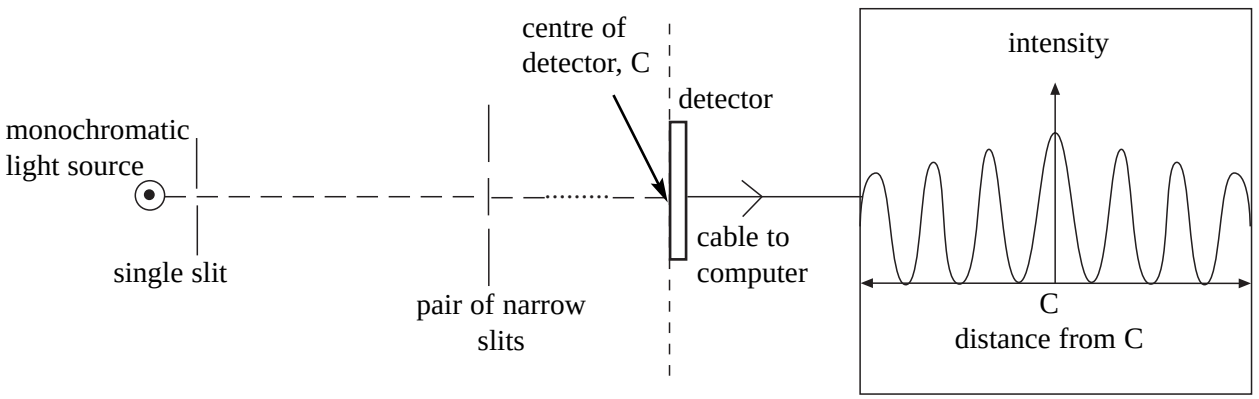
(8 marks)

QUESTION 3 CONTINUES ON THE NEXT PAGE

(b) The microscope is replaced by a fibre-optic detector linked to a computer. The detector consists of the flat end of many optical fibres fixed together along a line. The other end of each optical fibre is attached to a light-sensitive diode in a circuit connected to a computer.
The signal to the computer from each diode is in proportion to the intensity of light incident on the diode. The computer display shows how the intensity of light at the detector varies along the line of the detector when both of the narrow slits are open.



display seen on computer

(i) Describe and explain how the pattern on the display would change if the slit separation were increased.

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(ii) Each fibre consists of a core of refractive index 1.50 surrounded by cladding of refractive index 1.32. Calculate the critical angle at the core-cladding boundary.

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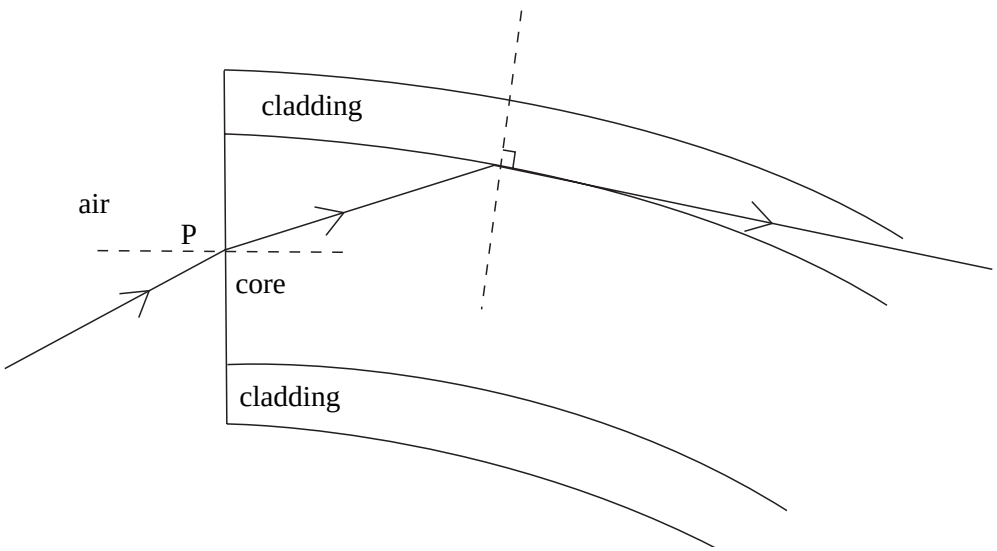
(iii) The diagram below shows a light ray entering an optical fibre at point P on the flat end of the fibre. The angle of incidence of this light ray at the core-cladding boundary is equal to the critical angle. On the diagram, sketch the path of another light ray from air, incident at the same point P, which is totally internally reflected at the core-cladding boundary.



(7 marks)

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15

TURN OVER FOR THE NEXT QUESTION

4 Protons and pions are produced in a beam from a target in an accelerator. The two types of particles can be separated using a magnetic field.

(a) State the quark composition of

(i) a proton,

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(ii) a positive pion, π^+.

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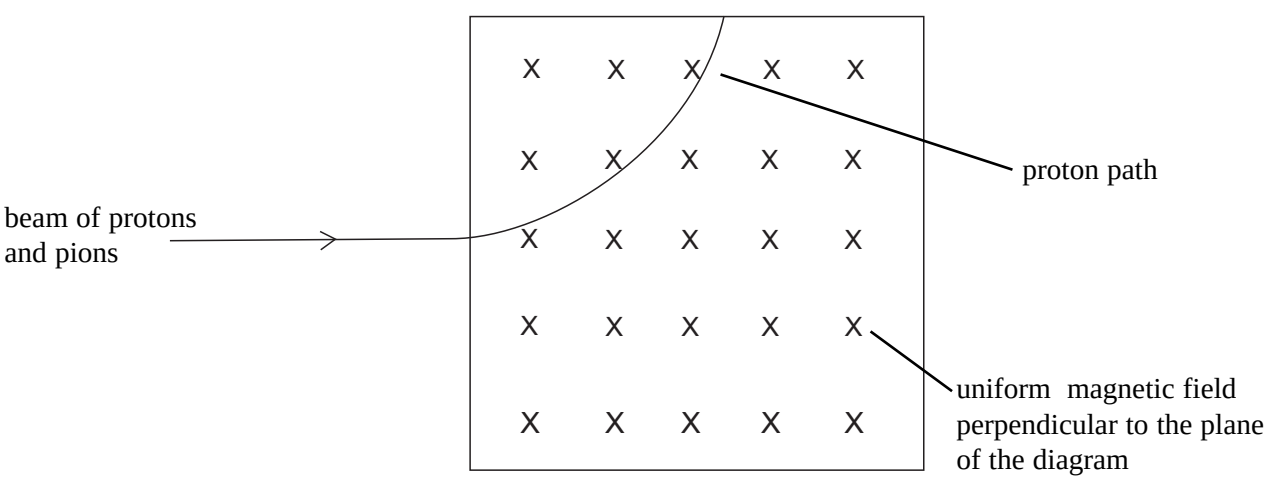
(2 marks)

(b) A narrow beam consisting of protons and positive pions, all travelling at a speed of $1.5 \times 10^7\,\text{m s}^{-1}$, is directed into a uniform magnetic field of flux density 0.16 T, as shown in the diagram.



(i) Calculate the radius of curvature of the path of the protons in the field.

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(ii) Sketch, on the diagram opposite, the path of the pions from the point of entry into the field to the point of exit from the field.

(iii) If the magnetic field were increased, how would this affect the paths of the particles?

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(7 marks)

9

TURN OVER FOR THE NEXT QUESTION

5 A domestic room heater which uses natural gas as the fuel, produces an output power of 4.5 kW. The energy obtained from a cubic metre of this fuel is 39 MJ. The density of the gas is 0.72 kg m^{-3} at atmospheric pressure.

(a) Show that the volume of gas which must be burnt each minute is $6.9 \times 10^{-3} m^3$.

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(2 marks)

(b) Calculate

(i) the mass of gas which is burnt each minute,

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(ii) the number of molecules of natural gas which pass through the burner each minute if the molar mass of the gas is 1.6×10^{-2} kg mol^{-1}.

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(4 marks)

(c) When the heater is first turned on, the temperature of the air entering it is 14 °C and the temperature of the air leaving it is 36 °C. If the specific heat capacity of air is 990 J $kg^{-1} K^{-1}$, calculate the mass of air passing through the heater in one minute.

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(3 marks)

(d) The room could have been heated using a 4.5 kW electric heater. Explain with a suitable calculation why such a heater could **not** be operated from a 13 A, 230 V socket.

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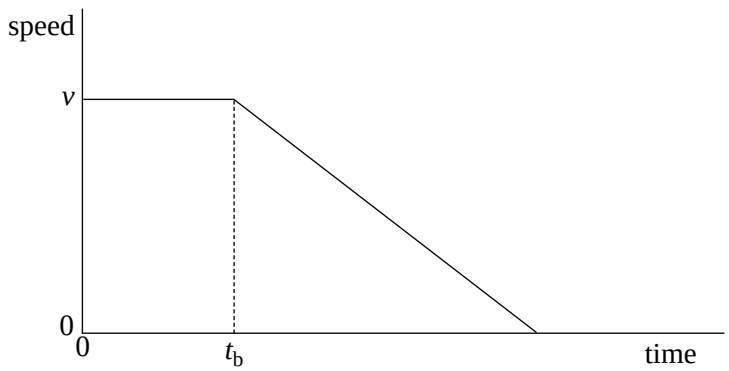
(2 marks)

6 The driver of a car sees an obstruction ahead and applies the brakes at time t_b later, bringing the car to a halt. The graph shows how the speed of the car varies with time.



The stopping distance, s, of the car which was travelling at speed v before the driver applied the brakes, can be represented by the equation

$$s = vt_b + \frac{v^2}{2a},$$

where a is the magnitude of the deceleration of the car (assumed constant).

(a) State what distance is represented by each of the terms

vt_b .....

$\frac{v^2}{2a}$ .....

(2 marks)

QUESTION 6 CONTINUES ON THE NEXT PAGE

(b) The table includes data on stopping distances of cars. Column C gives the total stopping distance for a car travelling at each of the speeds shown in column A.

column A	**column B**	**column C**	**column D**
speed v/km h^{-1}	speed v/m s^{-1}	stopping distance s/m	$\frac{s}{v}$/sec
32	8.9	12	
48		23	
64		36	
80		53	
96		73	
112		96	

(i) Complete column B.

(ii) In column D, calculate each of the corresponding values of $\frac{s}{v}$.

(2 marks)

(c) The equation for s can be rearranged as $\frac{s}{v} = t_b + \frac{v}{2a}$.

From the data you have calculated, plot a suitable graph on the grid provided to verify this equation.

(5 marks)

(d) From your graph determine the value of

(i) t_b .....

(ii) the magnitude of the deceleration, a.

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(4 marks)

13

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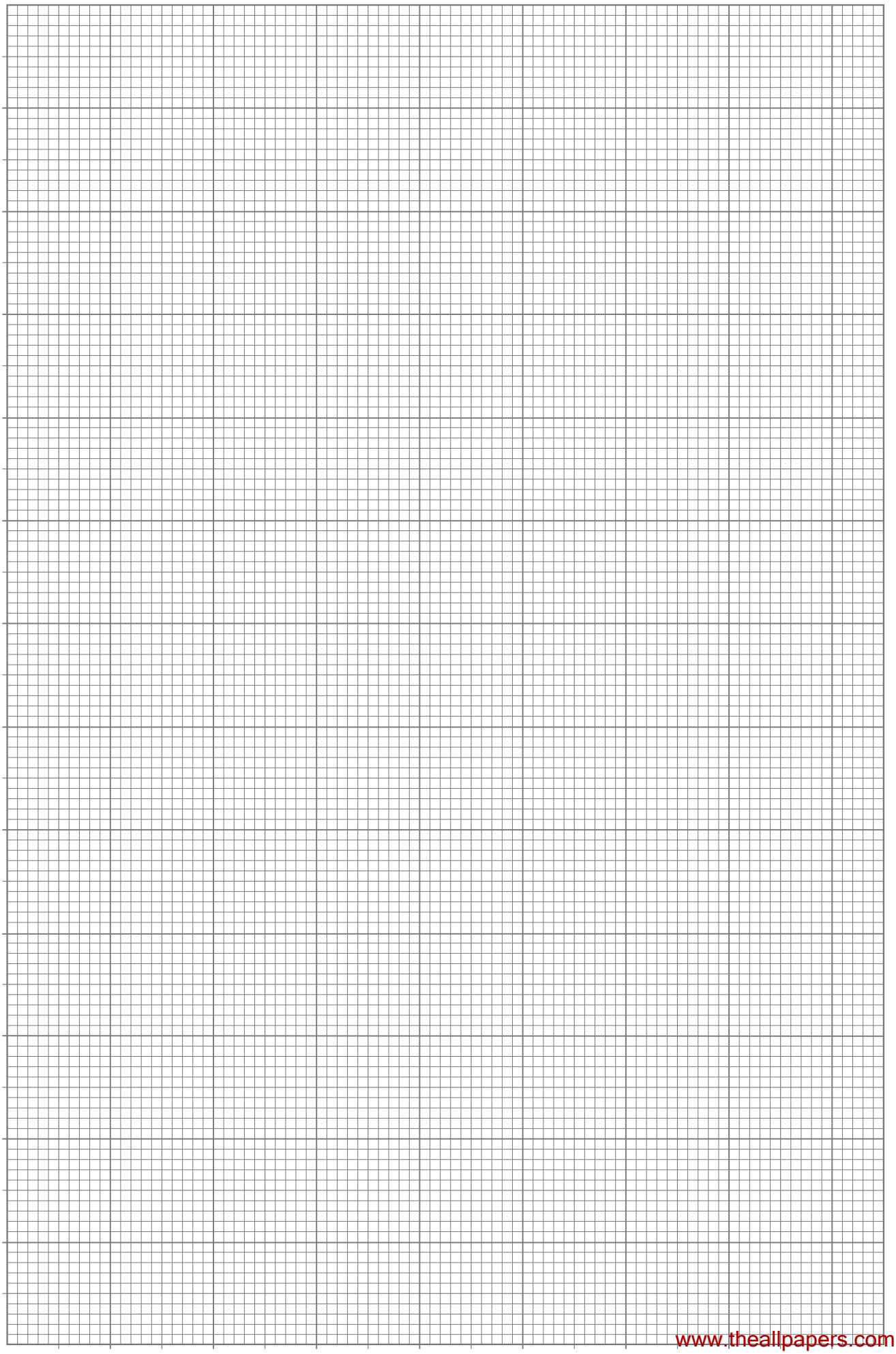

7 (a) A satellite moves in a circular orbit at constant speed. Explain why its speed does not change even though it is acted on by a force.

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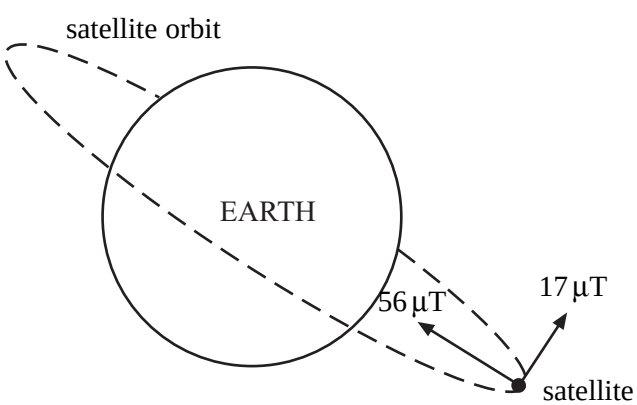
(3 marks)

(b) At a certain point along the orbit of a satellite in uniform circular motion, the Earth's magnetic flux density has a component of 56 μT towards the centre of the Earth and a component of 17 μT in a direction perpendicular to the plane of the orbit.



(i) Calculate the magnitude of the resultant magnetic flux density at this point.

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(ii) The satellite has an external metal rod pointing towards the centre of the Earth. Calculate the angle between the direction of the resultant magnetic field and the rod.

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(iii) Explain why an emf is induced in the rod in this position.

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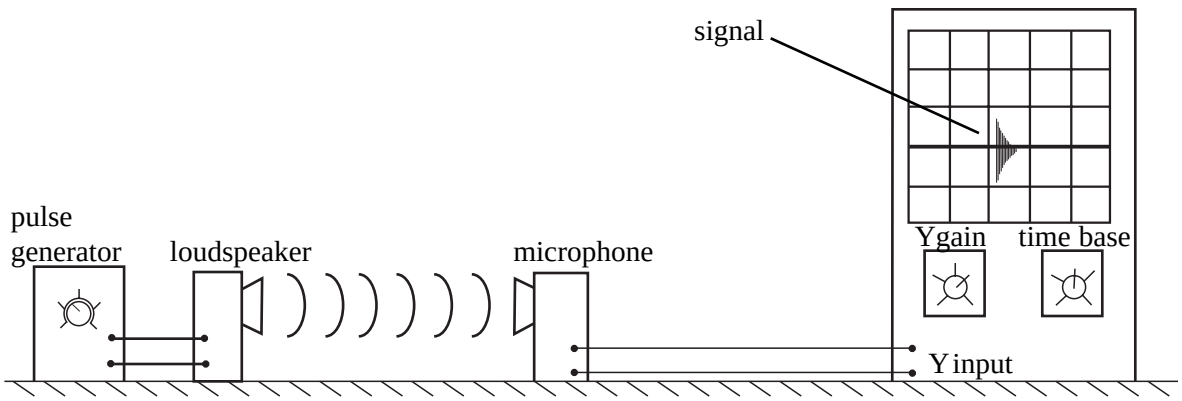
(4 marks)

7

TURN OVER FOR THE NEXT QUESTION

8 A loudspeaker connected to a pulse generator produces short pulses of sound. A microphone connected to an oscilloscope is used to detect the sound waves. The oscilloscope controls are adjusted so that the oscilloscope trace starts a sweep when a pulse is produced by the loudspeaker. When the sound pulse reaches the microphone, a signal appears on the screen.



(a) (i) Explain why the position of the signal is not at the start of each sweep.

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(ii) When the microphone is moved away from the loudspeaker, the signal on the screen moves to the right. Explain why this happens.

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(iii) The oscilloscope time base is set at $0.20\,\text{ms}\,\text{cm}^{-1}$. The signal moves 3.0 cm across the screen when the microphone is moved 20.0 cm further away from the loudspeaker.
Use these measurements to calculate the speed of sound in air.

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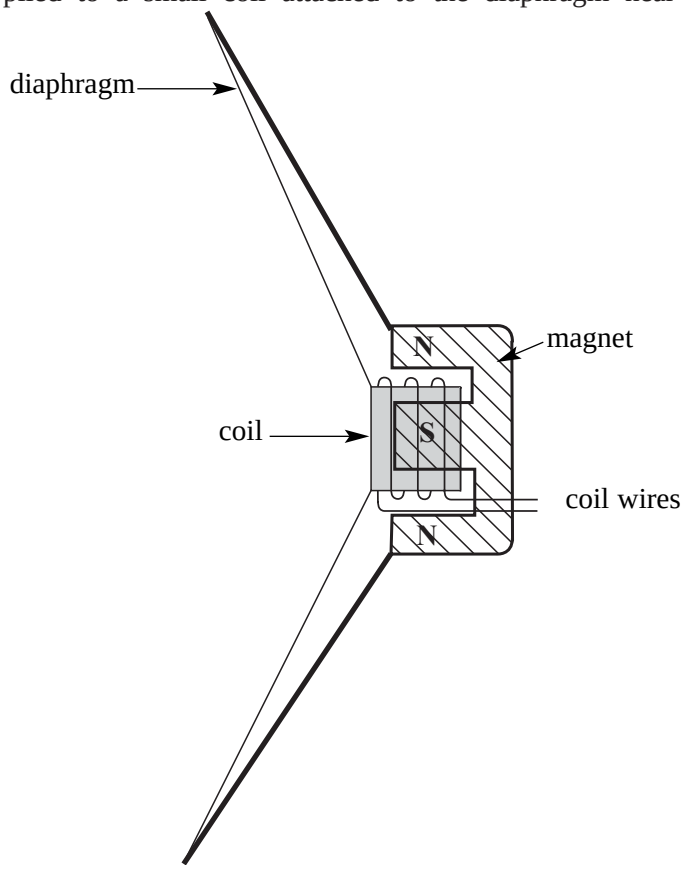
(5 marks)

(b) The loudspeaker diaphragm produces sound waves as a result of an alternating potential difference applied to a small coil attached to the diaphragm near a fixed magnet in the loudspeaker.



(i) Explain why the application of an alternating potential difference makes the coil vibrate.

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(ii) Explain why the loudspeaker would not operate as effectively if the magnet were attached to the diaphragm and the coil were fixed.

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(4 marks)