PDG

Candidate Name ______________________ (   ) [   ]

ANDERSON JUNIOR COLLEGE

2014 JC2 Preliminary Examination

PHYSICS **8866/02**

Higher 1

Paper 2 Structured Questions **Thursday 18 September 2014**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your **name** and **PDG** in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

The use of an approved scientific calculator is expected where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
1	
2	
3	
4	
5	
6	
Section B	
7	
8	
9	
Deduction	
Total	

This document consists of **22** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$

Section A

Answer **all** the questions in this section

1 **(a)** A body has an initial velocity u and an acceleration a. After a time t, the body moved a distance s and has a final velocity v. One of its equation of motion is

$$s = ut + \frac{1}{2}at^2.$$

State two conditions that must be satisfied for the above equation to be valid.

…………………………………………………………………………………………………..….

…………………………………………………..…………………..……………………..…. [2]

(b) A hot air balloon was rising steadily at a speed of 10.0 m s^{-1} when weather conditions turned windy. A constant breeze of 3.0 m s^{-1} blew horizontally across the sky, which caused the hot air balloon to travel with a resultant velocity of v_R at an angle θ to the horizontal, as shown in Fig. 1.1 below.

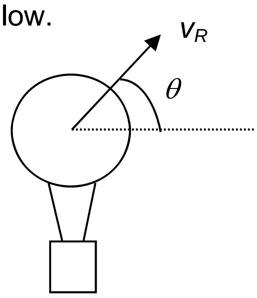

Fig. 1.1

(i) Calculate the magnitude and direction of the resultant velocity v_R.

θ = …………………….. °

v_R = …………………….. m s^{-1} [2]

(ii) A sandbag was dropped from the balloon.

Determine how far below the balloon would the sandbag be after 4.0 s. You may assume that the sandbag had not landed on the ground, the dropping of sandbag did not affect the velocity of the hot air balloon and that air resistance on the sandbag is negligible.

distance = …………………………… m [3]

2 Fig. 2.1 shows a signboard suspended by two elastic ropes of tension T_1 and T_2. The tension in T_1 is 300 N and the tension in T_2 is 252 N.

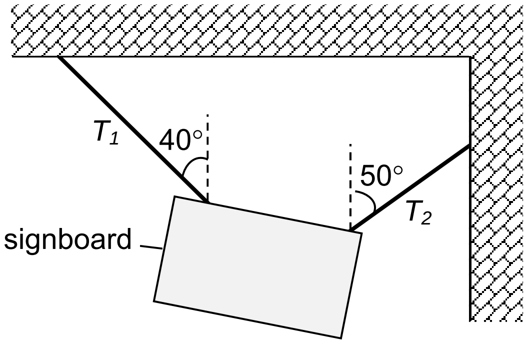

Fig. 2.1

(a) **(i)** State the conditions for equilibrium.

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) On Fig. 2.1, mark the centre of gravity of the signboard with a dot and label the point as G. Show clearly your construction to determine the centre of gravity on Fig. 2.1. [1]

(iii) Determine the weight of the signboard.

weight = …………………………….N [1]

(b) The signboard is pulled vertically downwards with a force of 20 N so that the ropes are stretched. Determine the acceleration of the signboard immediately after it is released.

acceleration = …………………………….m s^{-2} [2]

3 A mass *m*, attached to the end of an unstretched spring, is initially supported by a platform as shown in Fig. 3.1.

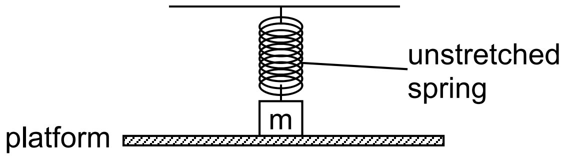

Fig. 3.1

The platform is then removed and the spring-mass system starts to oscillate.

Describe the energy changes taking place from the instant the platform is removed until the spring is first fully extended.

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……[4]

4 **(a)** Explain why resistance of a metal rises with increasing temperature.

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……[3]

(b) In Fig 4.1 below, an electrical device (load) is connected in series with a cell of e.m.f. 2.5 V and internal resistance *r*. The current I in the circuit is 0.10 A. The power dissipated in the load is 0.23 W.

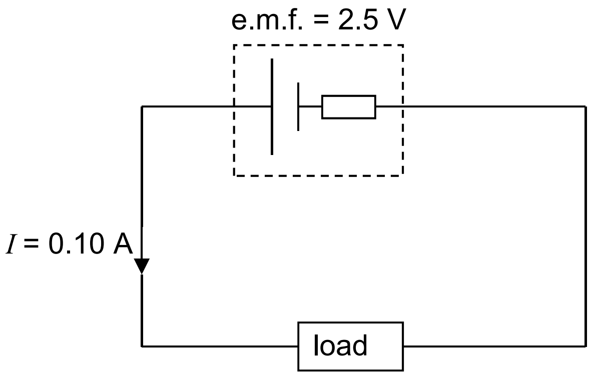

Fig 4.1

(i) Show that the internal resistance *r* of the cell is 2.0 Ω.

[1]

(ii) A second identical cell is connected into the circuit in **(b)(i)** as shown below in Fig. 4.2.

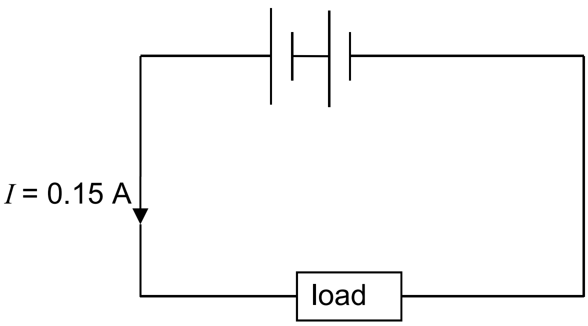

Fig. 4.2

The current in this circuit is 0.15 A. Deduce that the load is a non-ohmic device.

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………………………………………………………………………………………………[3]

5 Fig. 5.1 shows five energy levels for electrons in a mercury atom.

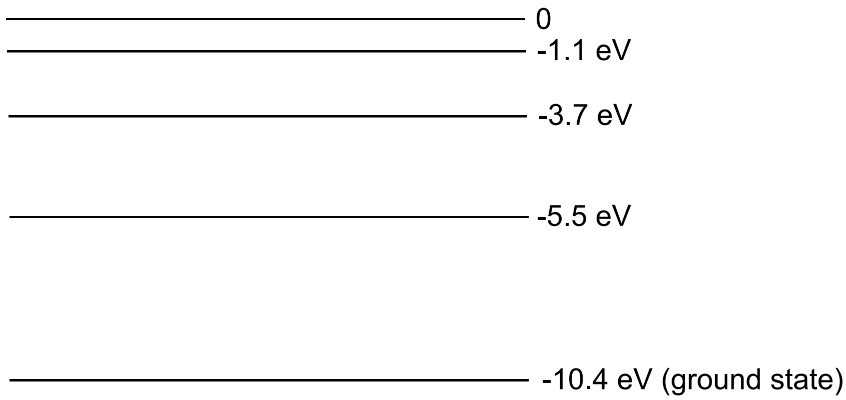

Fig. 5.1

(a) State the number of possible transitions between these five levels which result in photon emission.

number of transitions = ……………….. [1]

(b) Cool mercury vapour at low pressure is bombarded with electrons of kinetic energy 8.0 eV.

(i) Calculate the shortest wavelength photon that could be emitted.

wavelength = …………..……..….. nm [2]

(ii) State the region of the electromagnetic spectrum in which the radiation in **(b)(i)** lies.

……………………………………………………………………………………..….... [1]

(iii) For the possible transitions, sketch the spectrum produced. [2]

(c) Explain how Fig. 5.1 can be used to account for absorption spectra.

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………………………………….……………………………………………………..……….. [2]

6 A student is investigating the stopping distance for a motorcycle with high-performance brakes. A motorcyclist riding and stopping a motorcycle on a test track is recorded on film.

The stopping distance d is measured for different speeds v. It is found that the stopping distance d is related to the thinking distance d_1 due to reaction time of the motorcyclist and the braking distance d_2 of the motorcycle by the following equation

$$d = d_1 + d_2$$

The variation with speed v of the stopping distance d and the braking distance d_2 is shown in Fig. 6.1.

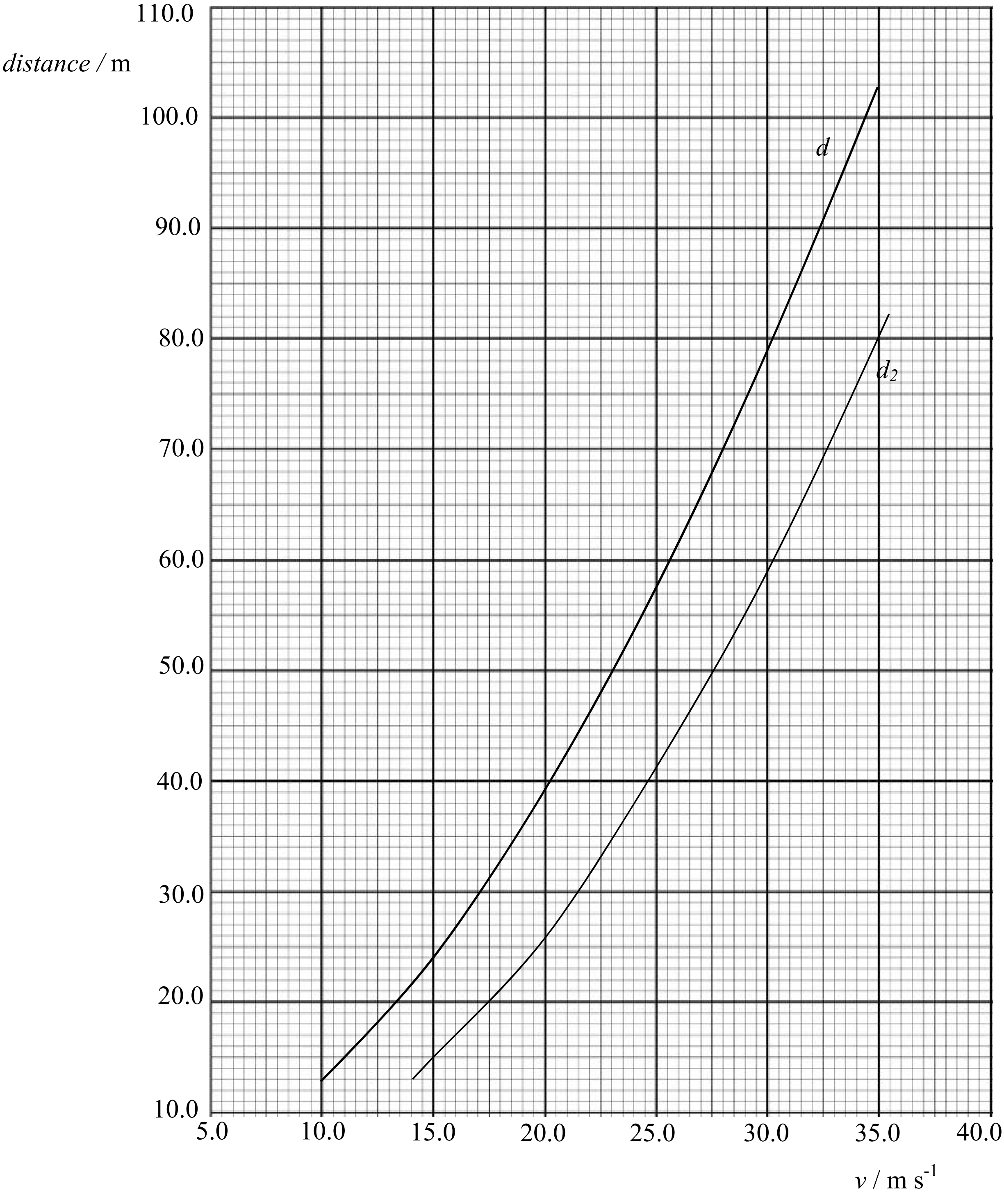
110.0
distance / m
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
v / m s-1
d
d2

Fig. 6.1

(a) Take values from the graphs to show how the values of stopping distance *d*, braking distance d_2 and hence the thinking distance d_1 vary with the speed *v*. Enter your values in the table below.

v / m s^{-1}	d / m	d_2 / m	d_1 / m
15.0			
20.0			
25.0			
30.0			
35.0			

[2]

(b) Plot a graph of d_1 against *v*.

[1]

(c) The relationship between d_1 and v is of the form $d_1 = Av$, where A is a constant. Find the value of A. Show your working.

A = ……………………….[1]

(d) What would be the effect on the thinking distance d_1 and the braking distance d_2 of each of the following conditions?

(i) The test track is wet.

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……………………………………………………………………………………………[2]

(ii) The motorcyclist is not fully alert.

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……………………………………………………………………………………………

……………………………………………………………………………………………[2]

Section B

Answer any **two** questions in this section

7 **(a)** Define force.

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………………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(b) Fig. 7.1 shows two bodies of mass *M* and *m* respectively (*M* > *m*) connected by a light rope which passes over two pulleys. Mass *m* moves along frictionless plane inclined at an angle 30° to the horizontal. The tensions in both sides of the rope may be assumed to be equal at all times.

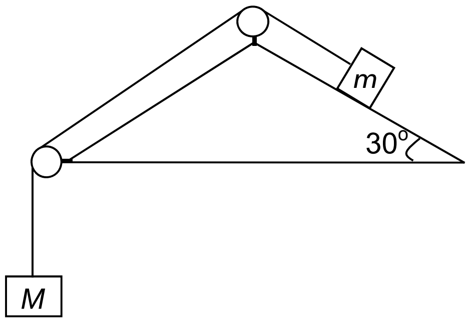

Fig. 7.1 (Not to scale)

(i) Use Fig. 7.2 to

1. draw free body diagrams for the masses *M* and *m*,

mass *M* mass *m*

Fig. 7.2 [3]

2. indicate the direction of positive accelerations for masses *M* and *m*. [1]

(ii) Show that the tension is

$$1.5\left(\frac{Mmg}{M+m}\right)$$

where g is the acceleration due to gravity.

[2]

(iii) Hence, or otherwise, calculate the acceleration of the body of mass M given that M is 6.0 kg and m is 3.0 kg.

acceleration = ……………… m s^{-2} [3]

(iv) If the track has friction, write down a word equation to show the energy conversions taking place in this system.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[1]

(c) A stationary radium nucleus ($^{224}_{88}Ra$) of mass 224 *u* undergoes radioactive decay and emits an α-particle ($^{4}_{2}He$) of mass 4 *u*. The α-particle is emitted with a kinetic energy of 5.2×10^{-13} J and the reaction gives rise to a nucleus of radon (Rn).

The nuclear equation representing the radioactive decay is as shown below.

$$^{224}_{88}Ra \rightarrow {}^{4}_{2}He + {}^{220}_{86}Rn$$

(i) State and explain whether this reaction is elastic.

……

……

……[2]

(ii) Calculate the speed at which the α-particle is emitted from the radium nucleus.

speed = ……………………m s^{-1}[2]

(iii) Explain why the given reaction obeys principle of Conservation of Momentum.

……

……[1]

(iv) Hence, determine the kinetic energy of the radon nucleus upon emission of the α-particle.

kinetic energy = ……………………… J [3]

8 **(a)** The wave nature of light may be demonstrated using the phenomena of interference. Describe an experiment to show how interference may be demonstrated using light. You may use a diagram to illustrate your answer.

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....[3]

(b) A microphone, connected to a cathode ray oscilloscope (c.r.o.), is placed at a distance of 1.2 m in front of a loudspeaker connected to a source of fixed frequency. The intensity of sound measured at this position is 0.65 W m^{-2}. The time base of the c.r.o. was set at 0.50 ms cm^{-1} and the display on the c.r.o. is shown in Fig. 8.1.

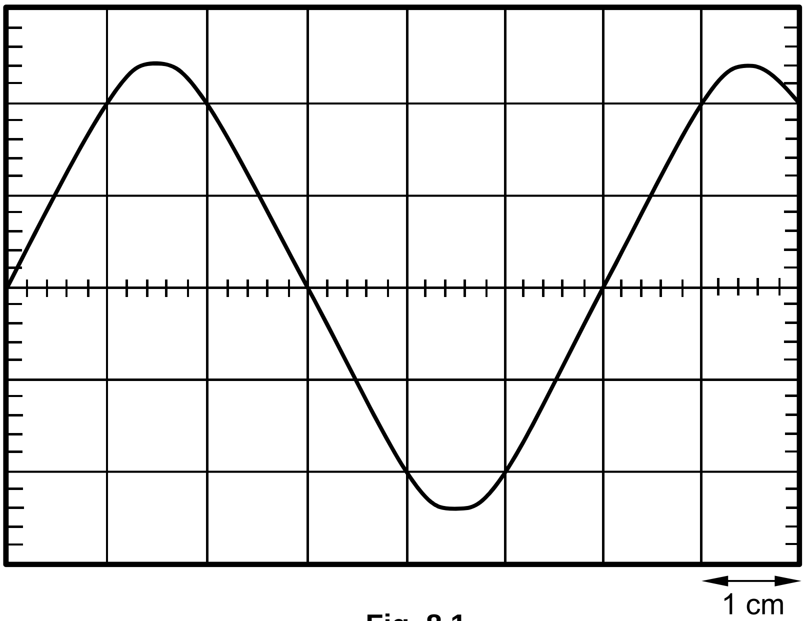

Fig. 8.1

(i) Determine the frequency of the sound wave.

frequency = ... Hz [2]

(ii) The speed of sound in air is given as 330 m s^{-1}.
Calculate the wavelength of the sound wave from the loudspeaker.

wavelength = ………………………………. m [2]

(iii) The same loudspeaker is now placed outdoors. A man stands in front of the loudspeaker at a distance 5.5 m away. Determine the intensity of the sound that the man hears at this distance.

intensity = ………………………………. W m^{-2} [2]

(c) Two identical loudspeakers, L_1 and L_2, connected to the same source as **(b)**, are placed 4.20 m apart. A sound detector is placed 8.40 m away from L_1, as shown in Fig. 8.2.

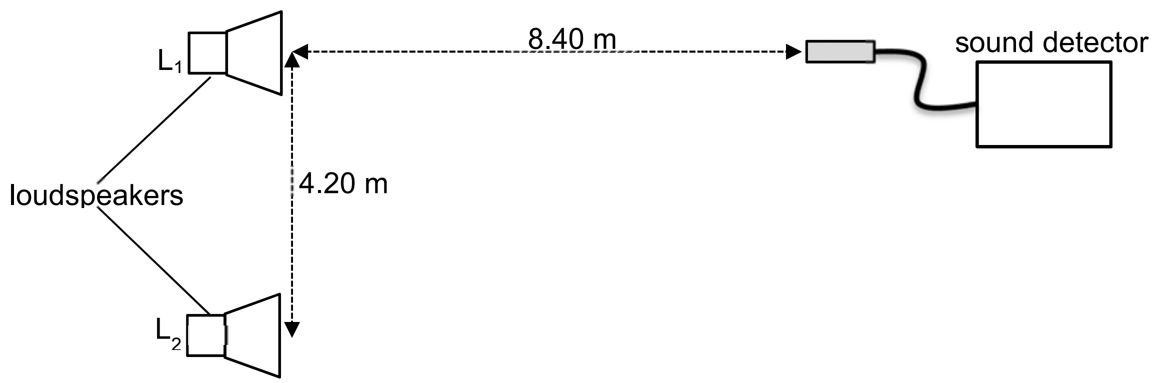

Fig. 8.2

(i) Show that the distance between L_2 and the sound detector is 9.39 m.

[1]

(ii) Hence, determine whether the intensity at the sound detector is a high or low.

[3]

(iii) The intensity of sound due to L_1 alone at sound detector 8.4 m away is I.

Show, in terms of I, the intensity at the sound detector due to both L_1 and L_2 is $3.6I$.

[3]

(iv) The loudspeaker L_2 is now moved towards the sound detector along the axis shown in Fig. 8.3.

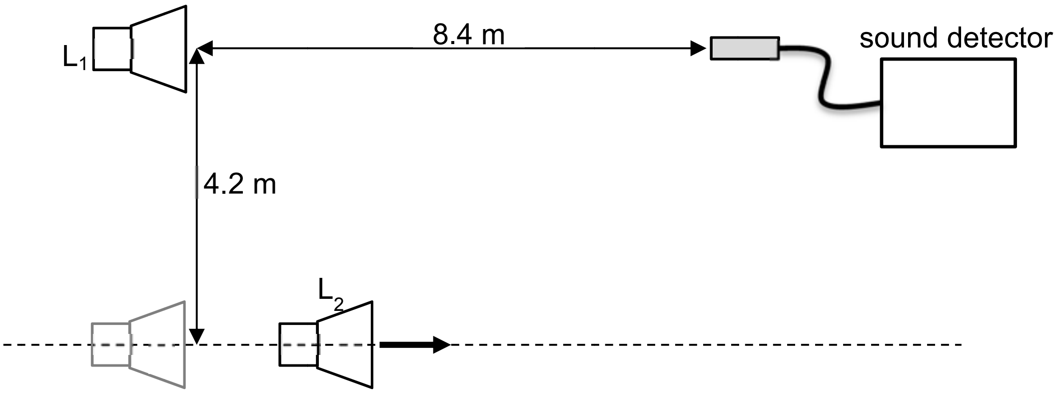

Fig. 8.3

Describe and explain the observation at the sound detector as L_2 is moved towards the sound detector, until L_2 is also 8.4 m away from the detector.

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…………………………………………………………………………………………………..[2]

(d) Noise cancellation headphones comes with embedded microphones, and actively makes use of interference to reduce noise that the listener hears.

Explain how this is achieved.

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………………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

9 **(a)** Define the *tesla*.

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……………………………………………………………………………………………………[2]

(b) Two long straight vertical wires PQ and XY are separated by a distance of r as shown in Fig. 9.1.

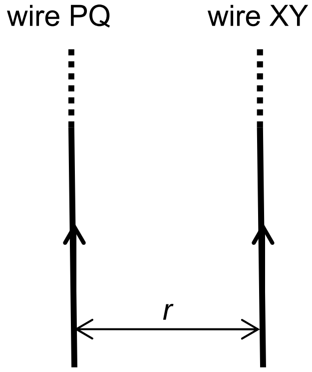

Fig. 9.1

(i) The current in wire XY is larger than the current in wire PQ.

Explain whether the force per unit length on the two wires will be the same, or different.

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…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(ii) Suppose that wire XY is free to move. Describe and explain the subsequent motion of wire XY in terms of its velocity and acceleration.

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…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(c) A large horseshoe magnet produces a uniform magnetic field of flux density *B* between its poles. Outside the region of the poles, the flux density is zero.
The magnet is placed on a top-pan balance and the wire XY is situated between its poles, as shown in Fig. 9.2.

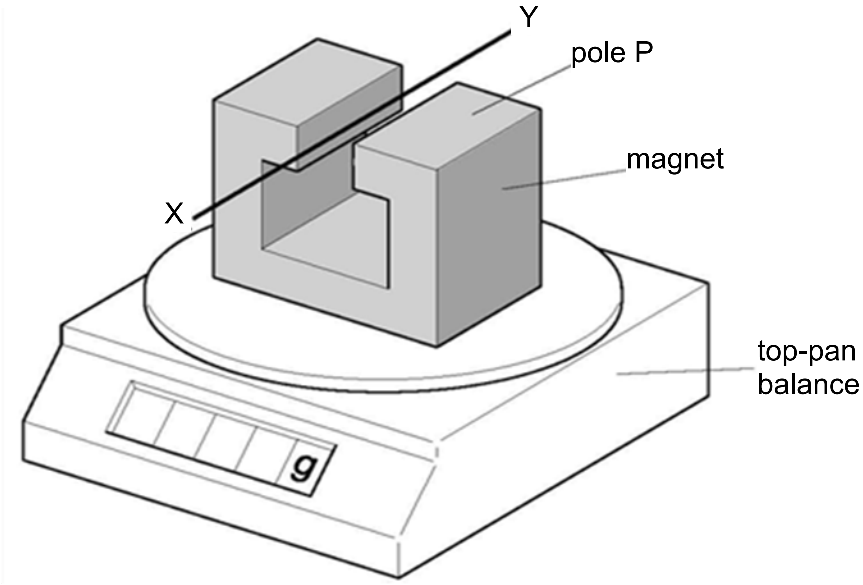

Fig. 9.2

The wire XY is horizontal and normal to the magnetic field. The length of wire between the poles is 4.4 cm.

A direct current of magnitude 2.6 A is passed through the wire in the direction from X to Y. The reading on the top-pan balance increases by 2.3 g.

(i) State and explain the polarity of the pole P of the magnet.

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…………………………………………………………………………………………

………………………………………………………………………………………… [3]

(ii) Calculate the flux density between the poles.

flux density = ……………………………..T [2]

(d) The $I - V$ characteristic of an electrical component C and a resistor R are shown in Fig. 9.3.

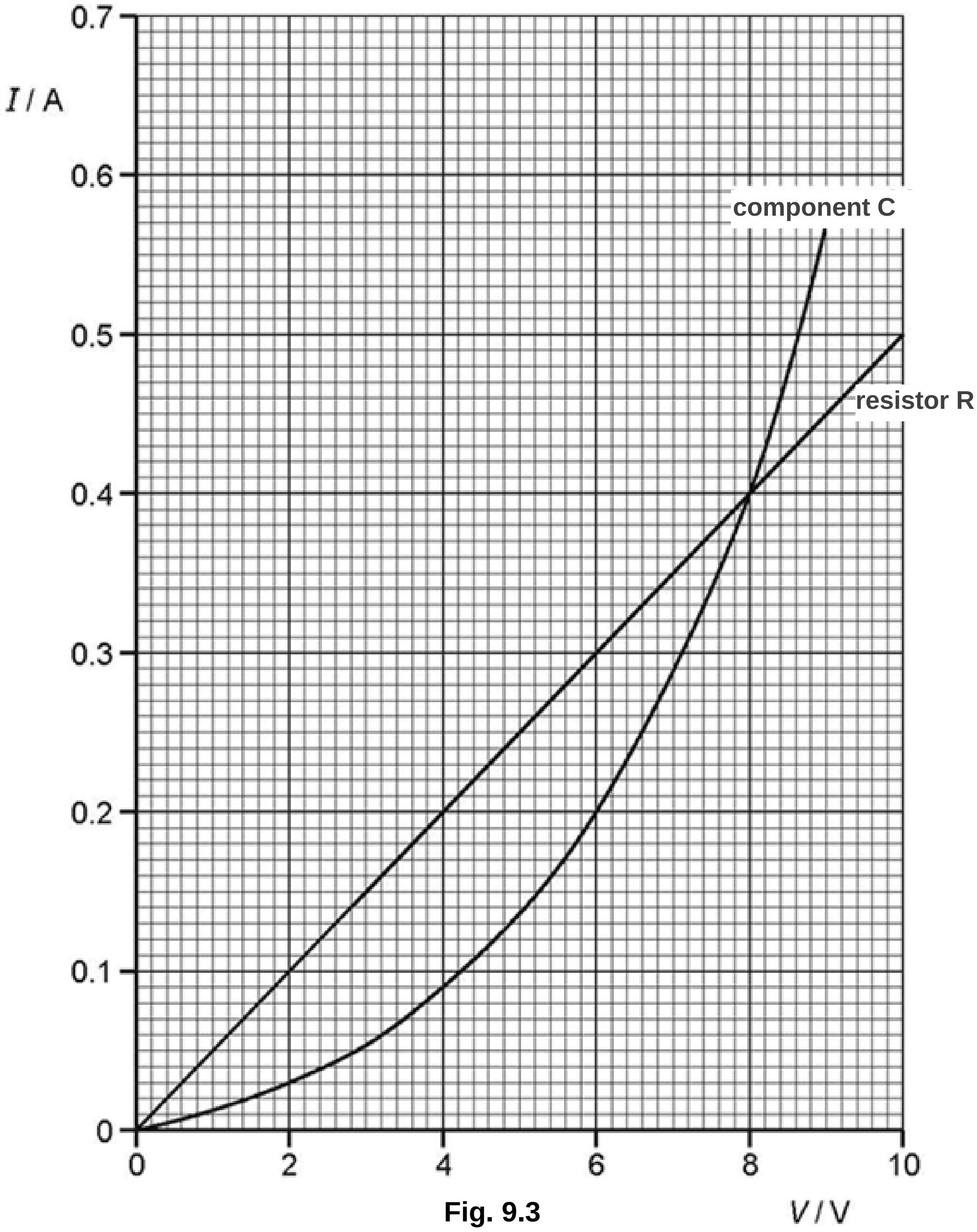

Fig. 9.3

(i) **1.** State, with a reason, whether the resistance of component C increases or decreases with increasing potential difference.

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……………………………………………………………………………………………...................

……………………………………………………………………………………………...................

……………………………………………………………………………………………..... [2]

2. Determine the resistance of component C at a potential difference of 6.0 V

resistance = ……………………………Ω [1]

(ii) A battery of e.m.f. *E* of 6.0 V and negligible internal resistance is connected to the component C and the resistor R in parallel as shown in Fig. 9.4.

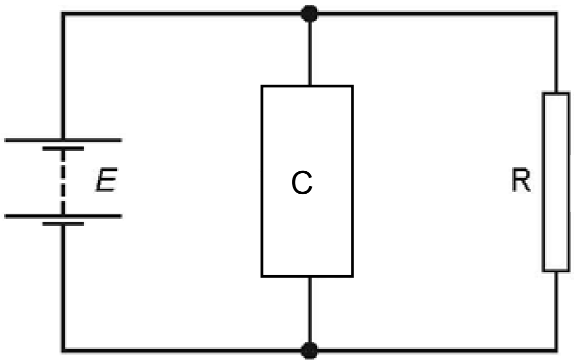

Fig. 9.4

Use data from Fig. 9.3. to determine

1. the current in the battery,

current = ...A [1]

2. the total power dissipated in component C and resistor R.

power = ...W [1]

(iii) The resistor R and the component C are now connected in series across a supply of e.m.f.10.0 V and negligible internal resistance.

Using information from Fig.9.3, state and explain which component, R or C, will dissipate thermal energy at a greater rate.

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…………………………………………………………………………………………….... [3]