PDG

Candidate Name ______________________________ [ ]

ANDERSON JUNIOR COLLEGE

2009 JC2 Preliminary Examination

PHYSICS **8866/02**

Higher 1

Paper 2 Structured Questions

Tuesday 22 September 2009

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 provided above.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **two** questions. Write down the numbers of the two questions attempted in the boxes on the right.

You are advised to spend about one hour on each section.
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 (40 marks)	
1	
2	
3	
4	
5	
Section B (40 marks)	
Significant Figure	
Total (80 marks)	

This question paper consists of **21** printed pages and **1** blank page.

[Turn over

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,	$h = 6.63 \times 10^{-34}$ Js
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,	$s = ut + ½at^2$ $v^2 = u^2 + 2as$
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 the spaces provided.

1 **(a)** Explain what is meant by the *moment of a force*.

....

....

.... [1]

(b) A desk lamp is illustrated in Fig. 1.1.

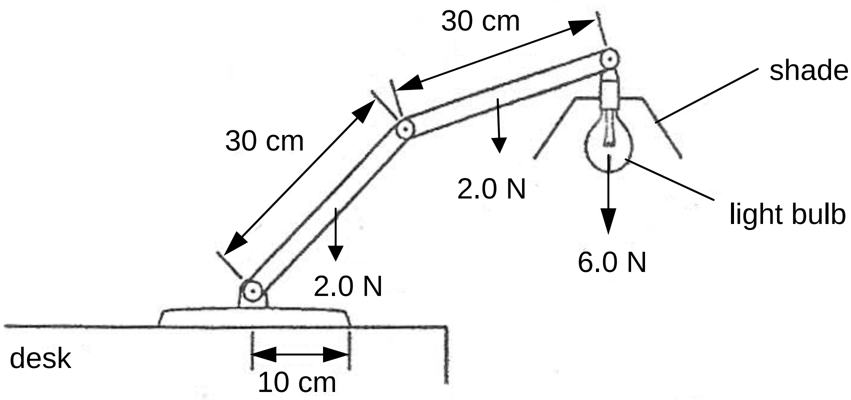

Fig. 1.1

The lamp must be constructed so that it does not topple over when fully extended as shown in Fig 1.2. The base of the lamp is circular and has a radius of 10 cm. Other dimensions are shown on the figure. The total weight of the light bulb and shade is 6.0 N and each of the two uniform arms has weight 2.0 N.

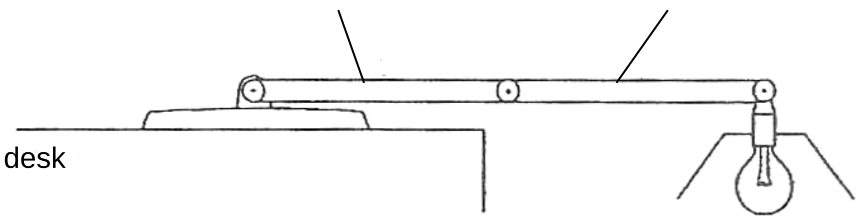

Fig. 1.2

(i) On Fig. 1.2, draw an arrow to represent the weight of the base and label it W. [1]

(ii) The lamp will rotate about a point if the base is not heavy enough. On Fig. 1.2, mark this point and label it P. [1]

(iii) Calculate the following moments about P.

1. moment of first arm

moment = ………………………… N m [1]

2. moment of second arm

moment = ………………………… N m [1]

3. moment of light bulb and shade

moment = ………………………… N m [1]

(iv) Use the principle of moments to calculate the minimum weight of base required to prevent toppling.

weight = .………………………… N [2]

2 Fig. 2.1 is a simplified representation of the six lowest energy levels of a hydrogen atom.

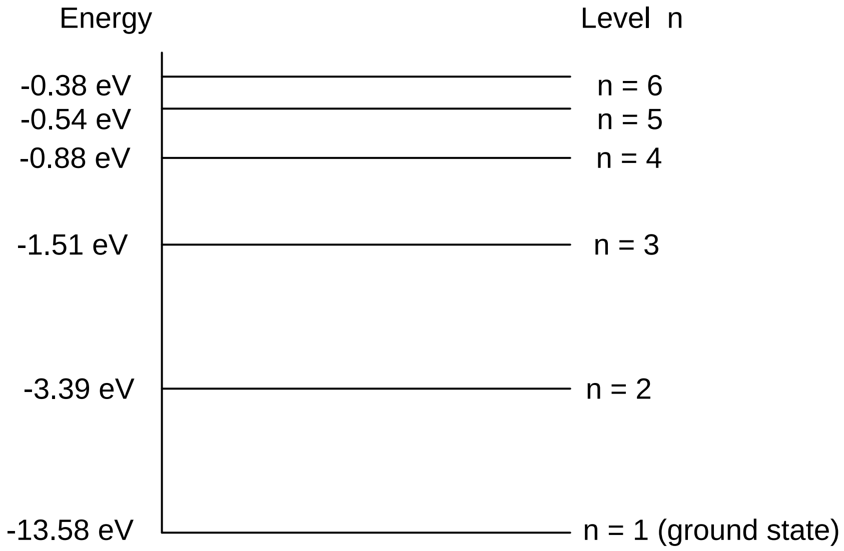

Fig. 2.1

Considering transitions between only these energy levels, the emission line spectrum due to transitions from higher energy levels to n = 1 (L-series) and n = 2 (B-series) is shown in Fig. 2.2.

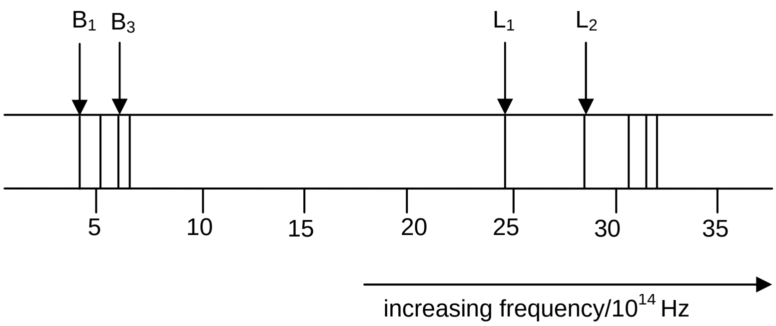

Fig. 2.2

(a) **(i)** On Fig. 2.1, draw an arrow to show the transition that gives rise to the B3 line. [1]

(ii) Calculate the frequency of the photon emitted by the transition indicated in **(a)(i)**.

frequency = ………………..…………… Hz [3]

(b) The frequencies of the B_1, L_1 and L_2 lines are f, f_1 and f_2 respectively.
Use Fig. 2.1 to show that $f = f_2 - f_1$.

[2]

(c) If the hydrogen atom is initially in the ground state, state the number of absorption lines that might be detected.

number of absorption lines = …………………………………… [1]

3 Fig. 3.1 shows an arrangement which demonstrates interference of sound waves.

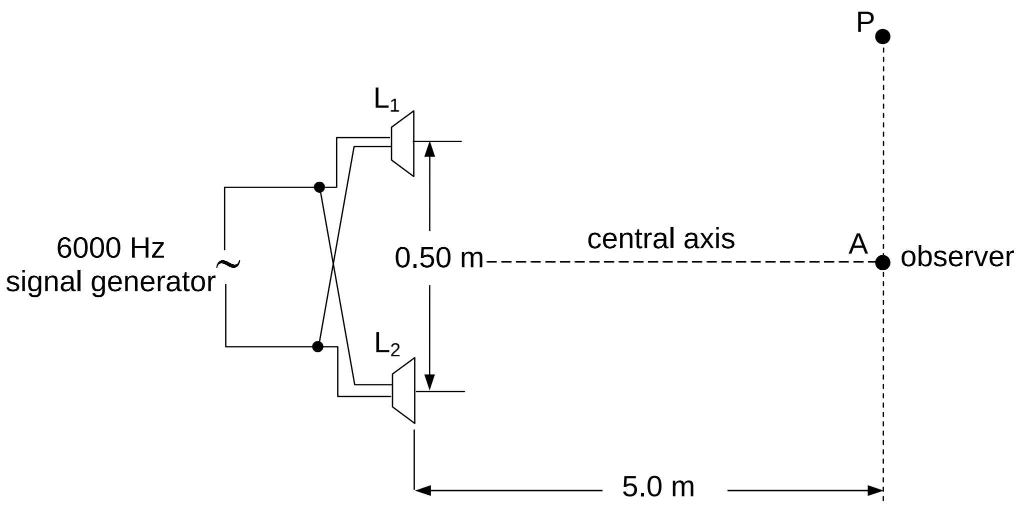

Fig. 3.1

The two loudspeakers L_1 and L_2 are driven by the same signal generator set to a frequency of 6000 Hz. The speakers are perfectly matched to emit the same power at this frequency. An observer identifies A as being the position where the loudest sound is heard.

(a) State and explain what conclusions can be drawn concerning the sound emitted by the two loudspeakers.

....

....

....

.... [3]

(b) Estimate how far the observer would need to move towards P in order to be in a position where a minimum sound intensity would be detected. Justify your answer.

Speed of sound in air = 340 m s^{-1}

....

....

.... [4]

4 A network of resistors R is connected between the terminals of a battery of e.m.f. *E* and internal resistance *r*, as shown in Fig. 4.1.

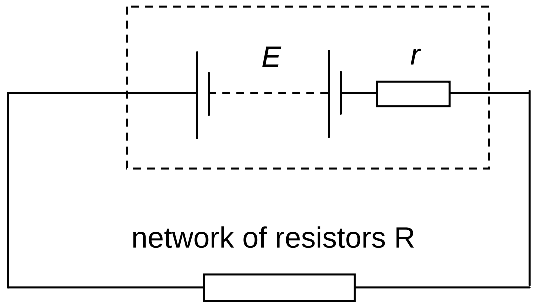

Fig. 4.1

The potential difference across R is V and the current in R is I.
The variation with potential difference V of the current I is shown in Fig. 4.2.

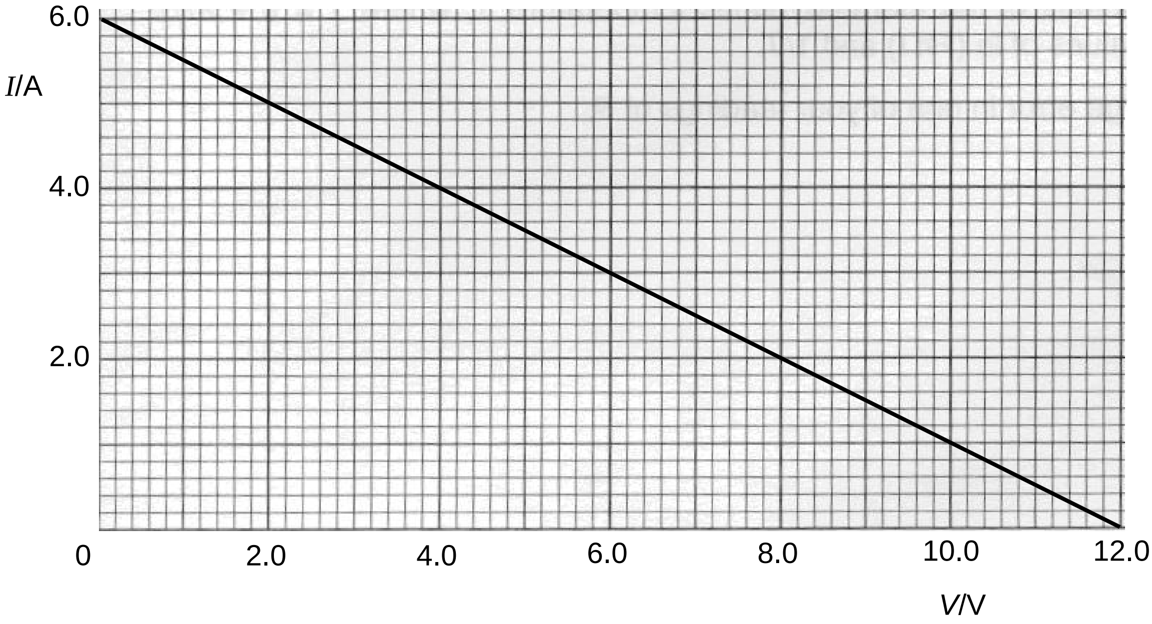

Fig. 4.2

(a) Use Fig. 4.2 to

(i) deduce the e.m.f. *E* of the battery. Suggest a reason for your answer.

E = ………………………………… V [2]

(ii) find the internal resistance *r* of the battery .

r = ………………………………… Ω [2]

(b) On Fig. 4.2, mark the positions when R comprises three resistors of resistances 2 Ω, 3 Ω and 5 Ω, and the resistors are all connected

(i) in series. Label the position S. [1]

(ii) in parallel. Label the position P. [1]

(c) An ammeter and a voltmeter are used to measure I and V respectively. Suggest how they should be connected to the network of resistors R.

ammeter ....

voltmeter .... [1]

5 This question is about the motion of a cricket ball from a bowling machine.
A bowling machine launches a cricket ball horizontally from a height of 3.0 m above the ground, as shown in Fig. 5.1.

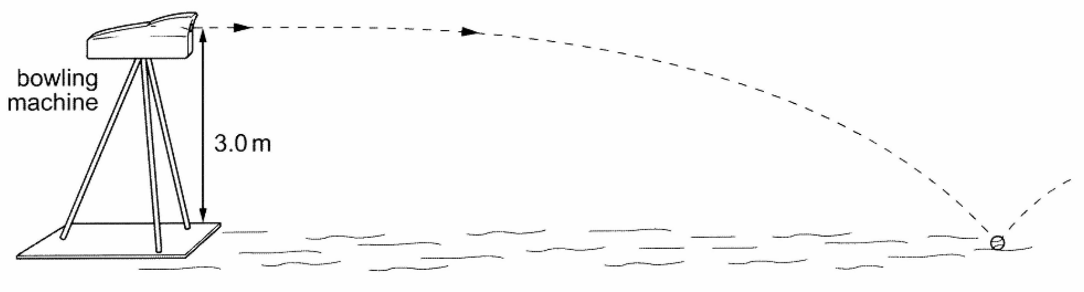

Fig. 5.1

Fig. 5.2 shows the height and the horizontal displacement of the ball at various times.

time / s	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7
height / m	3.00	2.95	2.80	2.56	2.22	1.78	1.24	0.60
horizontal displacement / m	0.0	2.5	4.8	6.9	8.8	10.5	12.1	13.6

Fig. 5.2

(a) (i) On Fig. 5.3 draw a graph to show how the height of the ball above the ground varies with time. The first three points have been plotted for you.

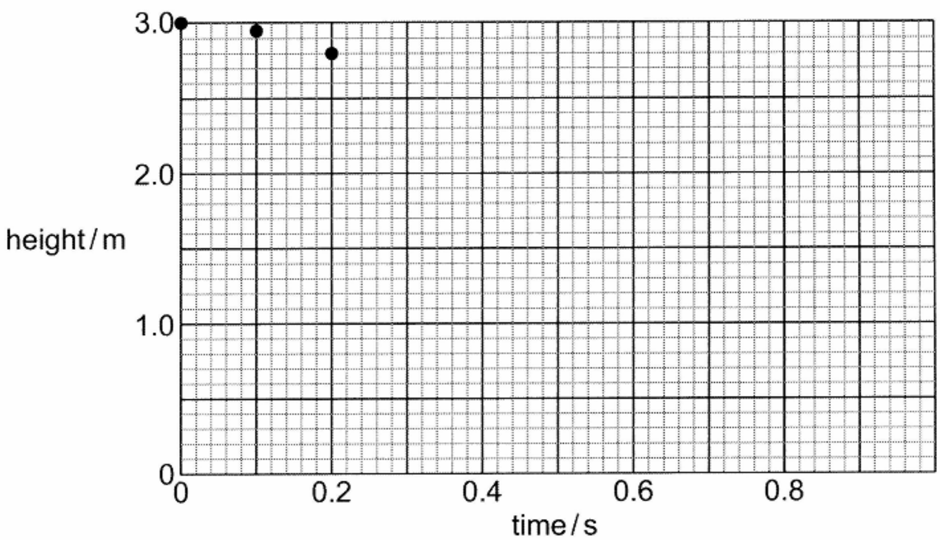

Fig. 5.3

[2]

(ii) State the feature of the graph that you have plotted in Fig. 5.3 to show that the ball is accelerating as it falls. Explain your reasoning.

....

....

....

.... [2]

(iii) Calculate the time taken for the cricket ball to fall to the ground from a height of 3.0 m, neglecting air resistance.

time = ……………………………………….. s [2]

(iv) Hence use your graph to show that the **vertical component** of the motion of the ball is hardly affected at all by air resistance.

....

....

.... [1]

(v) Use Fig. 5.2 to show that the **horizontal component** of the motion of the ball is significantly affected by air resistance.

....

....

....

.... [2]

(b) The vertical and horizontal components of velocity of the cricket ball as it reaches the ground are 7.6 m s^{-1} and 14 m s^{-1} respectively.

Calculate the angle to the horizontal at which the ball strikes the ground.

angle to horizontal = ………………………………… ° [2]

Section B

Answer **two** questions from this section.

6 The super liner Titanic, with a mass of 4.60×10^7 kg, was driven by two identical turbines at the stern of the ship, as shown in Fig. 6.1.

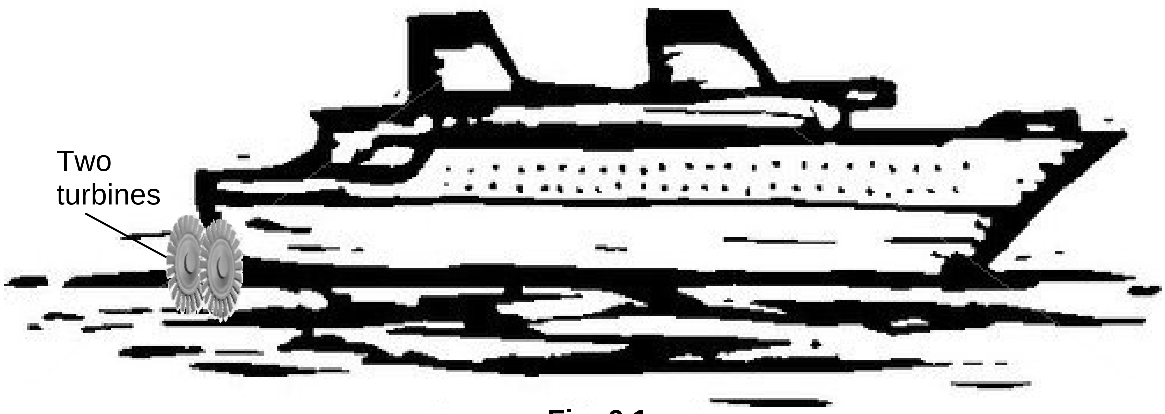

Fig. 6.1

(a) At one instant when Titanic was cruising, each turbine of radius r was driving seawater of density ρ backwards at speed v relative to the turbine.

(i) Determine, in terms of ρ, r, and v, the mass of water driven per unit time from a single turbine.

[2]

(ii) When both turbines were running, show that the total driving force acting on Titanic was given by the expression

$$F = 2\pi r^2 \rho v^2$$

[3]

(iii) Given that ρ = 1100 kg m^{-3} , r = 12.0 m and v = 8.00 m s^{-1} and assuming viscous effects were negligible, find

1. the acceleration on Titanic when both turbines were turning,

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

2. the time required for Titanic to accelerate from rest to its maximum cruising speed of 45 km h^{-1},

time required = ……………..…………………… s [2]

3. the efficiency of Titanic's engine if energy was supplied at a rate of 1800 MW during maximum speed.

efficiency = ………………………………….... % [2]

(b) (i) Explain what is meant by *linear momentum*.

....

....

.... [1]

(ii) State the *principle of conservation of momentum*.

....

....

.... [1]

(iii) According to an account of how Titanic sank when it collided with a **stationary** ice-berg in 1912, this was what an eyewitness said, "We saw a huge iceberg coming *head-on* towards us at about 10 m s^{-1}. Immediately after impact, the ship, together with the iceberg, continued to move at a speed of about 2 m s^{-1} for another 6 seconds."

Based on this account,

1. explain what is meant by *head-on* collision,

....

....

.... [2]

2. calculate the mass of the iceberg and

mass of iceberg = ……………………………….….. kg [3]

3. calculate the stopping force acting on the iceberg and Titanic after impact.

stopping force = ………………………………….. N [2]

7 **(a)** Give an equation that defines *magnetic flux density*, explaining clearly the terms you employ.

....

....

....

.... [2]

(b) Fig. 7.1 shows two long straight wires X and Y normal to the plane of the paper. Wires X and Y, separated by a distance 3.0 cm, carry equal currents of 18 A directed out of the paper.

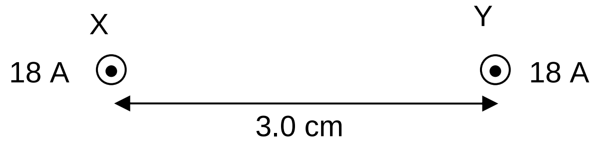

Fig. 7.1

(i) The magnetic field due to the current in wire X exerts a force F on wire Y**.** Show on Fig. 7.1 the direction of the force F**.** [1]

(ii) Fig. 7.2 shows the variation with r, the distance from the centre of wire X**,** of the magnetic flux density B due to the wire X.

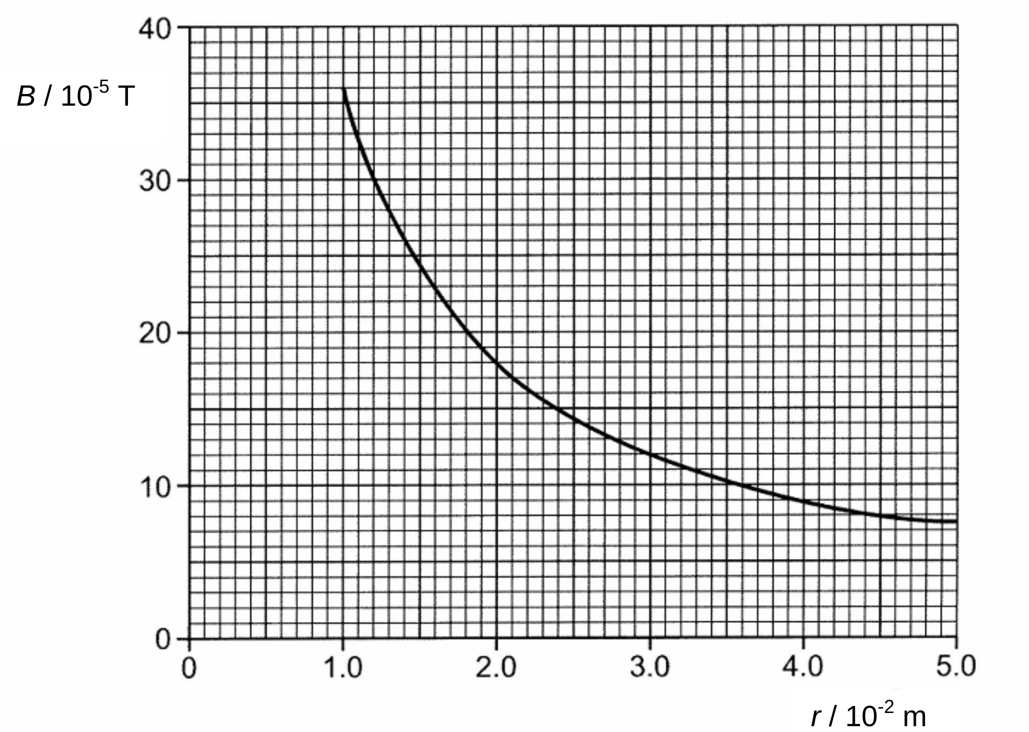

Fig 7.2

Using values from Fig.7.2, determine the force acting on a 0.25 m length of the wire Y when the wires are 3.0 cm apart.

force = ………………………………………. N [2]

(c) Fig. 7.3 shows a horizontal copper wire in a state of tension and is clamped at each end. The distance between the two clamped ends of the wire is 46.0 cm. Magnets are placed near to the centre of the horizontal section of the wire in order to produce a magnetic field at right angles to the wire.

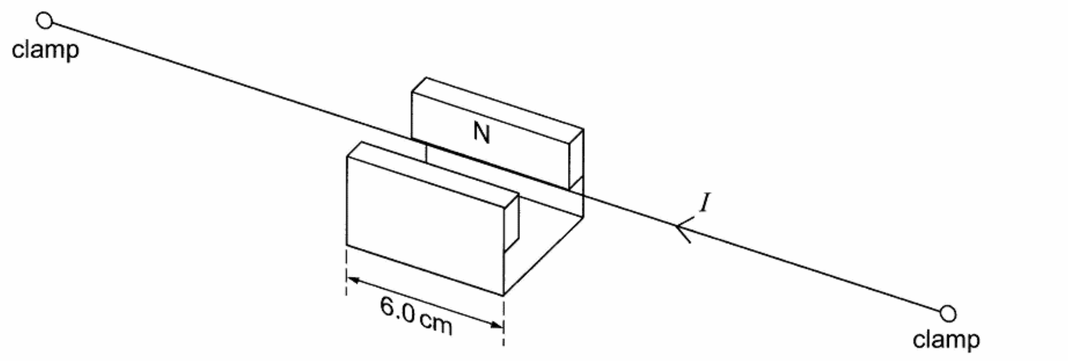

Fig. 7.3

A current I is passed through the wire causing the wire to vibrate at its fundamental mode of vibration.

Fig. 7.4 shows the variation with time of the displacement of the centre of the horizontal section of the wire between the poles of the magnets.

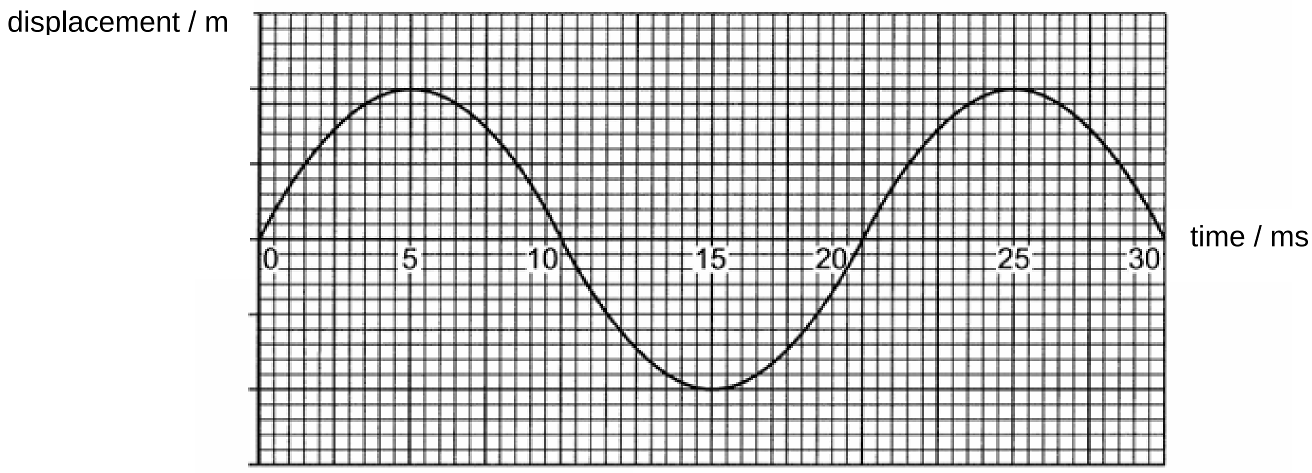

Fig. 7.4

By reference to Fig. 7.4,

(i) **1.** what can you infer about the direction of the current, and

....

....

.... [1]

2. hence explain why the wire vibrates.

....

....

....

.... [2]

(ii) Calculate

1. the frequency of the current I,

frequency = ……………………….……..……………... Hz [2]

2. the wavelength of the wave in the wire,

wavelength = ……………………………………..….. m [2]

3. the speed of the wave in the wire.

speed = ………..…………………….………… m s^{-1} [1]

(iii) Discuss whether all the points in the wire between the poles of the magnets have the same amplitude of vibration.

....

....

....

.... [2]

(d) Fig. 7.5 shows a narrow beam of electrons directed at right angles into a uniform electric field between two oppositely-charged parallel metal plates at a fixed potential difference.

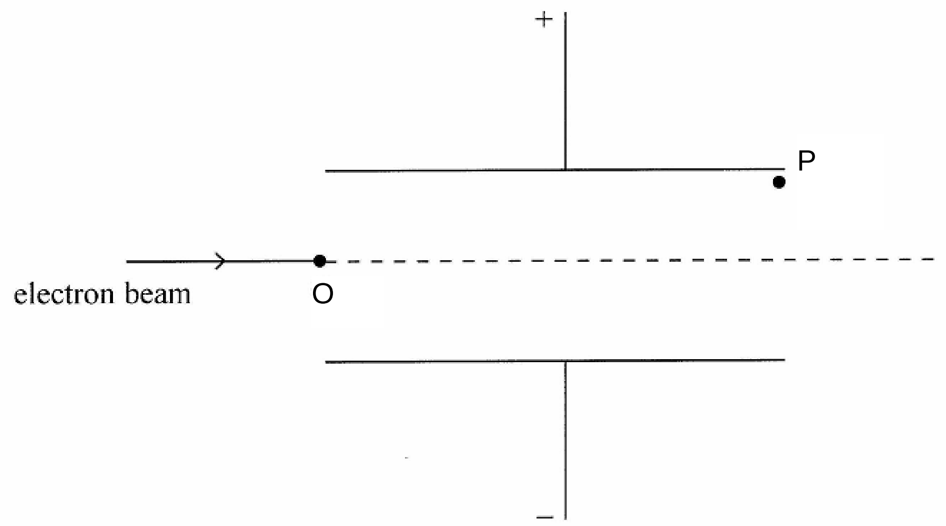

Fig. 7.5

(i) The electrons enter the field at O and experience a constant upward acceleration. They leave the field at P.

Sketch the path of the beam from O to P and beyond P. [2]

(ii) A uniform magnetic field is applied to the beam perpendicular to the electric field and to the direction of the beam. The magnetic field reduces the deflection of the beam from its initial direction.

1. Explain why the magnetic field has this effect on the beam.

....

....

....

.... [1]

2. The force F_E acting on the electron due the electric field is given by the expression $F_E = Ee$, where e is the charge of an electron and E is the electric field strength. The magnetic flux density B is adjusted until the beam passes through the two fields without deflection.

Show that the speed v of the electrons when this occurs is given by $v = \dfrac{E}{B}$.

[2]

8 **(a)** Fig. 8.1 shows an electrical circuit, which includes a photocell.

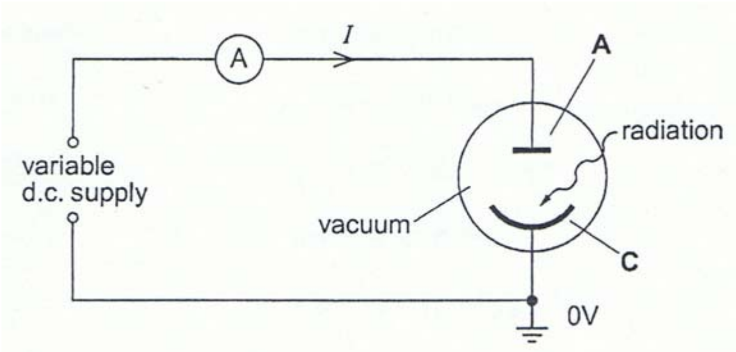

Fig. 8.1

The photocell consists of a metal plate C that is exposed to electromagnetic radiation. The photoelectrons emitted travel towards the electrode A. A sensitive ammeter measures the current in the circuit.

The plate C is illuminated with ultraviolet radiation of constant intensity and of wavelength 2.5×10^{-7} m. Fig. 8.2 shows the variation with potential difference V between A and C of the photoelectric current I in the circuit.

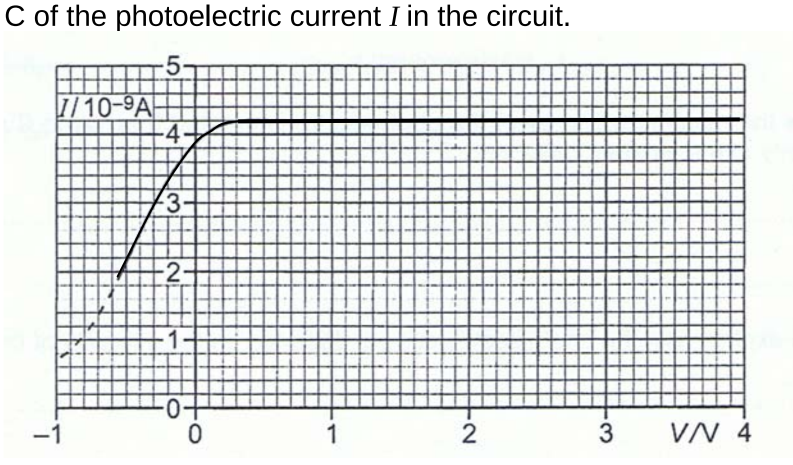

Fig. 8.2

(i) Use Fig. 8.2 to show that when the potential difference V is 2.0 V the number of electrons reaching the electrode A per unit time is $2.6 \times 10^{10}\ s^{-1}$.

[3]

(ii) The metal plate C has work function energy 2.2 eV. Calculate the maximum kinetic energy in joules of the emitted photoelectrons from this plate.

kinetic energy = …………………………………. J [4]

(iii) **1.** State how the maximum energy of the photoelectrons emitted from plate C depends on the intensity of the incident radiation.

--- [1]

2. State and explain how the photoelectric current depends on the intensity of the radiation.

--- [2]

(b) Fig. 8.3 shows an electrical cable consisting of bare copper wires encased in plastic insulation.

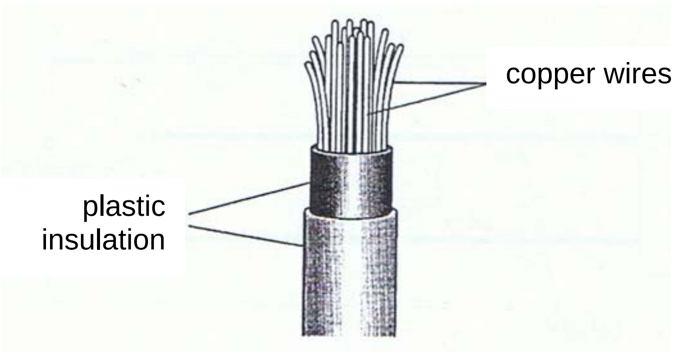

Fig. 8.3

(i) A particular cable contains 26 copper wires and is 12.0 m long. The radius of each copper wire is 3.50×10^{-5} m. The resistivity of copper is $1.70 \times 10^{-8}\ \Omega$ m.

1. Show that the resistance of a single copper wire is 53 Ω.

[2]

2. Explain why the resistance of the electrical cable is 2.0 Ω.

--- [2]

(ii) Fig. 8.4 shows two electrical cables used to connect a power supply to a lamp. Each cable has length 12.0 m and is identical to that described in **b(i)**.

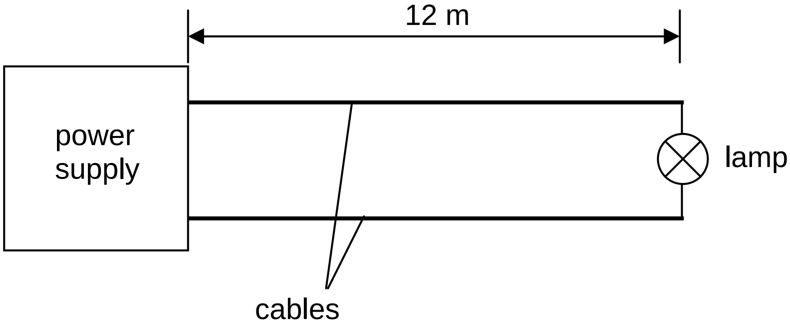

Fig. 8.4

The lamp is rated at 24 W, 6.0 V. The power supply has negligible internal resistance and its output is adjusted so that the potential difference across the lamp is 6.0 V.

1. Calculate the resistance of the lamp when operating at 6.0 V.

resistance = ………………………………… Ω [2]

2. Explain why the e.m.f. of the power supply is greater than 6.0 V.

....

....

.... [1]

3. Calculate the e.m.f. of the power supply.

e.m.f. = ………………………………… V [3]

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