Class	Adm. No.

Candidate Name: ______________________________

Preliminary Examinations II 2009

Pre-university 2

PHYSICS **8866/02**

Higher 1

Thursday 24 September 2 hours

Paper 2 Structured questions

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and admission number on all the work you hand in.
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.

Sections A
Answer **all** questions.
Sections 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	/5
2	/10
3	/9
4	/6
5	/10
Section B	
6	/20
7	/20
8	/20
Total	/80

This document consists of **25** printed pages and **1** blank page.

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,	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$

Section A

Answer **all** the questions in this section

1. A bullet of mass m is fired horizontally into a suspended block of wood of mass M. **Fig. 1.1** shows that the bullet is embedded in the block and the bullet and block rises by a vertical height h.

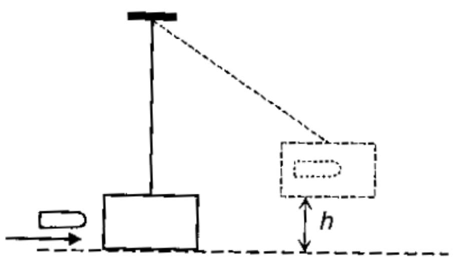

Fig 1.1

The bullet has mass 20 g, the block has mass 10 kg and the vertical height raised is 1.0 cm,

(a) Calculate the velocity of the bullet before the collision.

velocity = …………………… m s^{-1} [4]

(b) State any assumption you have made.

....

....[1]

2 The spring constant of a spring may be determined by finding the extension of the spring and the load applied using the apparatus shown in **Fig. 2.1**.

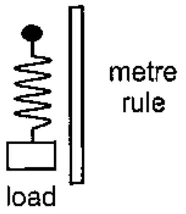

Fig. 2.1

(a) State an example of a systematic error and one example of a random error that could occur in this experiment.

Systematic error: ……………………………………………………………………………….

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

Random error: ………………………………………………………………………………….

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

(b) Using the same spring, a student set up the system as shown in **Fig. 2.2**. The weight of the metal bar was 5.0 N and the tension the student achieved in the spring was 37 N. The spring constant k of the spring is 550 N m^{-1}.

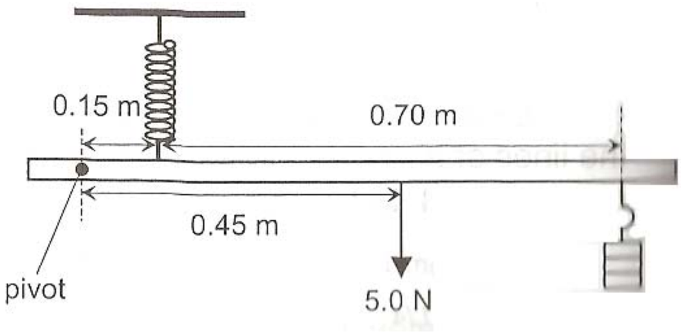

Fig. 2.2

(i) Apply the principle of moments to calculate the mass of the load that the student used.

mass of load = …………………….. kg [3]

(ii) Calculate the magnitude of the force exerted on the metal bar at that pivot.

force = ………………………. N [2]

(iii) Draw, on the **Fig. 2.2**, an arrow labelled F, to show the direction of the force calculated in **(b)(ii)**. [1]

(iv) Calculate the energy stored in the spring.

energy = ……………………. J [2]

3 **(a)** **Fig. 3.1** shows a plan view of a solenoid.

(i) Define *magnetic flux density*.

………………………………………………………………………………………….…

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………..……..[1]

(ii) On **Fig. 3.1**, sketch the pattern of the magnetic field in the solenoid and near its ends. [2]

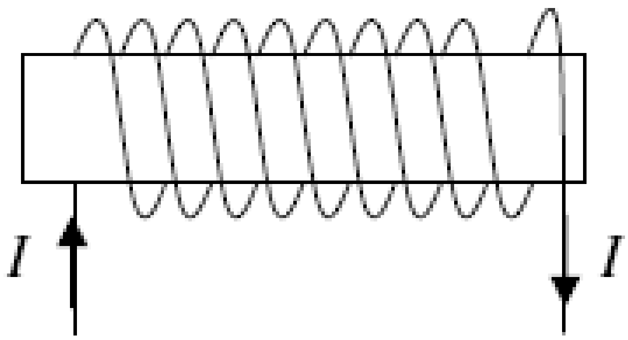

Fig. 3.1

(b) A copper wire has a resistivity 1.7×10^{-8} Ω m and a diameter of 2.0 mm.
Find the resistance of a 10 cm length of copper wire.

resistance = ………………….Ω [2]

(c) The copper wire in **(b)** is placed across the end of the solenoid where the magnetic flux density is 5.0×10^{-4} T as shown in **Fig. 3.2**. There is a current of 2.8 A in the copper wire. The diameter of the solenoid is 0.10 m and the density of the copper wire is 8920 kg m^{-3}.

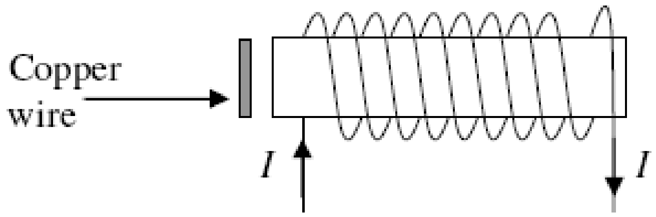

Fig. 3.2

(i) Calculate the

1. force acting on the copper wire in **(c)** when it is placed just outside the solenoid as shown in **Fig.3.2.**

force = ……………… N [1]

2. weight of the copper wire in **(c).**

weight = ………………N [2]

(ii) State one change which will allow the magnetic force to be equal to its own weight, using the wire in **(c).**

…………………………………………………………………………………….[1]

4 Radar is an acronym derived from the words Radio Detection and Ranging. It refers to the technique of using radio waves to detect the presence of objects (e.g. storm) in the atmosphere. A weather radar at a meteorological station has a frequency of 3.0×10^{9} Hz. It emits a pulse for 1.0×10^{-6} s and detects the return signal 1.0×10^{-3} s later.

(a) Calculate

(i) the wavelength of the radio waves

wavelength = ………………….. m [1]

(ii) the number of waves sent out in each pulse

number of waves = …………………… [2]

(b) Estimate the distance over which it can detect a storm.

distance = ……………… m [3]

5 **Fig. 5.1** gives the energies of the first eight energy states of the hydrogen atom. The zero of energy is taken as the energy of an electron at an infinite distance from the atom.

state	energy E / eV
lowest (ground state)	–13.6
first excited state	–3.4
second excited state	–1.5
third excited state	–0.9
four excited state	–0.6
Fifth excited state	–0.4

Fig. 5.1

(a) Use the data in **Fig. 5.1** to draw to scale a labelled energy level diagram for the hydrogen atom on the grid provided in **Fig. 5.2**.
Include the zero-energy level. [2]

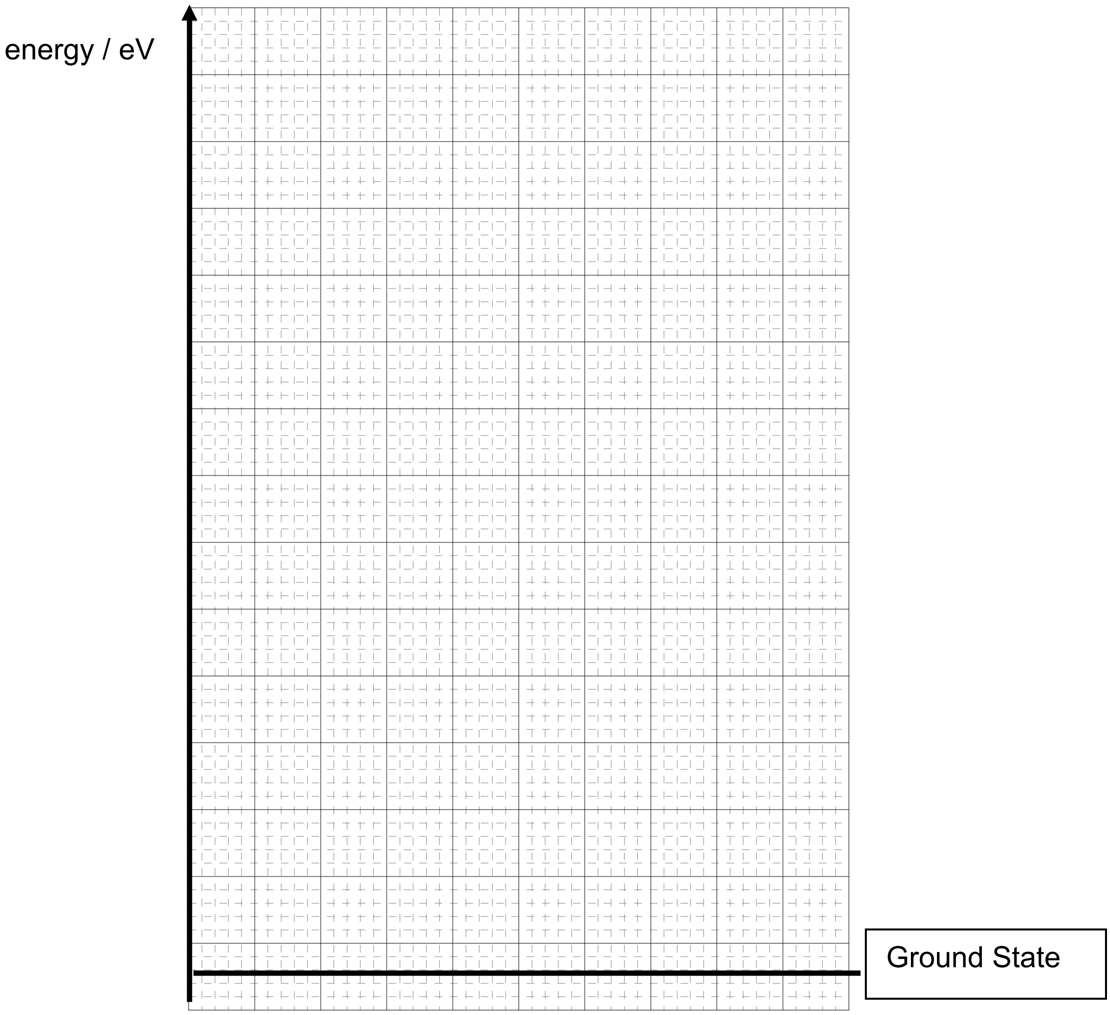

Fig. 5.2

(b) The wavelength λ of a series of lines in the spectrum of lithium are listed in **Fig. 5.3**.

n	λ / nm	$\frac{1}{(n-0.041)^2}$	$\frac{1}{\lambda}$ / m^{-1}
2	670.8		
3	323.3		
4	274.2		
5	256.2		
6	247.6		

Fig 5.3

According to a theory, the wavelengths are given by the equation:

$$\frac{1}{\lambda} = R\left[\frac{1}{(1+s)^2} - \frac{1}{(n-0.041)^2}\right],$$

where n = 2, 3, 4, 5, 6 as in **Fig. 5.3**, R is 1.097 x 10^7 m^{-1}, and s is a constant.

(i) Complete the last two columns in **Fig. 5.3**. [2]

(ii) Rearrange the equation so that it may be used to plot a straight line graph. Write down the expressions for the gradient and y-intercept of the graph.

gradient = ……………………………

y-intercept = …………………………… [2]

(iii) Plot a graph in the grid provided in **Fig. 5.4** using the values from **Fig. 5.3**. [2]

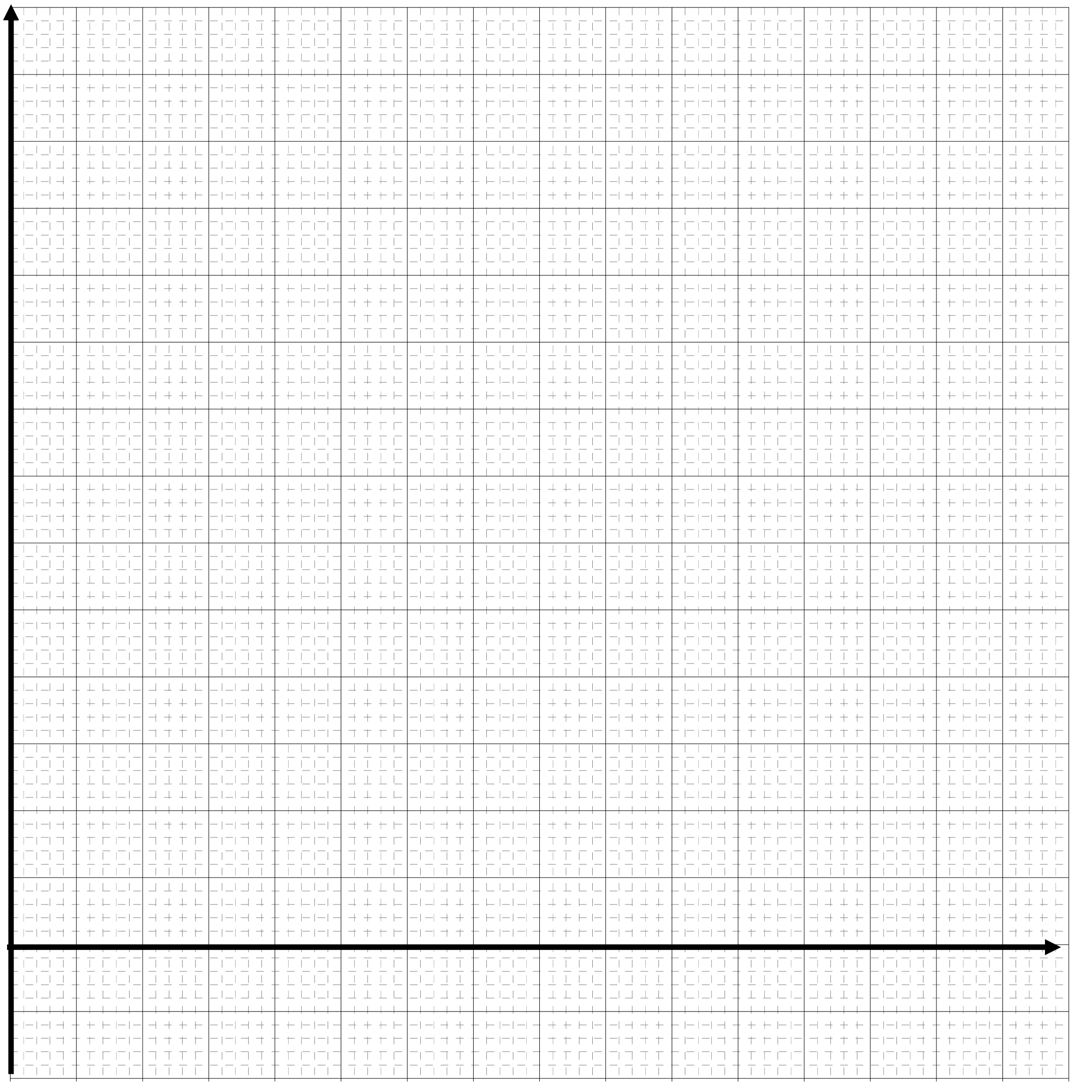

Fig. 5.4

(iv) From the graph or otherwise, discuss how well the experimental results fit the theory.

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

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

Section B

Answer **TWO** questions from this section.

6 **(a)** Define acceleration.

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

(b) **(i)** Use your definition in **(a)** to show that v = u + at, where v is the final velocity, u is the initial velocity and a and t are the acceleration and the time interval respectively. [2]

(ii) State the conditions that must be satisfied for the equation to be valid.

………………………………………………………………………………………..

………………………………………………………………………………………[2]

(c) The graph of **Fig. 6.1** shows the variation with time t of the velocity v of a ball from the moment it is thrown with a velocity of 26 m s^{-1} vertically upwards.

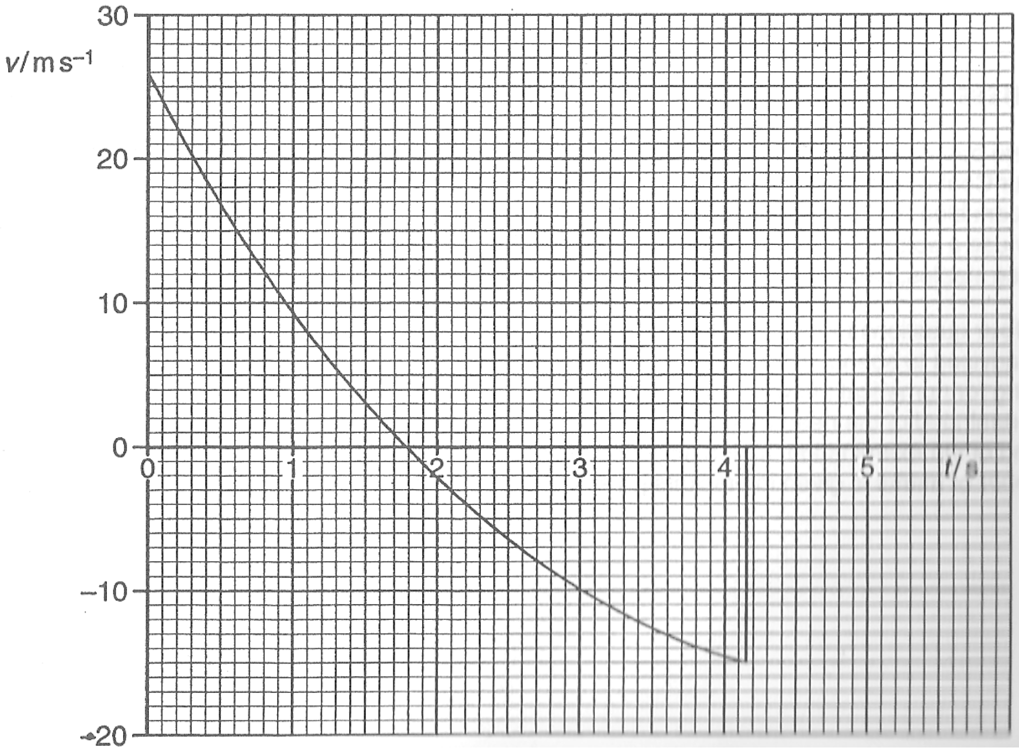

Fig. 6.1

(i) the *equilibrium* of a body.

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

(i) State the time at which the ball reaches its maximum height.

t = ... s [1]

(ii) State the feature of a velocity-time graph that enables the acceleration to be determined.

……………………………………………………………………………………….[1]

(iii) Just after the ball leaves the thrower's hand, it has a downward acceleration of approximately 20 m s^{-2}.

Explain how this is possible.

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………..

……………………………………………………………………………………….[2]

(iv) State the time at which the acceleration is *g*.

t = ... s [1]

(v) Explain why the acceleration has this value only at this particular time.

………………………………………………………………………………………..

……………………………………………………………………………………….[1]

(vi) Sketch an acceleration-time graph for the motion. Show the value of *g* on the acceleration axis. [3]

(d) Explain why, for all real vertical throws, the time taken to reach maximum height must be shorter than the time taken to return to the starting point.

....

....

....

....

....

....

....

....[2]

(e) The ball in **(c)** starts with kinetic energy of 54 J.

(i) Calculate the mass of the ball.

mass = ... kg [2]

(ii) Describe qualitatively how the amount of kinetic energy changes during the motion.

....

....

....

....

....

....

....

....[2]

7 **(a)** **(i)** State the *principle of superposition* of waves.

....

....

....

....[1]

(ii) A wave of amplitude x and intensity y is incident with a second wave of intensity $5y$. Both waves have the same frequency.

Find the resultant amplitude and intensity in terms of x and y when the phase difference is

1. zero,

amplitude = ... [1]

intensity = ... [1]

2. $180°$,

amplitude = ... [1]

intensity = ... [1]

3. 90°

amplitude = ... [1]

intensity = ... [1]

(iii) By comparing the intensities of the resultant wave in **(a)(ii)1.** and **2.** with the sum of the intensities of the two waves before superposition takes place (which is 6*y*), explain how energy is conserved.

....

....

....

....[2]

(b) **(i)** Explain what is meant by

1. *coherence*,

....

....

....[1]

2. *interference*.

....

....

....[1]

(ii) A single slit is viewed both directly and by reflection from a mirror surface as shown in **Fig. 7.1**.

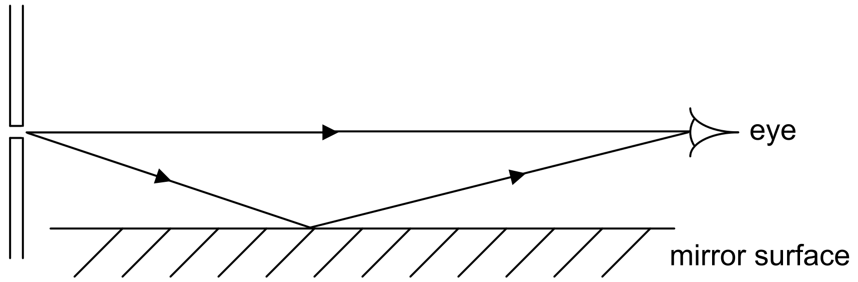

Fig. 7.1

Explain why this system produces a bright fringe.

....

....

....

....[2]

(c) In an experiment on superposition, light of wavelength 530 nm from a laser is incident normally on a double slits, and the interference pattern is observed on a screen situated at a distance *D* away from the slits.

The fringe separation *x* is measured for a number of different values of *D*, and a graph of *D* against *x* is plotted as shown in **Fig. 7.2**.

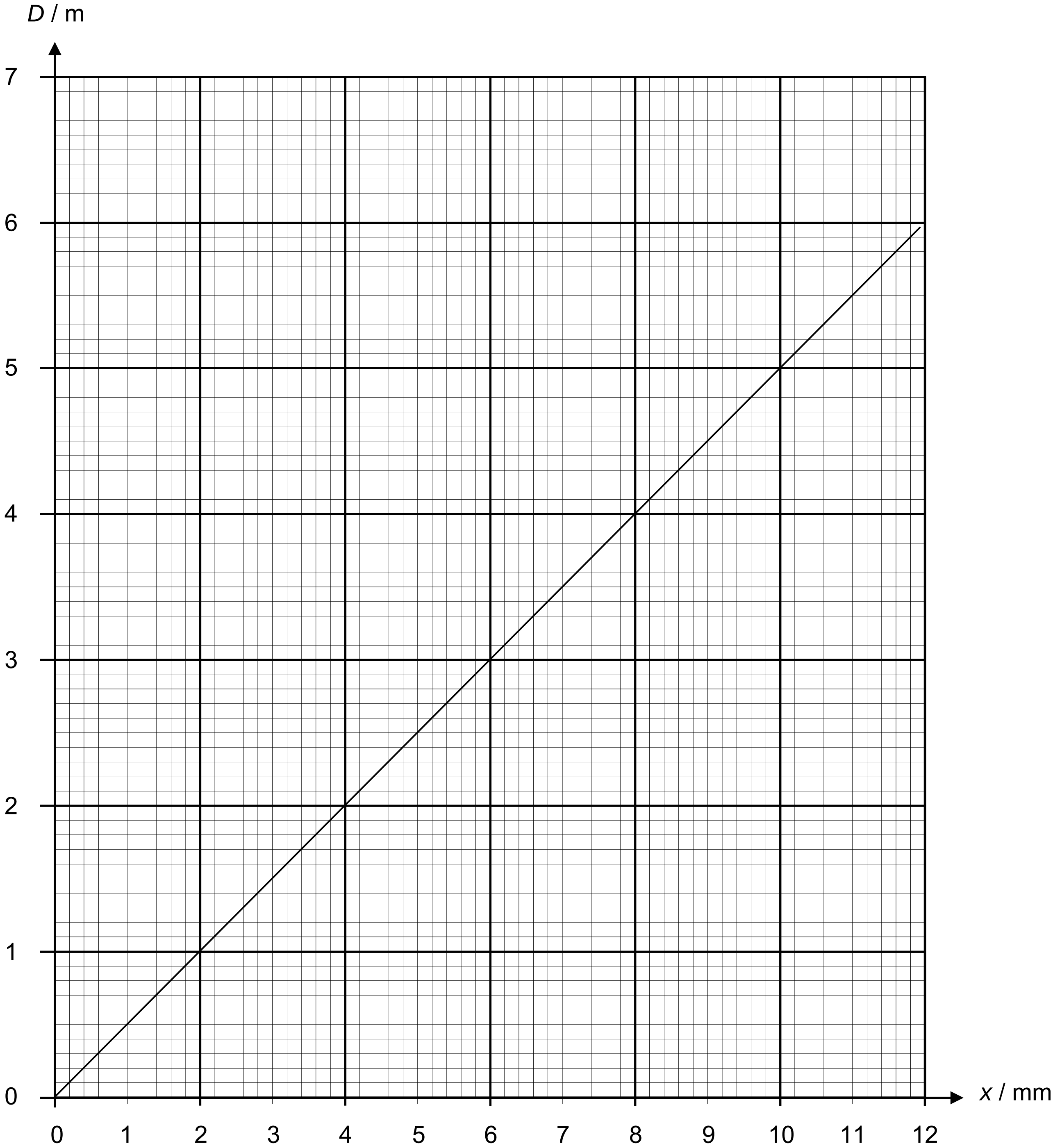

Fig. 7.2

(i) Determine the gradient of the graph, and use the result to find a value for the number of lines per mm for the slits.

gradient = ... [1]

number of lines per mm = ... [2]

(ii) State how the graph and the interference fringes will change when

1. the slit spacing is halved,

....

....

....

....[2]

2. the wavelength of light is halved.

....

....

....

....[2]

8 **Fig. 8.1** shows the *I*-*V* characteristic for a component A which obeys Ohm's law. Component B also obeys Ohm's law, but has a greater resistance than component A.

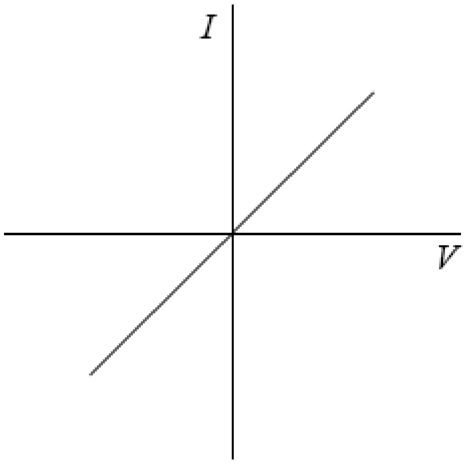

Fig. 8.1

(a) Define the unit *ohm*.

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

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

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

(b) **On Fig. 8.1,**

(i) Draw the *I*-*V* characteristic for component B on the same axes. [1]

(ii) Hence, explain your reasoning to **(b)(i)**.

…………………..……………………………………………………………………

…………………..……………………………………………………………………

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

(c) **Fig. 8.2** shows the *I*-*V* characteristic for a filament lamp.

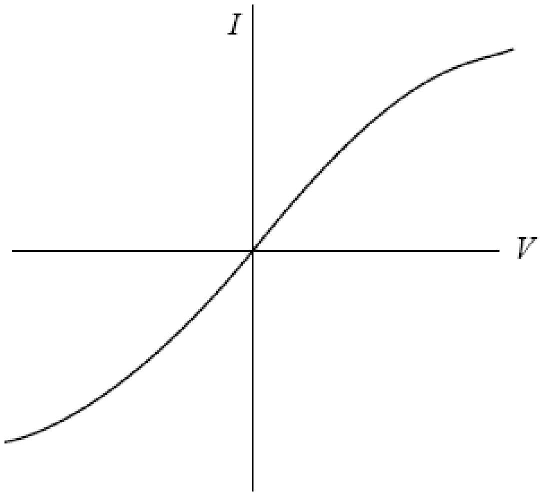

Fig. 8.2

Explain the shape of this characteristic.

....

....

....

....

....

....

....

....[4]

(d) **Fig 8.3** shows how the currents through two different conductors X and Y change as the potential difference applied to each is increased.

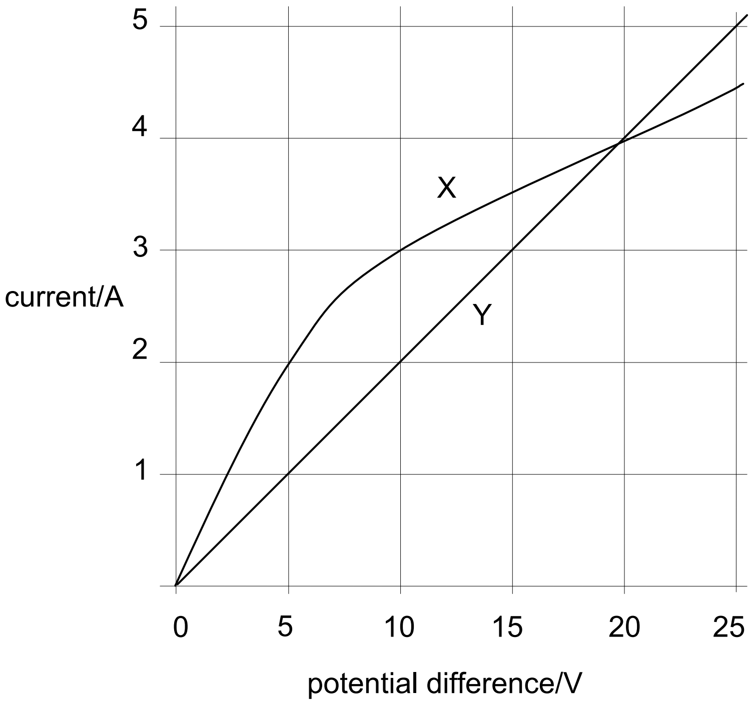

Fig. 8.3

(i) Find the resistance of X when the p.d. across it is 10 V.

resistance = ... Ω [2]

(ii) When X and Y are connected in series to a voltage supply, a current of 2.0 A flows. Use the graph to deduce the terminal potential difference.

terminal potential difference = ... V [2]

(iii) The voltage supply in **(d)(i)** is now connected to a parallel combination of X and Y.

Calculate the current drawn from the supply, assuming that its internal resistance is negligible.

current = ... A [2]

(e) A dry cell, with an e.m.f. *E* and internal resistance *r*, is connected to an external variable resistor *R* as shown in **Fig. 8.4**. A current *I* flows in the circuit when the potential difference across the terminals of the cell is *V*.

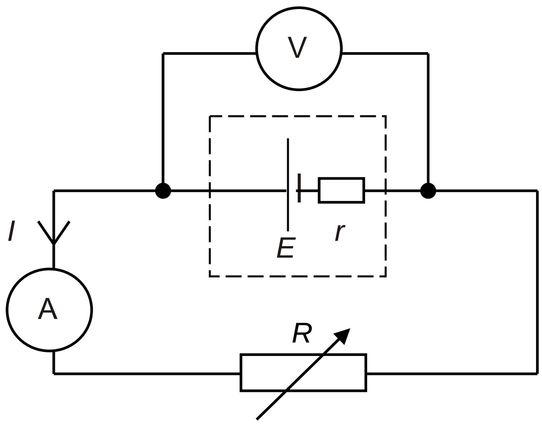

Fig. 8.4

Fig. 8.5 below shows the variation of *V* with *I* for the dry cell.

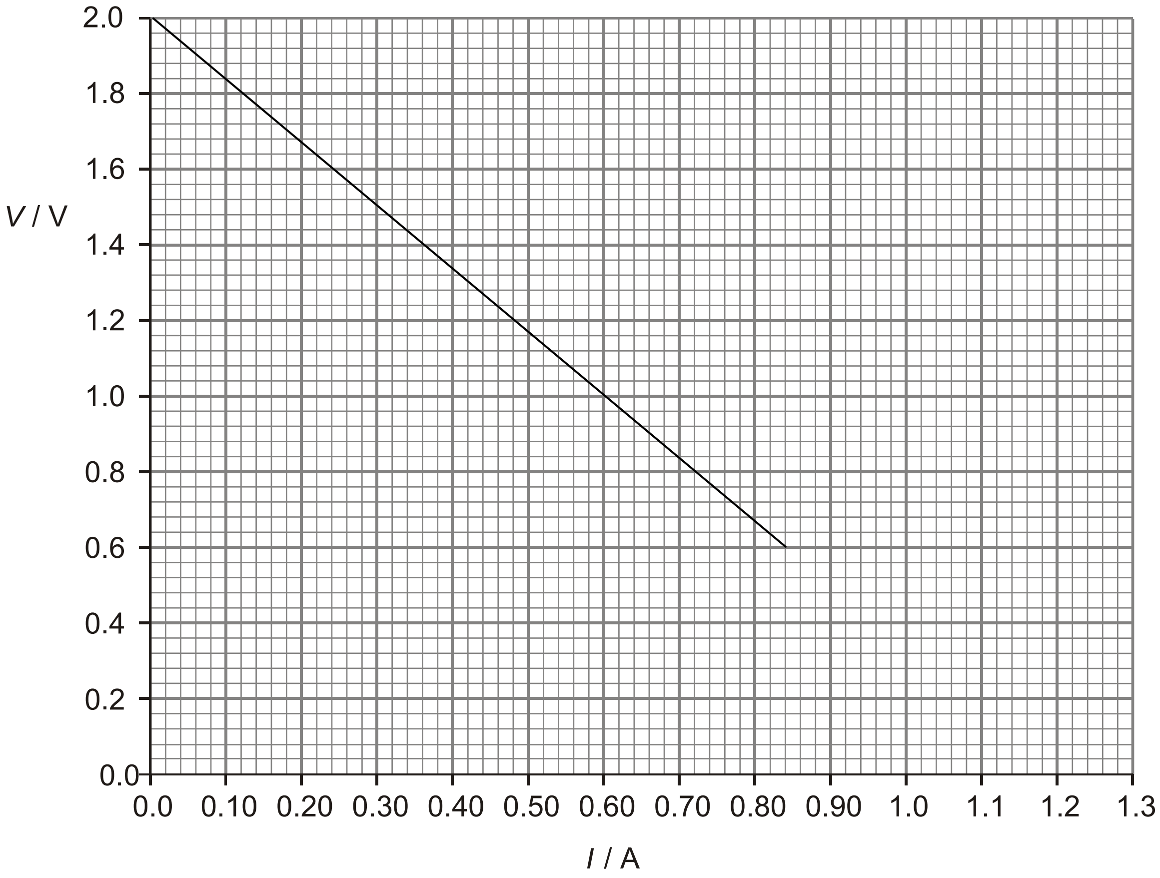

Fig. 8.5

(i) Define e.m.f.

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

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

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

(ii) Using the graph in **Fig. 8.5**,

1. state the e.m.f. *E* of the cell,

e.m.f. *E* = ………………V [1]

2. find the gradient of the graph. What is the significance of this value?

…………………………………………………………………………………………………

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

3. Hence, or otherwise, determine the current in the external circuit when the resistance *R* of the external variable resistor is very small compared to *r*.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

END OF PAPER

BLANK PAGE