EUNOIA JUNIOR COLLEGE
JC2 JC2 Mid-Year Examination 2020
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME					
CIVICS GROUP	1	9	-		

REGISTRATION NUMBER

PHYSICS

8867/02

Paper 2 Structured Questions

June/July 2020

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use 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 **one** question only.

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			**8**
2			**9**
3			**10**
4			**8**
5			**10**
6			**15**
Section B			
7	**8**		**20**
Total			**80**

This document consists of **23** printed pages and **1** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
elementary charge,	e	=	1.60×10^{-19} C
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
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 in the spaces provided.

1 An aeroplane is flying horizontally at a steady speed of $v = 67\ \text{m s}^{-1}$ as shown in Fig. 1.1. A parachutist jumps off the aeroplane and free falls for 80 m before releasing the parachute. Air resistance is negligible before the parachute opens.

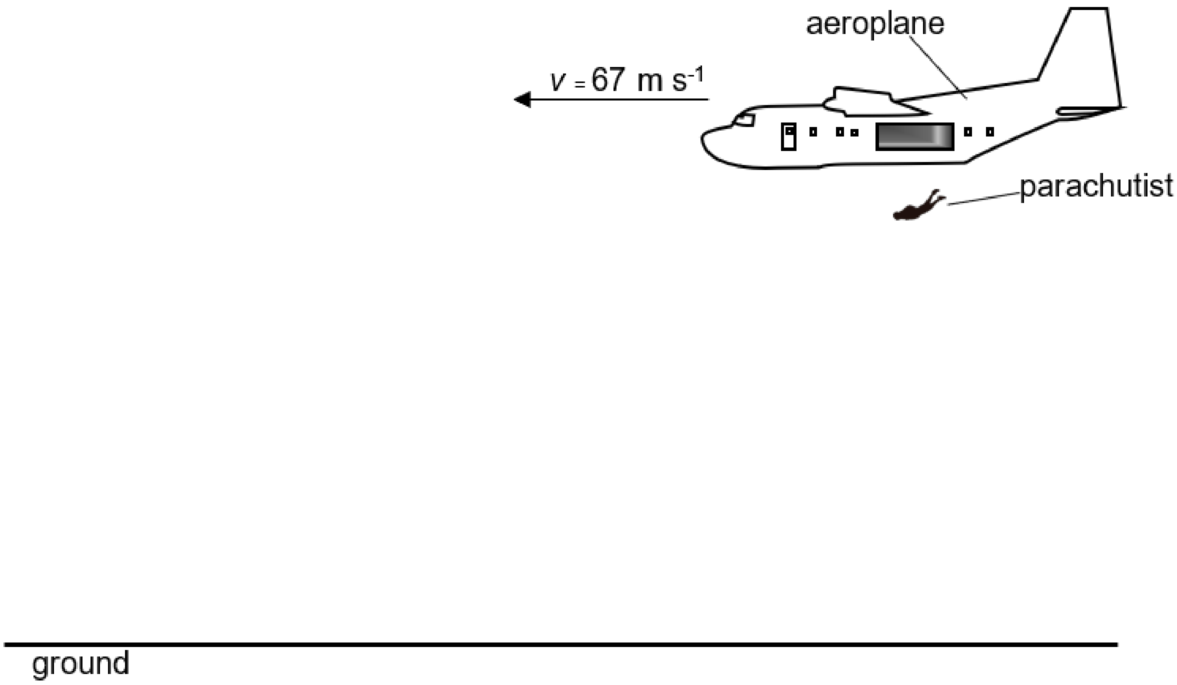

Fig. 1.1

(a) Deduce the magnitude and direction of the velocity of the parachutist just before the parachute is released.

direction of velocity = ……………………………………

magnitude of velocity = ……………………… m s^{-1} [3]

(b) In Fig. 1.1, sketch a possible path representing the parachutist's trajectory

(i) labelled P, and

(ii) labelled Q if the effects of air resistance cannot be ignored. [1]

(c) Some time after the parachute is released, the parachutist of mass 82 kg reaches a terminal velocity of magnitude 7.0 m s^{-1} with direction vertically downwards normal to the ground.

(i) State the condition that allowed the parachutist to fall at terminal velocity.

……

……..[1]

(ii) The parachutist loses gravitational potential energy during the fall at terminal velocity.

State and explain if the kinetic energy of the parachutist changes.

……

……

………[1]

(iii) The parachutist lands at terminal velocity and takes 0.25 s to come to a complete rest after making contact with the ground.

Calculate the average force experienced by the parachutist during the landing.

average force = …………………….. N [2]

[Total: 8]

2 (a) State the two conditions for static equilibrium.

1. ……………………………………………………………………………………………………

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

2. ……………………………………………………………………………………………………

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

(b) Fig. 2.1 below shows a horizontal antenna wire attached to two identical and vertical masts. The weight of each mast is 2000 N. The masts are attached to the ground by means of smooth hinges. A support cable, making an angle of 40° with the vertical, is attached to the mast at a height of 5.0 m. The tension in the support cable is 700 N.

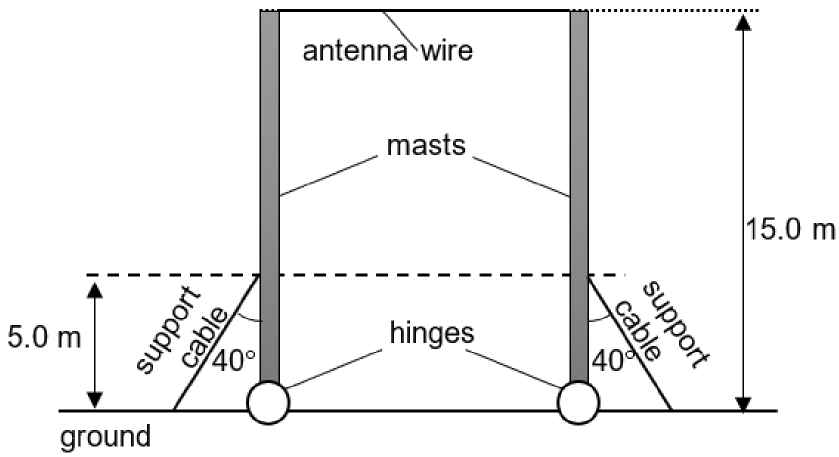

Fig. 2.1 (not to scale)

(i) Show that the tension in the antenna wire T_A is 150 N. [2]

(ii) Find the magnitude and direction of the force *F* that a hinge exerts on its mast.

direction = ………………………………

magnitude = ……………………………..N [3]

(c) A bird of weight 10 N perches on the antenna wire at the mid-point. The antenna wire dips at an angle of 1.5° to the horizontal as shown in Fig. 2.2.

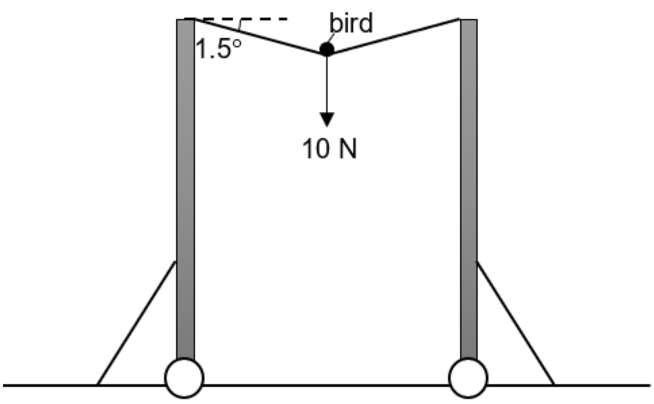

Fig. 2.2 (not to scale)

Determine the new tension in the antenna wire.

tension = …………………….. N [2]

[Total: 9]

3 A satellite can orbit the Earth along an east-to-west direction (known as a retrograde orbit) as well as along the west-to-east direction (known as a prograde orbit).

(a) (i) A satellite is launched in the west-to-east direction from a launch pad on the Equator to the geostationary orbit.

Explain why this launch direction is preferred.

……

……

……

……[2]

(ii) The Earth may be considered to be a uniform sphere of radius 6400 km with its mass of 6.0×10^{24} kg concentrated at its centre.

Show that the geostationary satellite is 3.59×10^{7} m above the Earth's surface. [2]

(b) (i) A geostationary satellite orbits above the Earth's surface possesses kinetic energy and gravitational potential energy.

Given that gravitational potential energy of the satellite, $E = -\frac{GMm}{R}$

Where G is the gravitational constant, M is the mass of the Earth, m is the mass of the satellite and R is the distance between the centre of Earth and the satellite.

Show that the total energy of the satellite is expressed as $-\frac{GMm}{2R}$. [2]

(ii) Find the total energy of the satellite if the mass of the satellite is 1000 kg.

total energy = ………………………… J [1]

(iii) Atmospheric drag is very low but nonetheless present at the height where geostationary satellites orbit.

Explain, in terms of energy, the impact of atmospheric drag on the subsequent trajectory of geostationary satellites.

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

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

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

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

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

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

[Total: 10]

4 **(a)** A charged particle of mass m and charge $+q$ is travelling with velocity v in a vacuum. It enters a region of uniform magnetic field of flux density B as shown in Fig. 4.1.

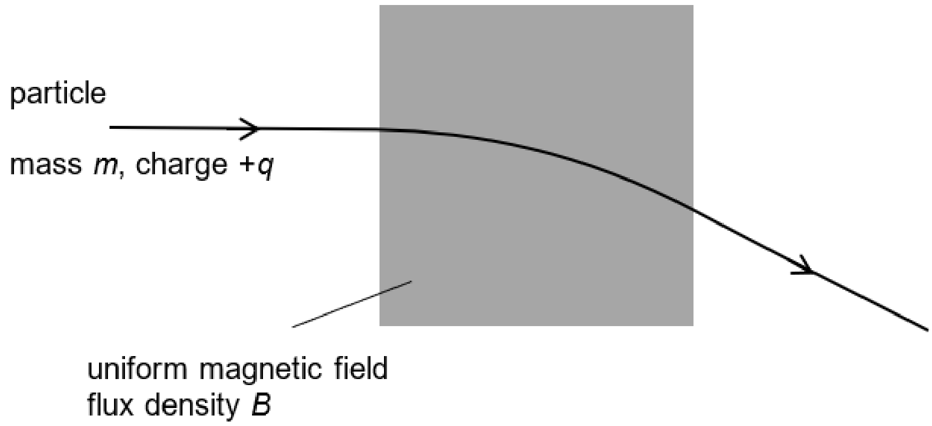

Fig. 4.1

Describe and explain the path of the particle in the magnetic field and after it leaves the magnetic field.

……

……

……

……

………[2]

(b) A uniform magnetic field in region PQRS is normal to the page, as shown in Fig. 4.2.

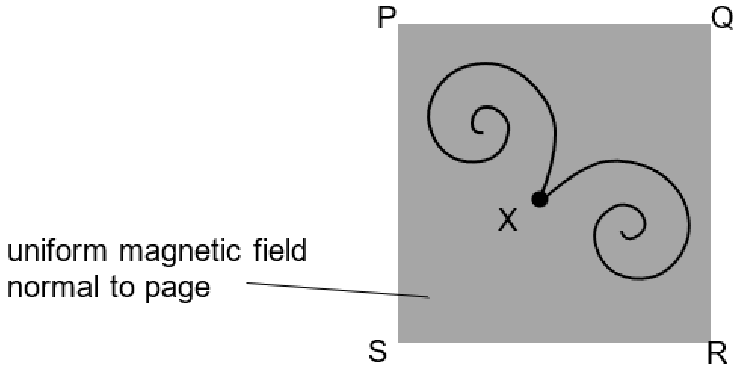

Fig. 4.2

At point X, an interaction causes two particles to form which then move along the paths shown.

(i) Suggest why each of the paths is a spiral.

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

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

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

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

(iii) State and explain what can be deduced from the paths about

1. the charges on the two particles

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

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

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

2. the initial speed of the two particles.

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

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

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

(c) Fig. 4.3 shows a segment of wire WXYZ. The current in the wire is 6.0 A. The angle between XY and YZ is 30°. YZ is 14 cm long.

A uniform magnetic field with flux density *B* of 0.4 T is directed perpendicular to YX.

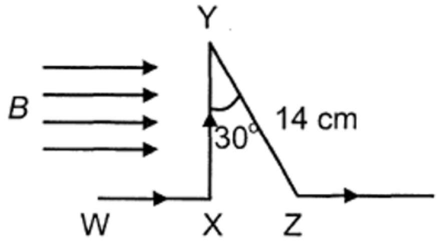

Fig. 4.3

Find the magnitude of the force on the segment YZ.

force = ………………………… N [2]

[Total:8]

5 (a) State what is meant by an electric field of force.

....

....[1]

(b) A wooden rod with a negatively charged metal tip is situated near a thin metal plate carrying positive charge. An uncharged metal sphere is introduced in the region between the rod and the metal plate.

On Fig. 5.1, sketch the electric field pattern around the objects.

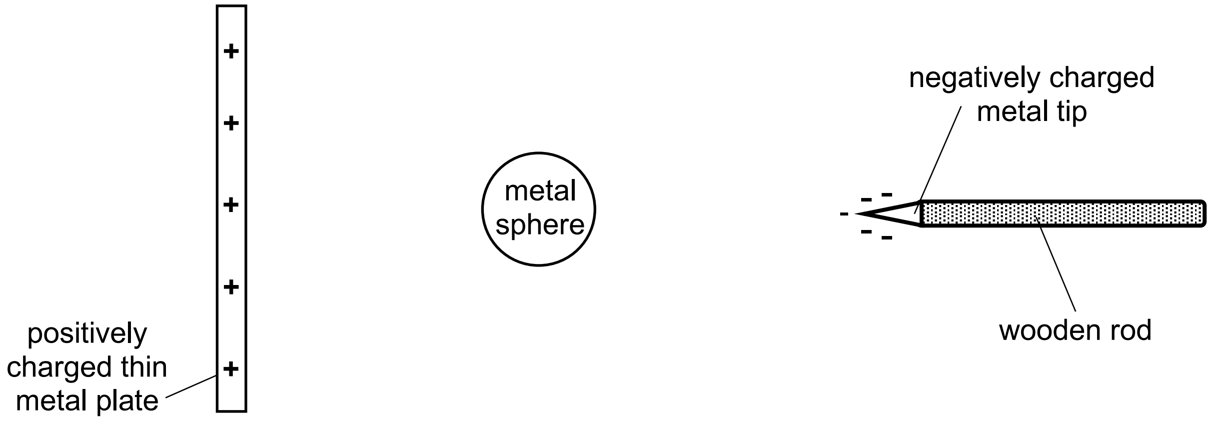

Fig. 5.1

[3]

(c) Fig. 5.2 shows two charged parallel plates with potentials 50 V and –50 V. The separation between the plates is 2.0 mm apart. An electron enters the region at an angle $\theta = 45°$ at a speed $v = 5.6 \times 10^6$ m s^{-1} mid-way between the plates as shown.

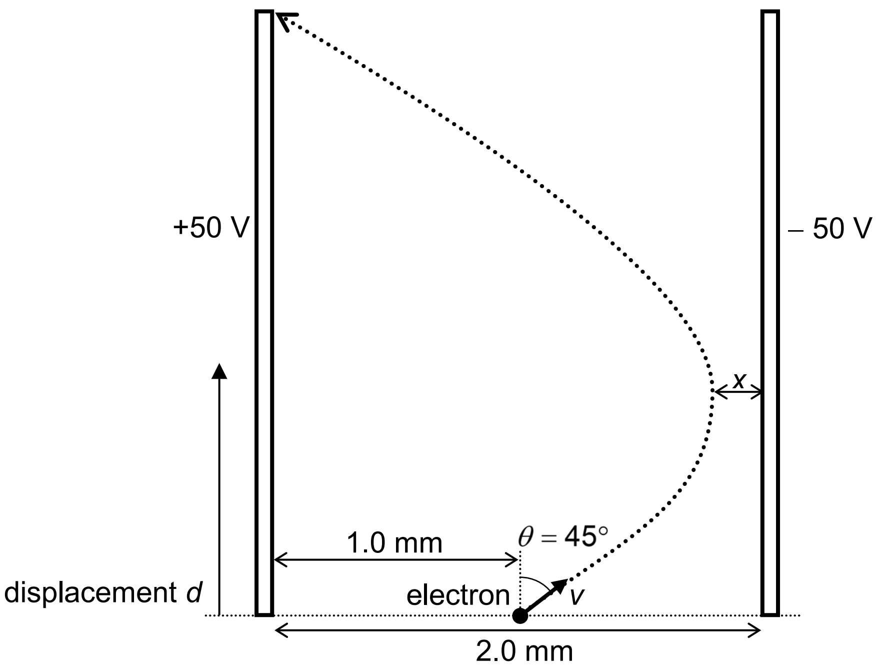

Fig. 5.2 (not to scale)

(i) Describe the energy changes of the electron as it moves between the plates.

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

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

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

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

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

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

(ii) By considering the acceleration of the electron between the pair of charged parallel plates or otherwise, find the electron's closest distance of approach, *x*, to the –50 V plate.

x = …………………….. m [3]

[Total: 10]

6 Fig. 6.1 shows the important features of the apparatus used by Millikan to measure the electron charge by observations on charged oil droplets.

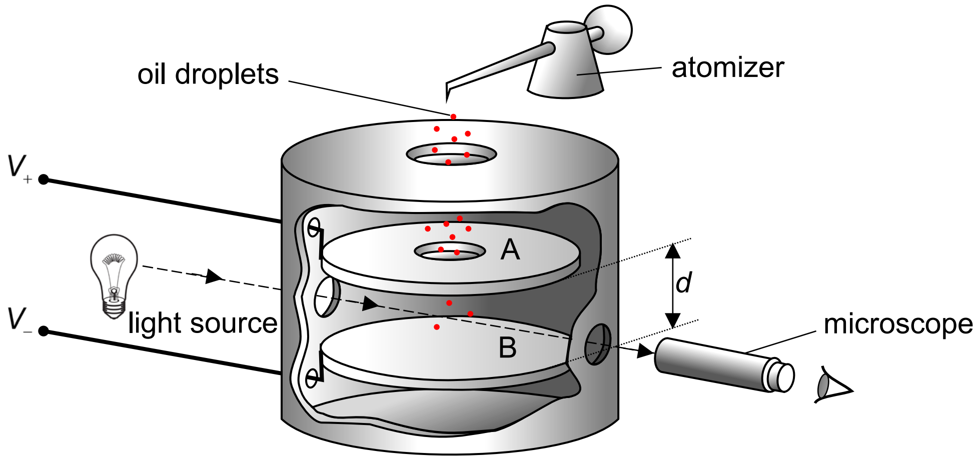

Fig. 6.1

A potential difference is applied across a pair of horizontal charged parallel plates A and B.

The microscope is focused on the illuminated space between the horizontal charged parallel plates A and B, under the hole through which oil droplets enter.

A squeeze on the atomizer causes a shower of droplets to be emitted. Most of these droplets are uncharged and drift downwards through the air at their terminal velocities. A few can be seen to move upwards. These are the ones which have acquired a negative charge and therefore experience an upward electrical force on each of them.

The potential difference between the plates (separated by a distance d) is adjusted to keep a particular oil droplet stationary and its value $\Delta V = V_+ - V_-$ is measured.

(a) **(i)** Each oil droplet carries a charge Q and has a weight *W*.

Ignoring upthrust due to air, state the condition for an oil droplet to remain at rest in terms of *Q*, *W* and any other variables required. Explain your answer.

....

....[2]

(ii) Explain why it is reasonable to neglect the upthrust due to air.

....

....

....[1]

The weight of the oil droplet is found by measuring the time taken for it to tall over a standard distance at terminal speed, when the potential difference across the plates is zero. Fig. 6.2 shows the relationship between the weight W of oil droplets and the time T taken by the oil droplets to fall 1.00 mm in air. The density of oil is 864 kg m^{-3}.

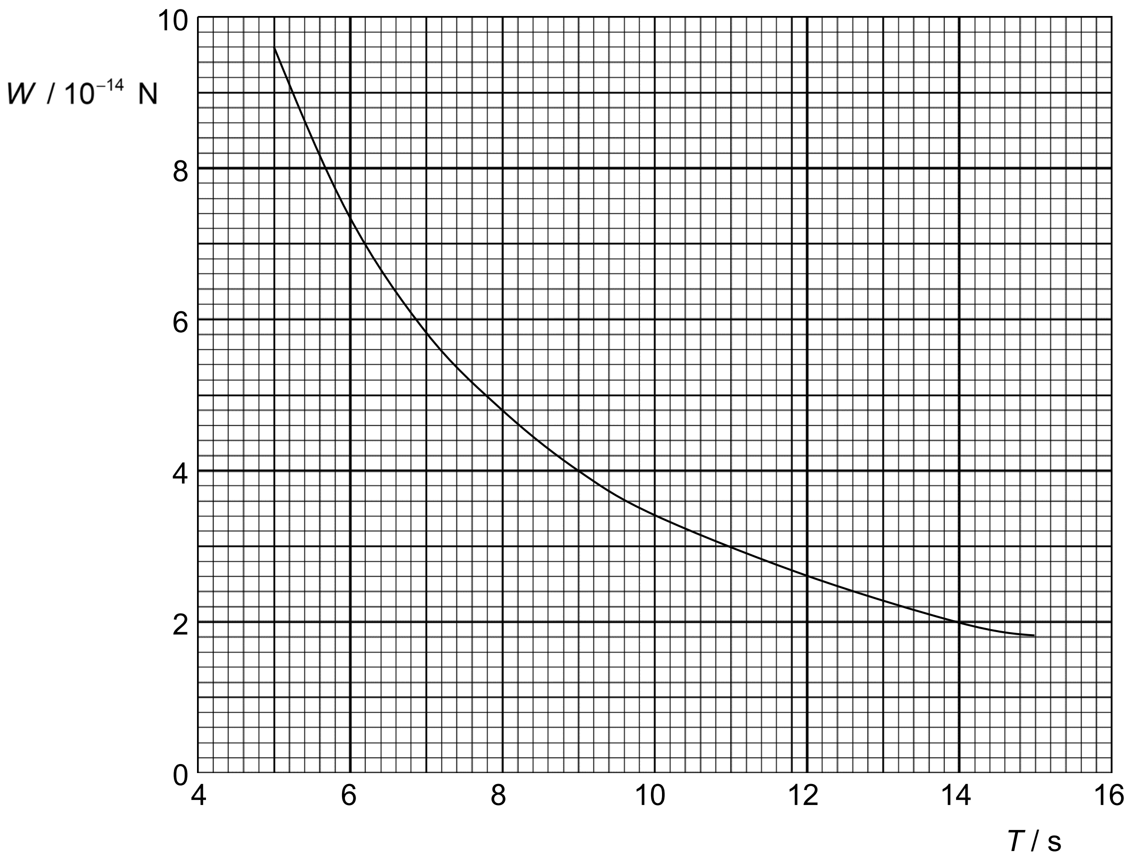

Fig. 6.2

(b) The results shown in Fig. 6.3 were obtained with a Millikan apparatus. For each oil droplet, the experimenter measured ΔV across the plates (which were 4.42 mm apart) at which the droplet was observed to be stationary, and the time T for the droplet to fall 1.0 mm in air with terminal speed after switching off the potential difference.

The charge Q carried by an oil droplet is given by $Q = Ne$, where N is a whole number and e is a basic charge.

ΔV / V	T / s	W / 10^{-14} N	Q / 10^{-19} C	N
770	11.5	2.9	1.66	....
230	10.0	3.4	6.53	....
1030	9.4	....	....	....
470	7.6	....	....	....
820	6.9	5.9	3.18	....
395	6.2	7.0	7.83	....

Fig. 6.3

Complete Fig. 6.3 by

(i) using Fig. 6.2 to determine W of droplets for ΔV = 1030 V and ΔV = 470 V [1]

(ii) finding Q to 3 significant figures, on each droplet for ΔV = 1030 V and ΔV = 470 V, [1]

(iii) calculating values for whole number N. [2]

(c) Using your answer to **(b)(iii)**, show with clear working to determine an average value for e.

e = …………………… C [2]

(d) It is thought that, when the potential difference between the plates is zero, the weight W of an oil droplet varies with time T of its fall (with terminal speed over a standard distance) according to the equation

$$W = aT^{b},$$

where a and b are constants.

Some data from Fig. 6.2 is used to plot the graph of Fig. 6.4.

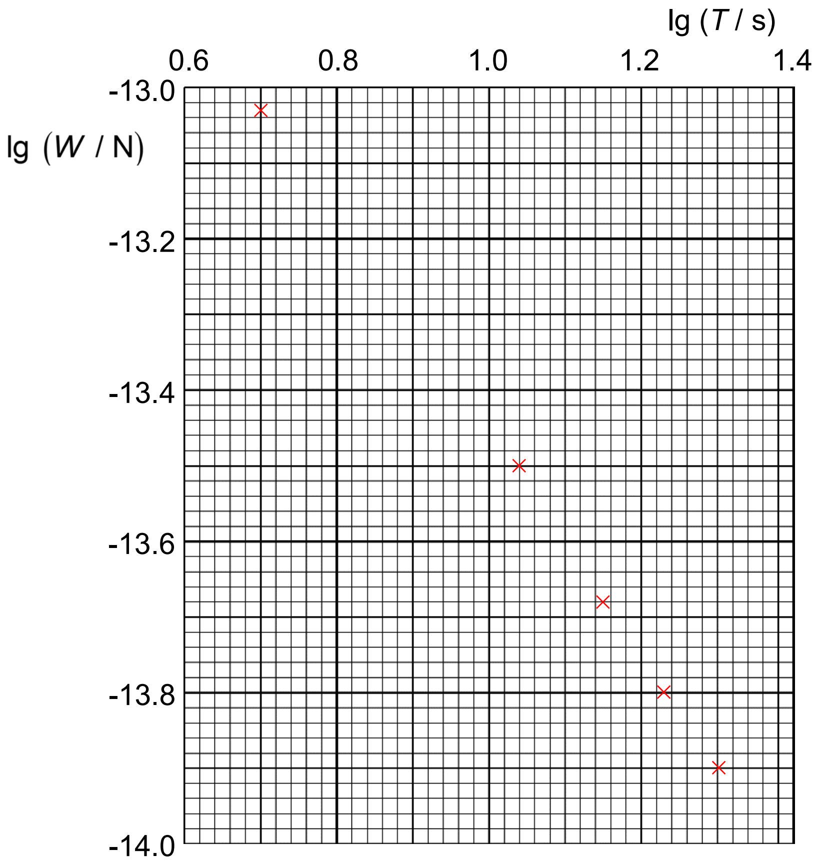

Fig. 6.4

(i) Use Fig. 6.2 to determine lg (W / N) for time T = 8.0 s.

lg (W / N) = ... [1]

(ii) On Fig. 6.4,

1. plot the point corresponding to T = 8.0 s [1]
2. draw the line of best fit for the points. [1]

(iii) Use the line drawn in (d)(ii) to determine constant b in the equation $W = aT^b$.

b = ... [2]

(iv) The density of the oil droplet is proportional to $\frac{1}{a^2}$, where a is the constant in $W = aT^b$.

A similar experiment is performed under the same conditions, using oil of higher density.
On Fig. 6.4, sketch a graph to show a possible variation of lg W with lg T.

Label your graph (**iv**). [1]

[Total: 15]

Section B

Answer **one** question from this section.

7 (a) Fig. 7.1 shows a cart of mass 0.80 kg moving with constant velocity on a frictionless surface. It then collides with a wall and rebounds in the opposite direction.

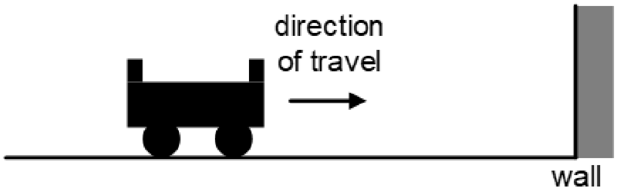

Fig. 7.1

The variation with time t of its momentum p is shown in Fig.7.2.

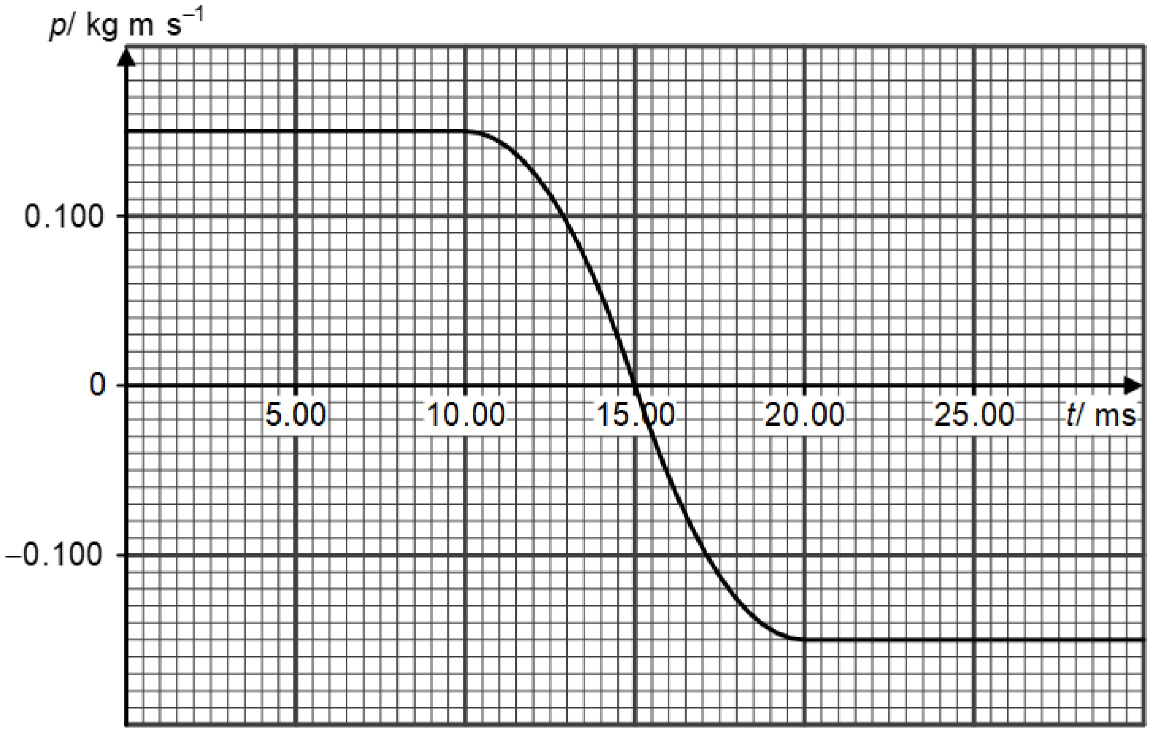

Fig. 7.2

(i) Using Fig. 7.2, explain why the collision is elastic.

....

....

....

....[2]

(ii) Determine the magnitude of the average force acting on the cart during the collision.

average force = ……………………… N [2]

(iii) On Fig. 7.3, sketch the variation with time t of the force F acting on the cart from $t = 0$ ms to $t = 25$ ms .

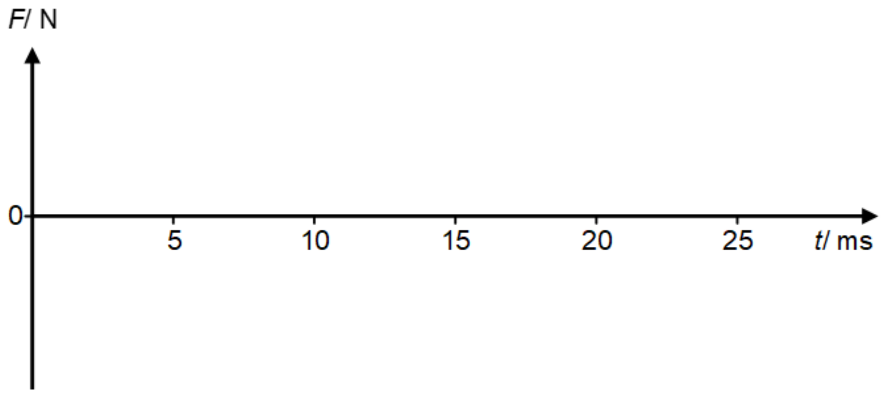

Fig. 7.3

[2]

(iv) A light spring is now attached to the front of the cart, as shown in Fig. 7.4.

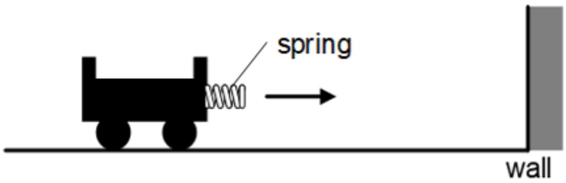

Fig. 7.4

The cart is set to move towards the wall with the same initial velocity. Assuming that the collision with the wall is still elastic, state two changes to the graph in Fig. 7.3.

1. ………………………………………………………………………………………

   ………………………………………………………………………………………

2. ………………………………………………………………………………………

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

(b) The cart is now placed on a bench. It is connected to a mass $M = 0.50$ kg by a string that runs over a smooth pulley at the edge of the bench, as shown in Fig. 7.5.

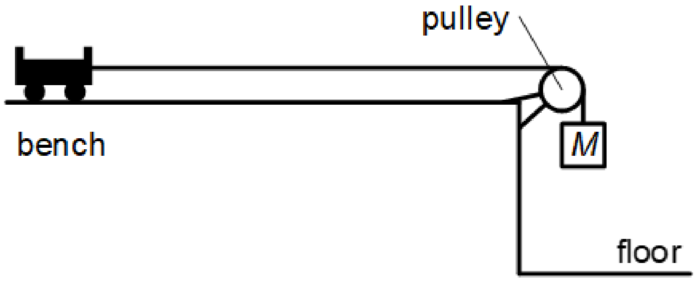

Fig. 7.5

Fig. 7.6 shows the variation with time t of the velocity v of the cart as mass M is released.

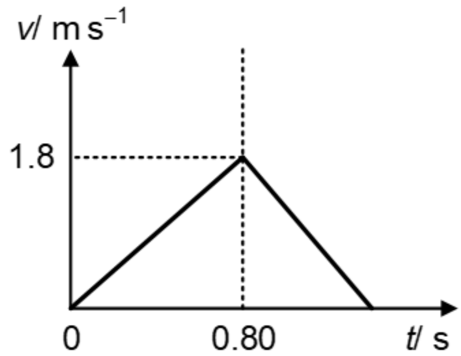

Fig. 7.6

(i) State what happens to mass M at t = 0.80 s.

…….....

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

(ii) Explain how Fig. 7.6 gives conclusive evidence for the existence of a resistive force acting on the cart.

…….....

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

(iii) Determine the resistive force acting on the cart.

resistive force = ………………… N [3]

(iv) On Fig. 7.6, sketch the variation with time *t* of the velocity *v* of the cart if there were no resistive force. [2]

(c) Fig. 7.7 shows the forces acting on a block of dimensions 2.5 cm by 1.2 cm placed on top of the cart which is accelerating.

N is the normal contact force, *W* is the weight and *f* is the frictional force. Point O is the centre of mass of the block.

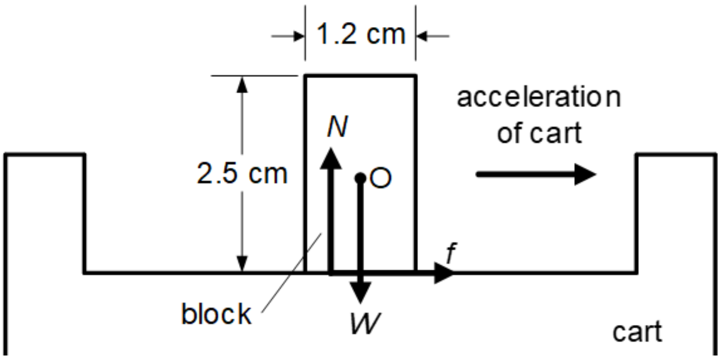

Fig. 7.7

(i) Explain why the line of action of *N* does not pass through O.

………

………[1]

(ii) The acceleration of the cart is gradually increased until the block rotates without sliding.

1. On Fig 7.8, draw the normal contact force *N* when the block is about to rotate. [1]

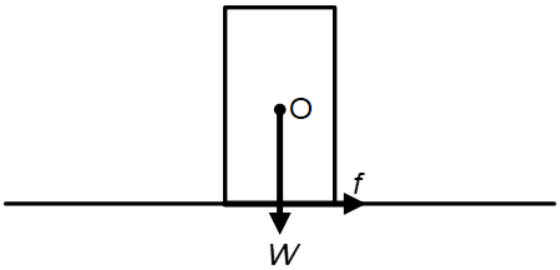

Fig. 7.8

2. Calculate the acceleration of the cart just before the block rotates.

acceleration = …………………… m s^{-2} [3]

[Total: 20]

8 (a) Sketch the current-voltage (*I*-*V*) characteristics of

(i) a metallic conductor at a constant temperature,

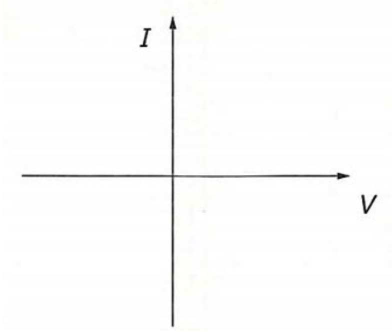

Fig. 8.1

[1]

(ii) an ideal semiconductor diode.

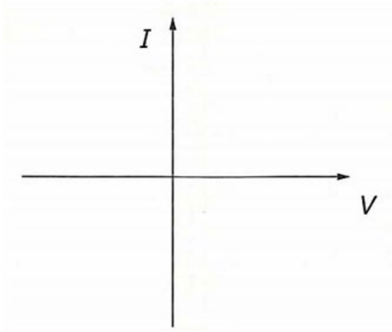

Fig. 8.2

[2]

(b) (i) Define *potential difference.*

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

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

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

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

(ii) Distinguish between *potential difference* and *e.m.f* in terms of energy considerations.

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

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

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

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

(c) A fully charged car battery has an e.m.f. of 12 V and an internal resistance of 0.026 Ω. This battery can deliver a constant current of 2.3 A for a period of 6.0 hours.

(i) Calculate the total number of electrons passing through the battery in a time of 6.0 hours.

number of electrons = …………………….. [2]

(ii) The fully charged car battery is connected to a starter motor, four sidelights and two headlights as shown in Fig. 8.3.

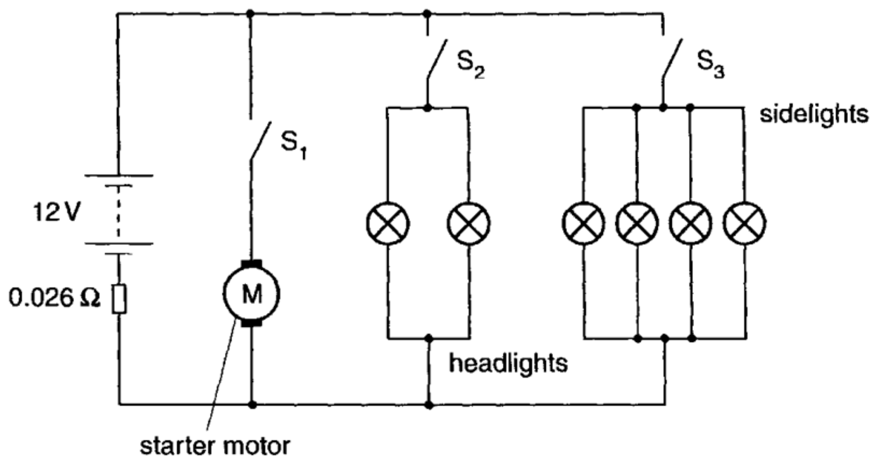

Fig. 8.3

At 12 V, the power rating of each headlight is 48 W. When operating at 12 V, the material of the filament in the headlights has a resistivity of 8.1×10^{-7} Ω m and a radius of 9.1×10^{-5} m.

1. Calculate the resistance of a single headlight.

resistance = ……………….. Ω [2]

2. Calculate the length of the filament of the headlight.

length = …………….. m [3]

3. The resistance quoted for the filament at room temperature is very different from the working resistance of the filament lamp at 12 V. Suggest why this is so.

……….

……….

……….

……….[2]

4. The resistance of each sidelight is 24 Ω.

Calculate the current in the battery and the terminal p.d. of the battery when switches S_2 and S_3 are closed and switch S_1 is open.

current = ………………… A

terminal p.d = ……………….. V [3]

5 The sidelights and headlights are switched on. With S_1 closed, the current in the starter motor is 120 A. Explain why all the lights become less bright when S_1 is closed.

……..

……..

……..

……..[2]

[Total: 20]

END OF PAPER

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