a
EUNOIA JUNIOR COLLEGE
JC2 MID YEAR EXAMINATIONS 2023
General Certificate of Education Advanced Level
Higher 1

CANDIDATE NAME								
CIVICS GROUP	2	2	-			REGISTRATION NUMBER		

PHYSICS

8867/02

Structured Questions

26th June 2023

2 hours

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
The use of an approved scientific calculator is expected where appropriate.
Answer **all** questions.

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.

Section A

Answer **all** questions from this section.

Section B

Answer the question from this section.

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

For Examiner's Use	
Q1	**10**
Q2	**6**
Q3	**6**
Q4	**7**
Q5	**7**
Q6	**14**
Q7	**10**
Q8	**20**
P2 Total	**80**

This document consists of **19** 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
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
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ 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 (a) A smooth pebble, made from uniform rock, has the shape of an elongated sphere as shown in Fig. 1.1.

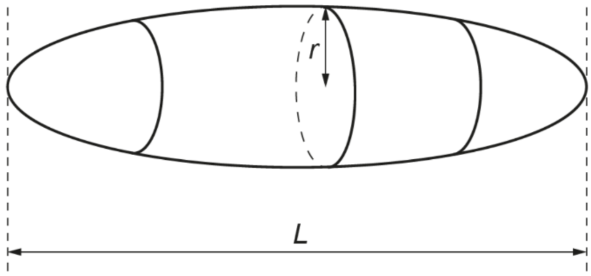

Fig. 1.1

The length of the pebble is L. The cross-section of the pebble, in the plane perpendicular to L, is circular with a maximum radius r.

A student investigating the density of the rock makes measurements to determine the values of L, r and the mass M of the pebble as follows:

$L = (0.1242 \pm 0.0001)$ m
$r = (0.0420 \pm 0.0004)$ m
$M = (1.072 \pm 0.001)$ kg

(i) State the name of a measuring instrument suitable for making this measurement of L.

....[1]

(ii) Determine the percentage uncertainty in the measurement of r.

percentage uncertainty = ... % [1]

(b) The density of ρ of the rock from which the pebble in **(a)** is composed is given by

$$\rho = \frac{Mr^n}{kL}$$

where n is an integer and k is a constant, with no units, that is equal to 2.094.

(i) Use SI base units to show that n is equal to -2.

[2]

(ii) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ………………………...% [3]

(iii) Determine ρ with its absolute uncertainty. Give your values to the appropriate number of significant figures.

ρ = (………………………±………………...) kg m^{-3} [3]

[Total: 10]

2 A block X of mass m_X slides in a straight line along a horizontal frictionless surface, as shown in Fig. 2.1

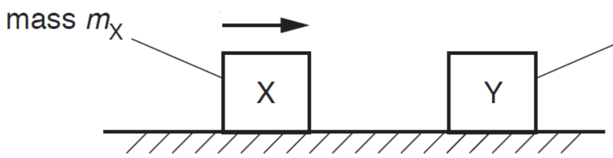

Fig. 2.1

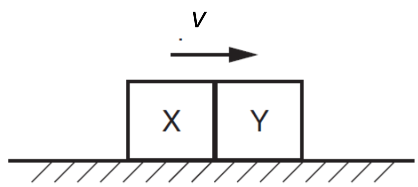

Fig. 2.2

The block X collides head-on with a stationary block Y of mass m_Y. The two blocks stick together and then move with common speed v, as shown in Fig. 2.2.

Fig. 2.3 shows the variation with time t of the momentum of block X.

The values on the momentum axis is **not** given intentionally.

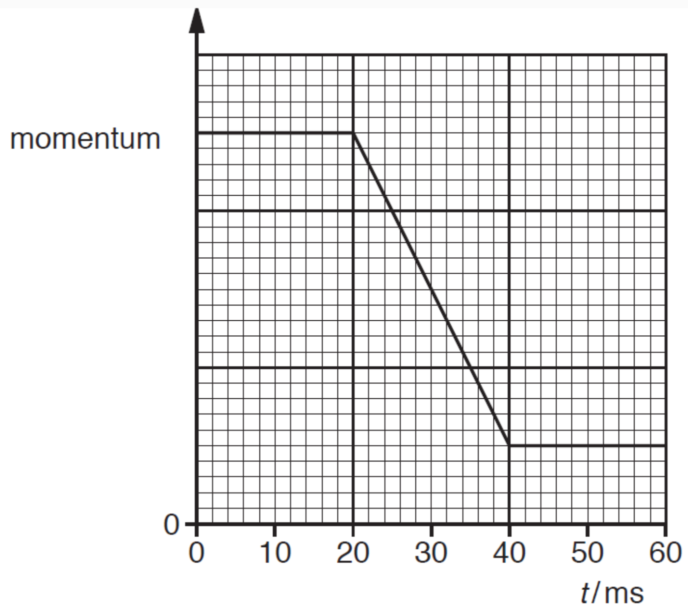

Fig. 2.3

(a) (i) By considering conservation of momentum, calculate the ratio

$$\frac{\text{total kinetic energy of X and Y after collision}}{\text{total kinetic energy of X and Y before collision}}.$$

ratio = ……………………………………… [3]

(ii) State the value of the ratio in **(i)** for a perfectly elastic collision.

ratio = ……………………………………… [1]

(b) On Fig. 2.3, sketch the variation of the momentum of block Y with time t from t = 0 to t = 60 ms. [2]

[Total: 6]

3 **(a)** State *Newton's Second Law of Motion*.

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

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

(b) Fig. 3.1 below shows a smooth ramp inclined at 30° that is flat at the top.

Two boxes of masses 8.0 kg and 4.0 kg are connected by a string that is passed over a smooth pulley. A force of 150 N is applied on the 8.0 kg mass in the downslope direction.

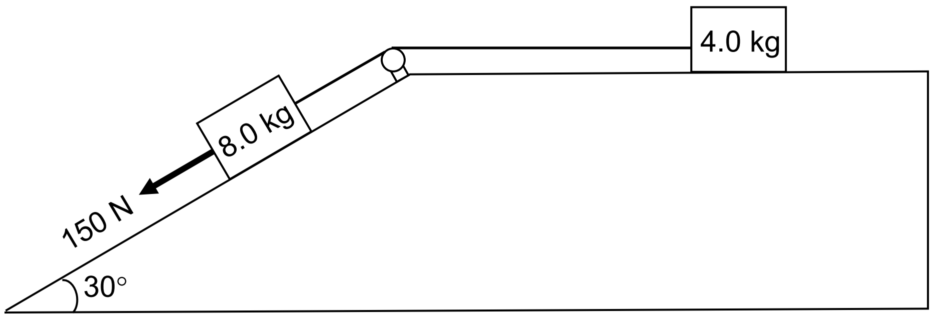

Fig. 3.1

Determine the tension in the string and the acceleration of the masses.

tension = …………………………….N

acceleration = ………………………… m s^{-2} [4]

[Total: 6]

4 A ball of mass 1.5 kg is attached to one end of a light rigid rod of length 2.0 m. The other end of the rod is pivoted at C. The ball is given an initial push to set it into a circular motion in a vertical plane with centre at C.

At a certain point in the trajectory, when the ball is moving at a speed of 9.5 m s^{-1}, the rod makes an angle of 50° to the vertical, as shown in Fig. 4.1 below.

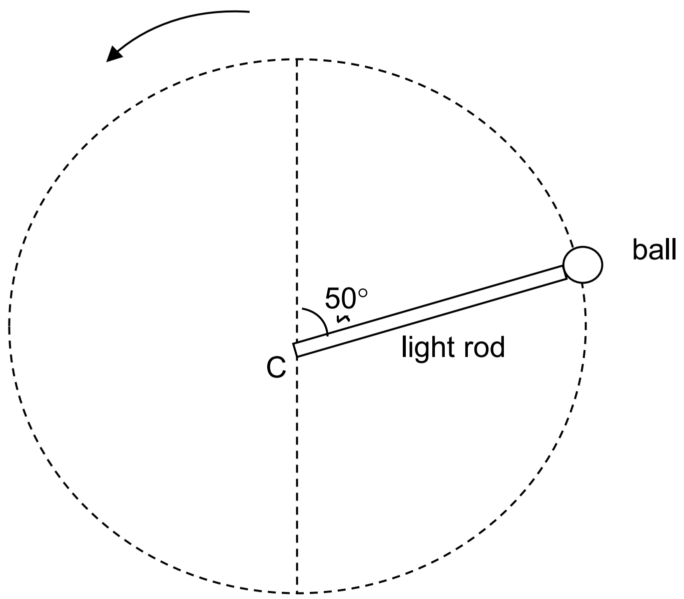

Fig. 4.1

(a) Determine the force in the rod along the radial direction at the instant shown in Fig. 4.1. State whether the rod is in compression or tension.

force in rod = …………………….. N

Compression or tension: ……………………….. [3]

(b) Determine the minimum magnitude of force in the rod through the trajectory.

minimum force in rod = …………………….. N [4]

[Total: 7]

5 A battery of electromotive force (e.m.f.) 12.0 V and internal resistance r is connected to a filament lamp and a resistor, as shown in Fig. 5.1.

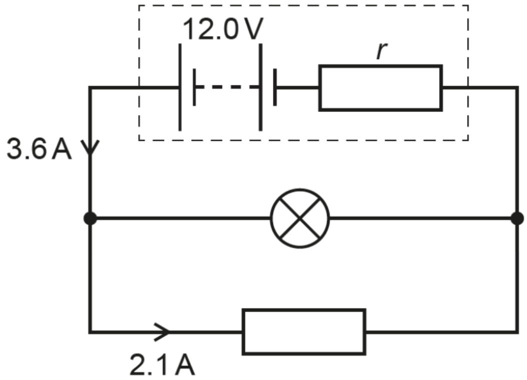

Fig. 5.1

The current in the battery is 3.6 A and the current in the resistor is 2.1 A. The I-V characteristic for the lamp is shown in Fig. 5.2.

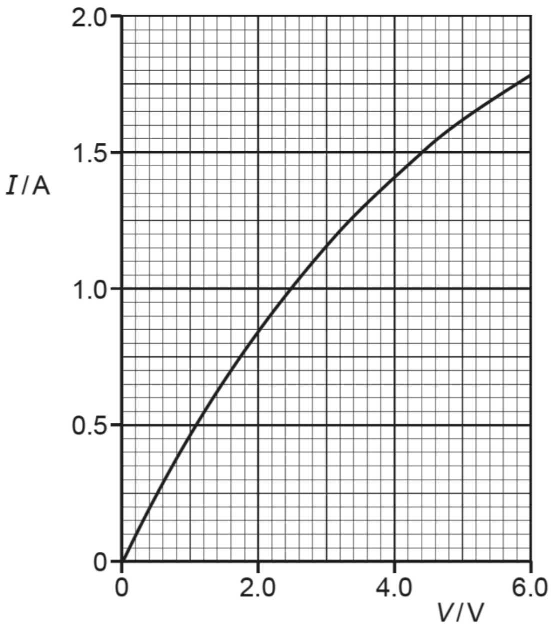

Fig. 5.2

(a) Determine the resistance of the lamp in Fig. 5.1.

resistance = ... Ω [3]

(b) Determine the internal resistance *r* of the battery.

r = …………………………… Ω [2]

(c) The initial energy stored in the battery is 470 kJ. Assume that the e.m.f. and the current in the battery do not change with time.

Calculate the time taken for the energy stored in the battery to become 240 kJ.

time = …………………………….. s [2]

[Total: 7]

6 Two long straight wires P and Q are parallel to each other, as shown in Fig. 6.1. There is a current in each wire in the direction shown.

The pattern of the magnetic field lines in a plane normal to wire P due to the current in the wire is also shown.

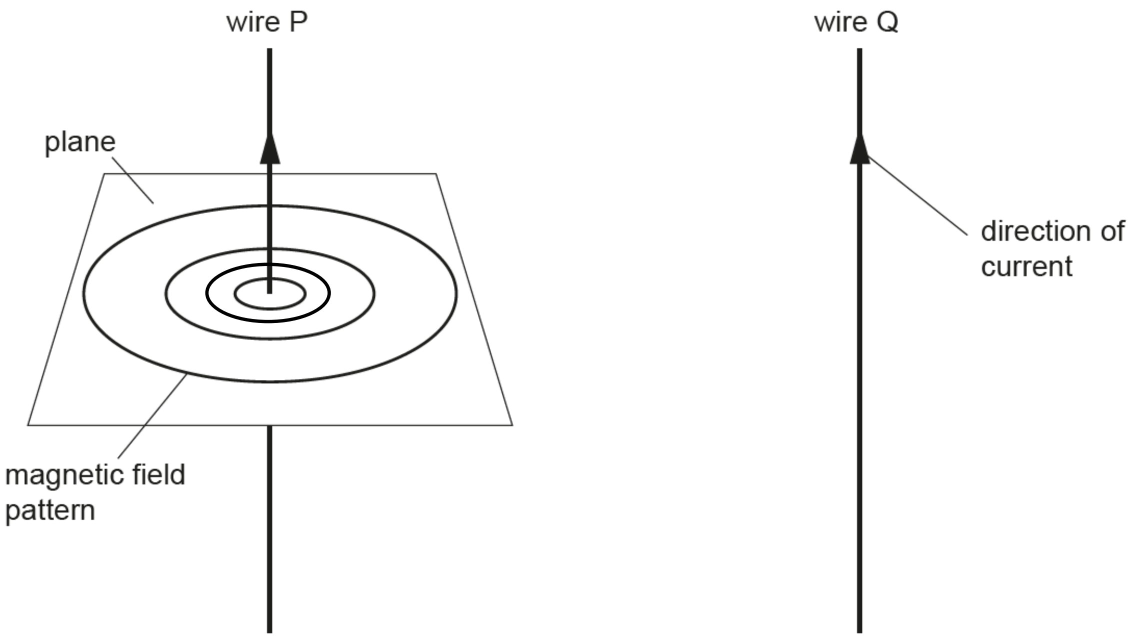

Fig. 6.1

(a) Draw arrows on the magnetic field lines in Fig. 6.1 around wire P to show the direction of the field.

[1]

(b) Determine the direction of the force on wire Q due to the magnetic field from wire P.

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

(c) The current in wire Q is less than the current in wire P.

State and explain whether the magnitude of the force on wire P is less than, equal to, or greater than the magnitude of the force on wire Q.

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

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

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

(d)

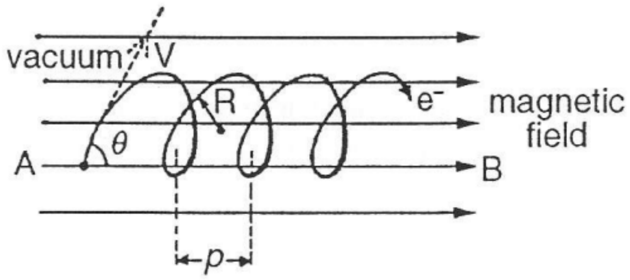

Fig. 6.2

An electron is injected at a speed v of 7.0×10^{6} m s^{-1} at an angle θ of 36.9° into a uniform magnetic field of flux density 3.14×10^{-5} T. It describes a helical path as shown in Fig. 6.2.

(i) calculate the radius R of the helical path.

radius = ………………………….. m [3]

(ii) calculate the time for the electron to complete one revolution in the helix.

time = ………………………….. s [3]

(iii) calculate the pitch, p, of the helix.

pitch = ………………………….. m [2]

(iv) if the angle θ were very small, what would be the pitch of the helix?

pitch = ………………………….. m [2]

[Total: 14]

7 **(a)** Explain why an alpha-decay is not considered a nuclear fission reaction.

……...

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

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

(b) The fission of ^{235}U may be represented by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{\dots}Ba + ^{89}_{36}Kr + \dots ^{1}_{0}n$$

(i) Complete the above nuclear equation by filling the blanks above. [1]

(ii) The binding energy per nucleon of the nuclides involved in the nuclear reaction are shown in Fig. 7.1

nuclide	binding energy per nucleon / MeV
^{235}U	7.59
^{144}Ba	8.27
^{89}Kr	8.62

Fig. 7.1

Calculate the energy released in the fission reaction.

energy = …………………………...J [3]

(iii) State the two forms this released energy can take.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(iv) The nuclear masses of some of the particles involved are shown in Fig. 7.2.

nuclide	mass / *u*
^{235}U	235.043923
^{89}Kr	88.917633
$^{1}_{0}n$	1.008665

Fig. 7.2

Using your answer in **(ii)** and Fig. 7.2, calculate the mass of ^{144}Ba.

mass = …………………………………… kg [3]

[Total: 10]

Section B

Answer the question from this section in the spaces provided.

8 (a) (i) Define the term *electric field strength*.

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

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

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

(ii) Two charged parallel plates are separated by a distance d and have a potential difference V between them. Using your definition in **(a)**, show that electric field strength of the uniform field between the plates is

$$E = \frac{V}{d} .$$

[3]

(b) A charged oil drop is in a vacuum between two horizontal metal plates. A uniform electric field is produced between the plates by applying a potential difference of 1340 V across them, as shown in Fig. 8.1.

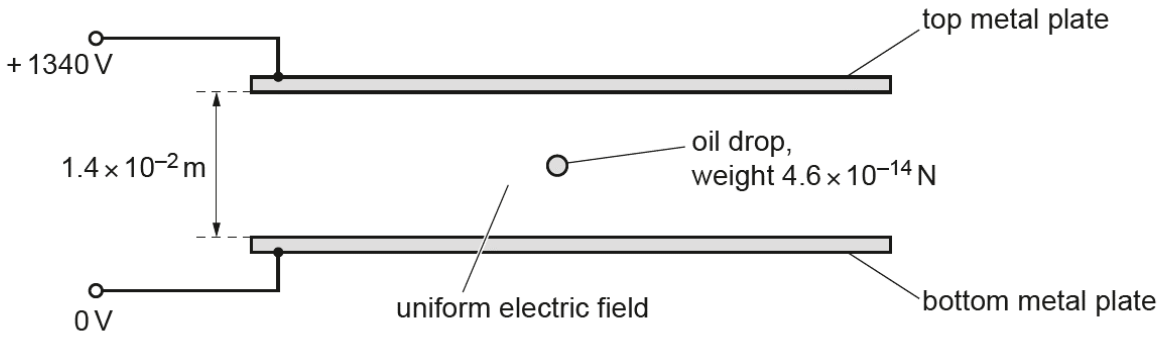

Fig. 8.1

The separation of the plates is 1.4×10^{-2} m.

The oil drop of weight 4.6×10^{-14} N remains stationary at a point mid-way between the plates.

(i) Calculate the magnitude of the electric field strength.

electric field strength = ... N C^{-1} [2]

(ii) Determine the magnitude and the sign of the charge on the oil drop.

magnitude of charge = ... C

sign of charge ....

[3]

(iii) The electric potentials of the plates are instantaneously reversed so that the top plate is at a potential of 0 V and the bottom plate is at a potential of +1340 V. This change causes the oil drop to start moving downwards.

1. Compare the new pattern of the electric field lines between the plates with the original pattern.

…………………………………………………………………………………………………

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

2. Determine the magnitude of the resultant force acting on the oil drop.

resultant force = ….. N [2]

3. Show that the magnitude of the acceleration of the oil drop is 20 m s^{-2}.

[2]

4. Assume that the radius of the oil drop is negligible.

Use the information in **(b)(iii)** to calculate the time taken for the oil drop to move to the bottom metal plate from its initial position mid-way between the plates.

time = ….. s [2]

5. The oil drop in **(b)** starts to move at time t = 0. The distance of the oil drop from the bottom plate is x.

On Fig. 8.2, sketch the variation with time t of distance x for the movement of the drop from its initial position until it hits the surface of the bottom plate. Numerical values of t are not required.

[2]

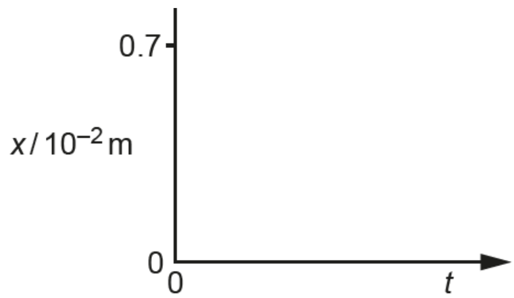

Fig. 8.2

[Total: 20]

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