EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2024
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	2	3	-			REGISTRATION NUMBER	

PHYSICS — 9749/03

Longer Structured Questions

September 2024

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.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

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

For Examiner's Use	
Q1	7
Q2	8
Q3	7
Q4	10
Q5	10
Q6	10
Q7	8
Q8	20
Q9	20
s.f.	
P3 Total	80

This document consists of **24** printed pages.

Data

speed of light in free space,	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-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
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-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,	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T / \text{K} = T / {}^\circ\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{\left(x_0^2 - x^2\right)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer all questions in this section in the spaces provided.

1 Fig. 1.1 shows a simple pendulum consisting of a mass *m* attached to a light inextensible string of length *L*. The pendulum is secured to a fixed point and made to undergo oscillations when displaced sideways by a small angle *θ*.

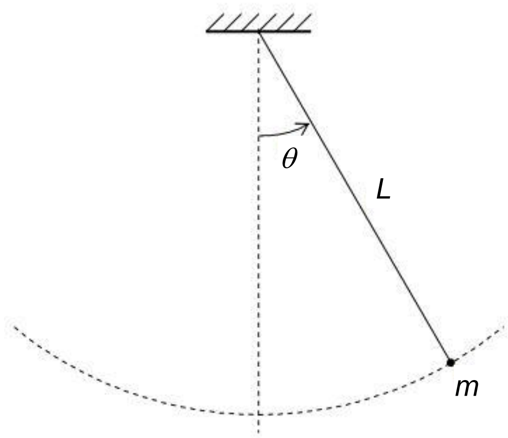


Fig. 1.1 (not to scale)

The following equation describes the period *T* of the oscillation:

$$T^2 = 4\pi^2 \frac{L}{g}$$

where *g* is the acceleration of free fall.

(a) Given L = 50.0 ± 0.2 cm and g = 9.8 ± 0.1 m s^{-2}, find *T* with its associated uncertainty.

T = ………………… ± ………………… s [4]

(b) A student measures the period of an oscillation using two methods.

In the first method, he measures the period of one oscillation directly.

In the second method, he measures the total time for 20 oscillations, and then divides the total time by 20 to obtain the period for one oscillation.

(i) The student took three readings each using the two methods.

Using suitable calculation, predict which set of data will be more precise.

....

....

.... [2]

(ii) In reality, the student mistook the time for half an oscillation to be one period.

Explain whether calculating the period by dividing the total time taken for multiple oscillations by the number of oscillations will reduce this type of error committed.

....

.... [1]

[Total: 7]

2 **(a)** Define *acceleration*.

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

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

(b) An object is released from rest in a viscous fluid. Fig. 2.1 shows the variation with time t of the acceleration a of the object as it falls in the fluid.

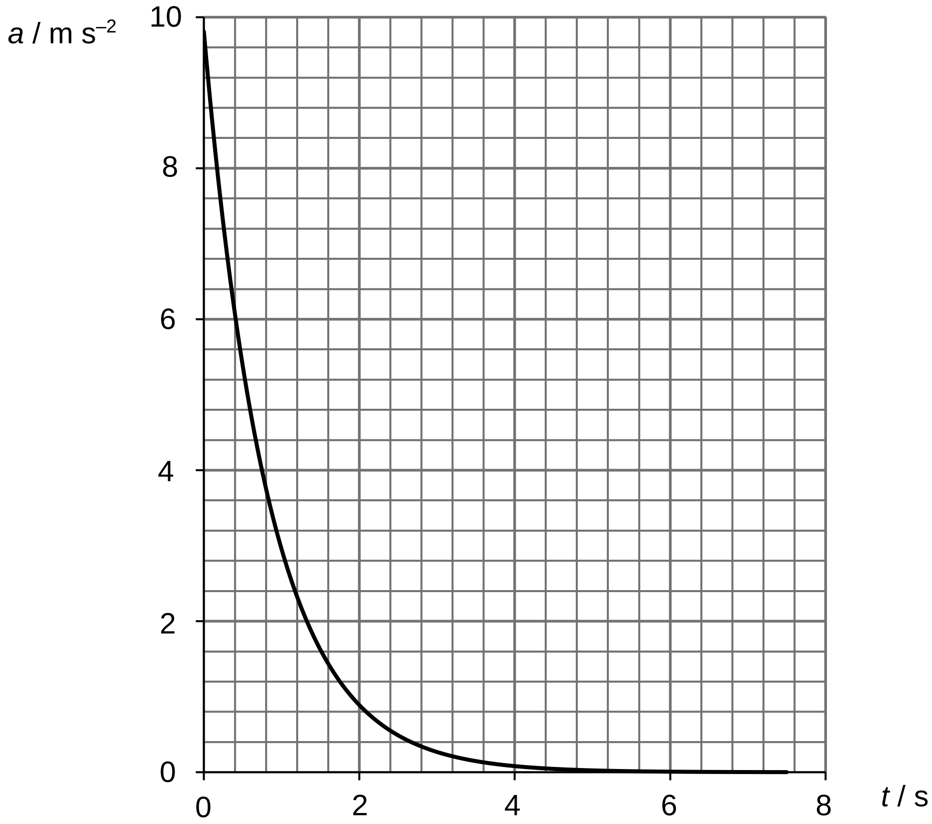


Fig. 2.1

(i) Explain why the acceleration of the object decreases with time.

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

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

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

(ii) Explain why the initial value of the acceleration is 9.81 m s^{-2}.

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

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

(iii) Use Fig. 2.1 to estimate the speed of the object when its acceleration is zero. Explain your working clearly.

speed = ……………………… m s^{-1} [2]

(iv) In Fig. 2.2, sketch the variation of the displacement s of the object with time t, from t = 0 s to t = 8 s. There is no need to label the displacement axis.

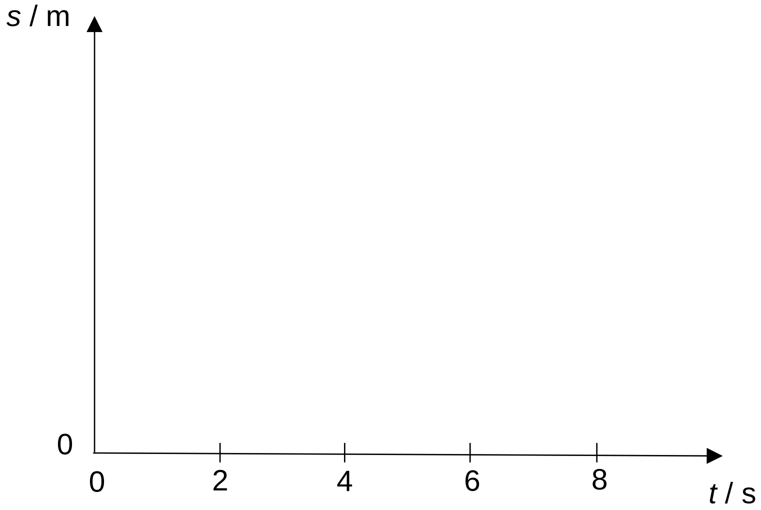


Fig. 2.2

[2]

[Total: 8]

3 A 12 V cell of internal resistance 30 Ω, a light-dependent resistor (LDR) and a 600 Ω resistor are connected as shown in Fig. 3.1.

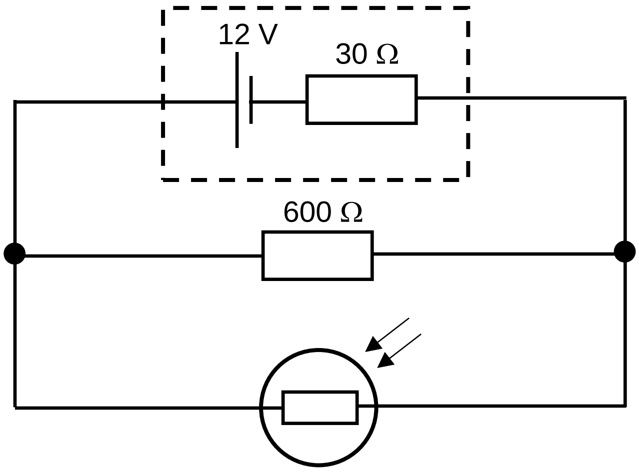


Fig. 3.1

(a) In conditions of low intensity light, the resistance of the LDR is 3000 Ω.

(i) Show that the current through the LDR is 3.8 mA.

[3]

(ii) Hence or otherwise, determine the power dissipated in the LDR.

power = ……………………… W [1]

(b) The LDR is exposed to bright sunlight.

State and explain what would happen to the terminal potential difference.

……

……

……

……

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

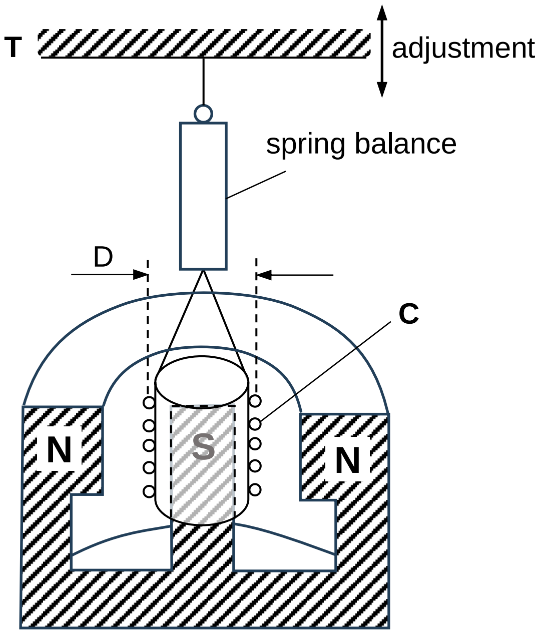
[Total: 7]

4 **(a)** Define magnetic flux density.

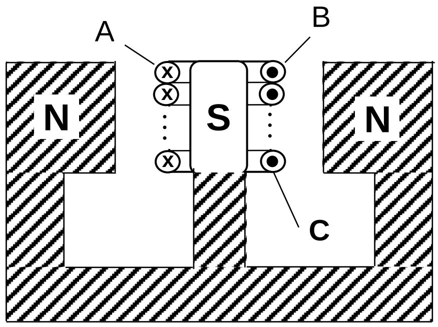
....

....[1]

(b) Fig. 4.1 shows a loudspeaker magnet consisting of a circular north pole **N** and a cylindrical south pole **S**. Part **C** is a moving coil that coils around **S**, and it is attached to a spring balance, which is attached to an adjustable support **T**.



(a) section view



(b) side view

Fig. 4.1

Current was passed through the coil **C**, and the adjustable support **T** was then adjusted so that the coil **C** was restored to its original position. The readings *F* on the balance for various currents *I* are recorded in Table 4.1 below.

Table 4.1

I / A	0.20	0.41	0.60	0.81
F / N	1.50	2.02	2.48	3.05

(i) The direction of current flowing in the coil is indicated in Fig. 4.1(b). Draw two arrows, one each at positions A and B, to indicate the direction of the magnetic force acting on the coil. Explain your answer.

....

....

....

.... [3]

(ii) In Fig 4.2, draw a graph using values from Table 4.1 to determine the force per unit current required to restore coil **C** to its original position**,** and find the zero error of the balance.

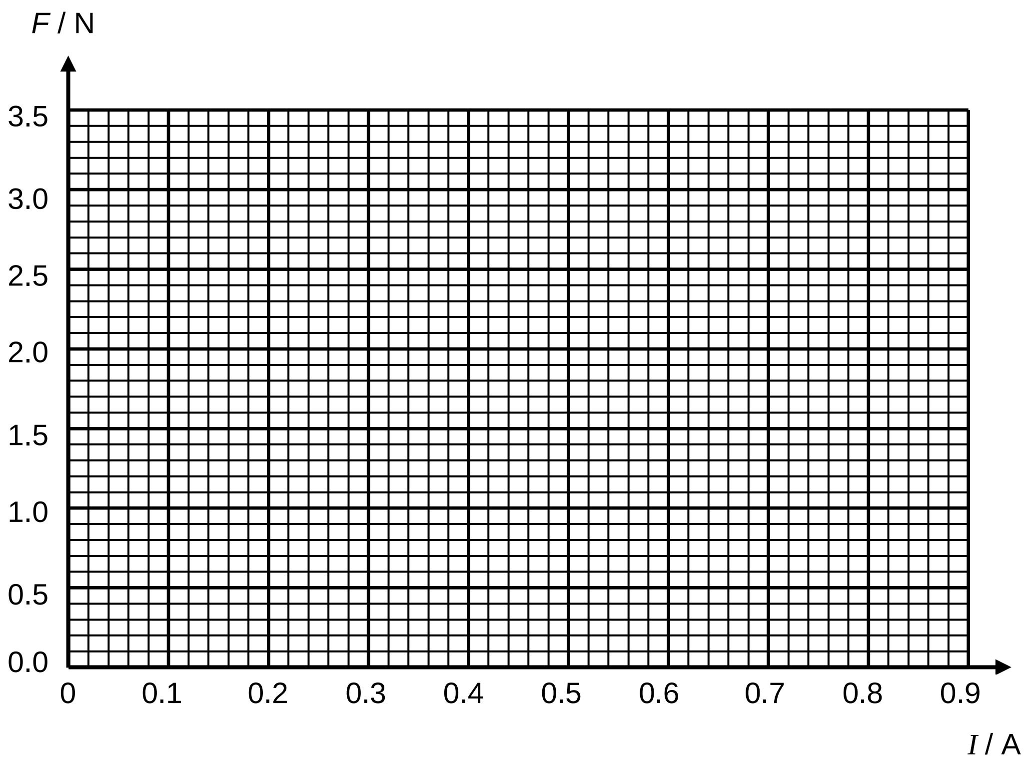


Fig. 4.2

force per unit current = …………………………N A^{-1}

zero error of the balance = ……………………. N [4]

(iii) If the mean diameter, *D*, of the coil is 0.025 m and the number of turns is 50, calculate the flux density at the coil, assuming that the field is radial.

magnetic flux density= ……………………T [2]

[Total:10]

5 **(a)** Explain what is meant by *gravitational field strength* at a point.

....

....[1]

(b) A satellite of mass m orbits a planet of mass M in a circular orbit, with orbital radius r.

Show that its kinetic energy E_K and gravitational potential energy E_P are related by

$$E_K = -\frac{E_P}{2}.$$

[2]

(c) The variation of gravitational potential ϕ with distance r from the centre of Jupiter is shown in Fig. 5.1.

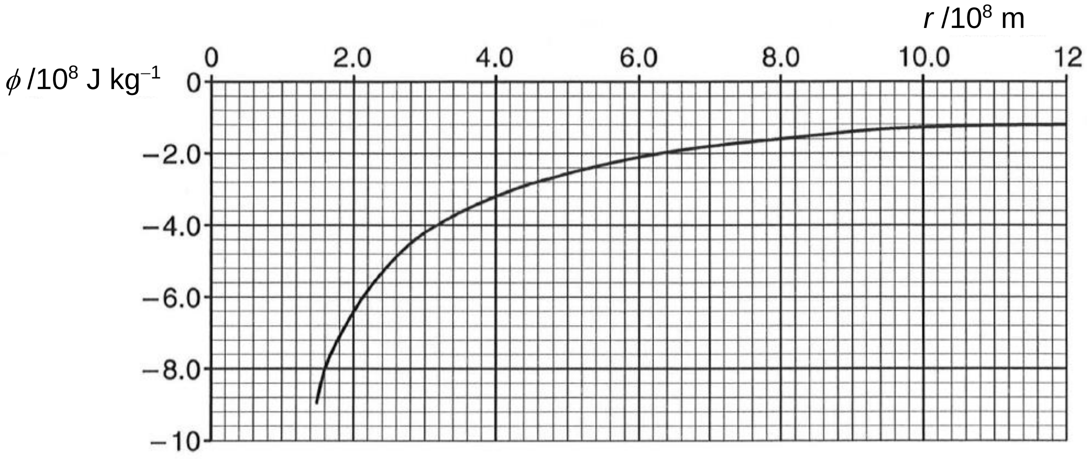


Fig. 5.1

(i) A satellite orbiting Jupiter has a mass of 8.93×10^{22} kg and orbital radius 4.0×10^{8} m.

Determine the total energy of the satellite.

total energy = ……………………. J [3]

(ii) The orbital radius of the satellite is reduced. State and explain the effect on

1. the kinetic energy of the satellite,

…………………………………………………………………………………………………

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

2. the total energy of the satellite.

…………………………………………………………………………………………………

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

(iii) Use Fig. 5.1 to determine the gravitational field strength due to Jupiter at a distance of 4.0×10^8 m from its centre.

gravitational field strength = ……………………. m s^{-2} [2]

[Total: 10]

6 **(a)** State the first law of thermodynamics.

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

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

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

(b) The temperature of a sample of ideal gas is raised via two different processes.

In the first process, the ideal gas is heated up with its volume kept constant.

In the second process, the ideal gas is heated up at constant pressure.

The initial and final temperatures of the ideal gas are the same for the two processes.

Using the first law of thermodynamics, explain why the second process requires more heat transfer to the gas than the first.

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

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

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

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

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

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

(c) A car tyre has a fixed internal volume of 0.036 m^3. The temperature and pressure of the air inside the car tyre are 25 °C and 2.6×10^5 Pa, respectively.

Assume that the air inside the tyre can be considered as an ideal gas.

(i) Determine the number of air particles in the car tyre.

number of air particles = …………………. [2]

(ii) The average molar mass of the air is 6.5 g.

Calculate the root mean square (r.m.s.) speed of the air molecules.

r.m.s. speed of molecules = …………………………… m s^{-1} [3]

[Total: 10]

7 **(a)** Define electric potential.

……

…… [1]

(b) Fig. 7.1 is a **full-scale** diagram that shows a series of equipotential lines around a few point charges. A, B and C are points within the field.

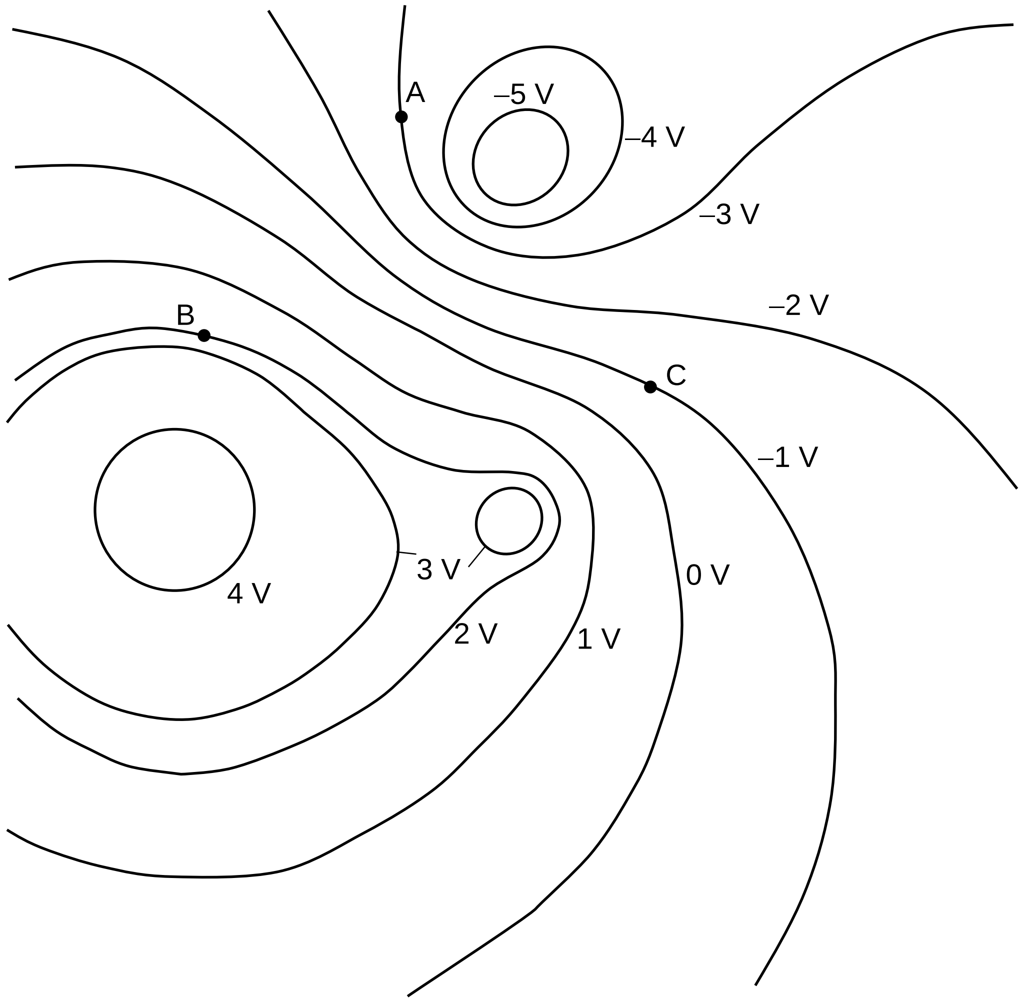


Fig. 7.1 (drawn to scale)

(i) On Fig 7.1, sketch the electric field line that joins points A and B. Label the line E.

Indicate the direction of the field line with an arrow drawn on the line.

[2]

(ii) An electron moves from point A with an initial speed of 2.6×10^6 m s^{-1}, eventually reaching point B.

Calculate the speed of the electron at point B.

speed = ………………………. m s^{-1} [3]

(iii) Using Fig. 7.1, determine the magnitude of the electric force experienced by an electron placed at point C. Show your working clearly.

electric force = ………………………. N [2]

[Total: 8]

Section B

Answer one question in this section in the spaces provided.

8 **(a)** **(i)** State what is meant by a polarized wave.

....

....[2]

(ii) Explain what is meant by coherent light waves.

....[1]

(b) A double slit consists of two parallel slits of the same width *x*. The separation of the slits is 1.40 mm, as illustrated in Fig. 8.1.

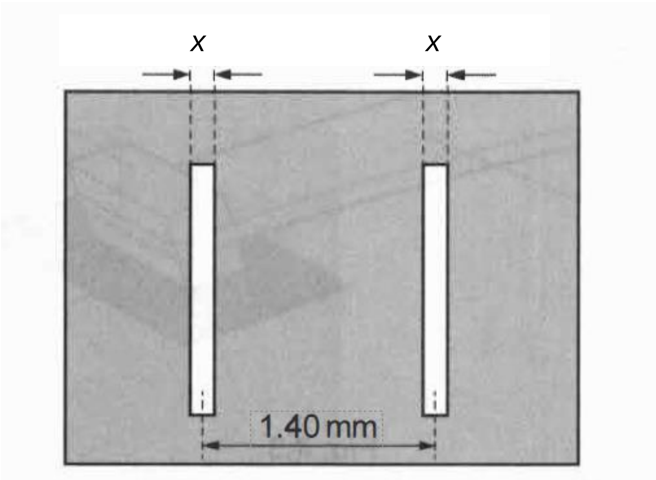


Fig. 8.1

A parallel beam of light of wavelength 590 nm is incident normally on the double slit.

A screen is placed parallel to the plane of the double slit at a distance of 2.60 m from the slits, as illustrated in Fig. 8.2. Point N on the screen is on the central axis of the double slit.

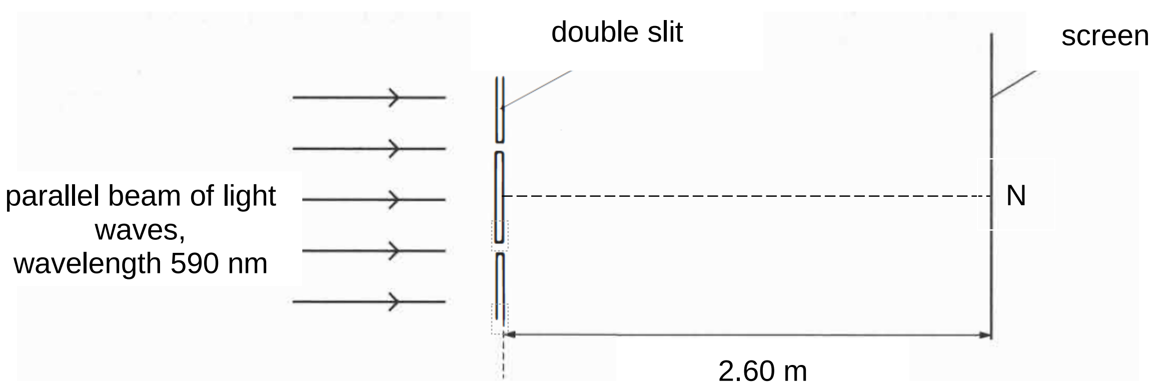


Fig. 8.2

Initially, one of the two slits is covered, and a central maximum of width 30.7 mm is observed on the screen.

(i) Determine *x*.

x = ... m [2]

(ii) Calculate the minimum angular separation between two objects, such that their images can be resolved by the slit.

minimum angular separation = ... rad [2]

(iii) Both slits are now uncovered. Describe how the central maximum changes.

....

....[2]

(iv) The intensity at point N is I_{single} when one slit is uncovered and I_{double} when both slits are uncovered.

Determine

$$\frac{I_{\text{single}}}{I_{\text{double}}}.$$

$\frac{I_{\text{single}}}{I_{\text{double}}}$ = ... [1]

(v) Another experiment is conducted, where the two slits are replaced by lights from two separate point sources.

Suggest two reasons why the pattern in **(b)(iii)** may not be observed in the new experiment.

1. ....

....

2. ....

.... [2]

(c) Some electron energy levels of the mercury atom are illustrated in Fig. 8.3.

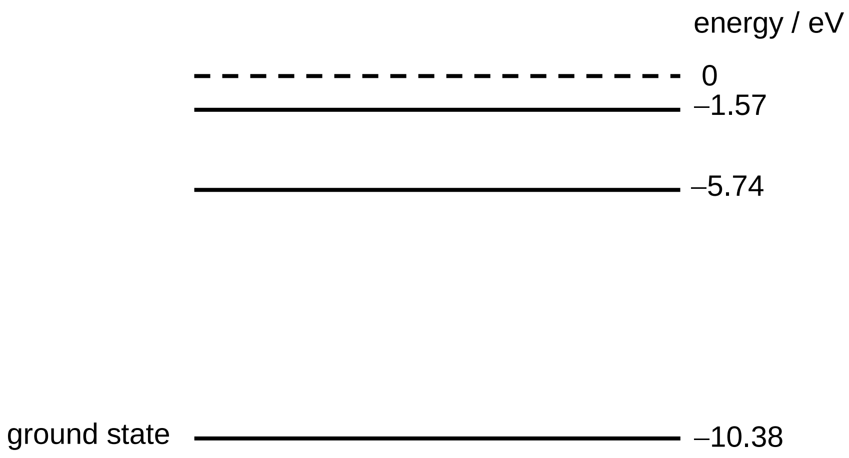


Fig. 8.3 (not to scale)

(i) Explain the significance of the energy levels being negative.

....

.... [1]

(ii) State the ionisation energy of the mercury atom.

ionisation energy = ... eV [1]

(iii) An electron with energy 8.9 eV collides with a mercury atom in its ground state.

Consider only the three energy levels shown in Fig. 8.3.

1. On Fig. 8.3, draw arrows to show electron transitions between energy levels that produce the emission spectrum.

[2]

2. determine the longest wavelength of the spectral lines.

wavelength = ... nm [2]

(iv) A photon with energy 8.9 eV interacts with a mercury atom in its ground state.

For the three energy levels shown in Fig. 8.3, state and explain the number of transition lines in the resulting spectrum.

....

....

....

.... [2]

[Total: 20]

9 **(a)** **(i)** Explain what is meant by diffraction of light.

....

.... [1]

(ii) A parallel beam of red light is incident normally on a diffraction grating, and a diffraction pattern is observed. The red light in is then replaced with blue light.

State and explain the effect on the diffraction pattern, apart from the change in color.

....

....

.... [2]

(b) A loudspeaker is held above a vertical tube of liquid, as shown in Figure 9.1.

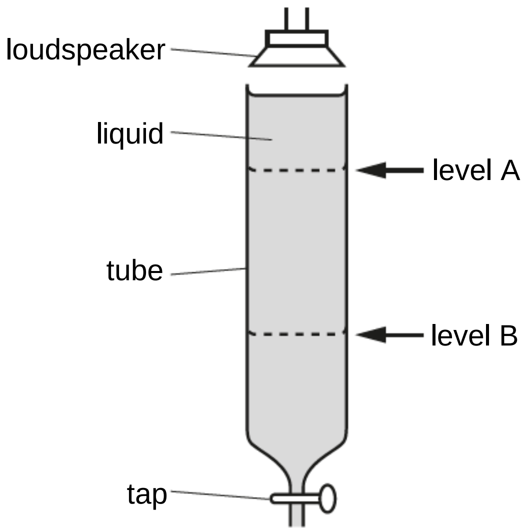


Fig. 9.1

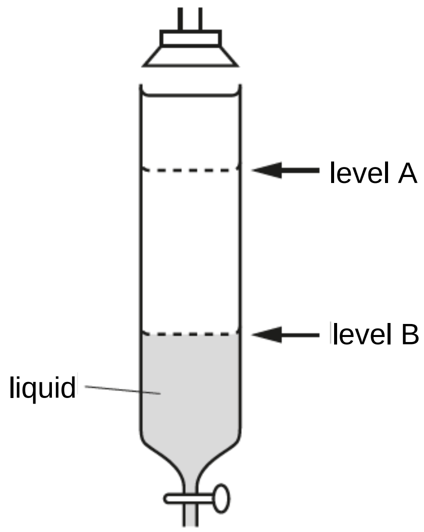


Fig 9.2

A tap at the bottom of the tube is opened so that liquid drains out slowly. The wavelength of the sound from the loudspeaker is 0.30 m.

The sound that is heard first becomes much louder when the liquid surface reaches level A. The next time that the sound becomes much louder is when the liquid surface reaches level B, as shown in Fig. 9.2.

(i) Calculate the vertical distance between level A and level B.

distance = ... m [1]

(ii) On Fig. 9.2, label with the letter N the positions of the displacement nodes of the stationary wave that is formed in the air column when the liquid surface is at level B.

[1]

(c) S_1 and S_2 are two loudspeakers directly facing each other, emitting continuous sound waves of frequency 1100 Hz. **M** is a microphone which runs on a straight track from S_1 to S_2 at a speed of 20 m s^{-1}, as shown in Fig. 9.3.

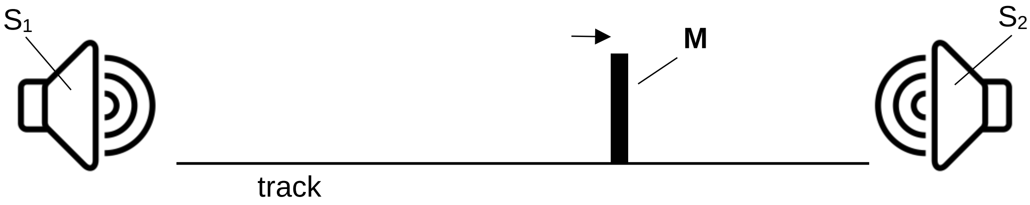


Fig. 9.3

(i) The intensity of sound received by **M** fluctuates regularly. Explain.

....

....

....

.... [2]

(ii) If the speed of sound is known to be 330 m s^{-1}, calculate the frequency at which the maxima in sound are detected by **M**.

frequency = ... Hz [3]

(d) **(i)** With reference to the photoelectric effect, explain why the existence of the threshold frequency provides evidence for the particulate nature of EM radiation.

....

....

....

....

....

.... [3]

(ii) Electromagnetic radiation of wavelength λ is incident on a metal surface. Electrons are emitted from the surface, with maximum kinetic energy E_{max}.

The variation of E_{max} with λ is shown in Fig. 9.4.

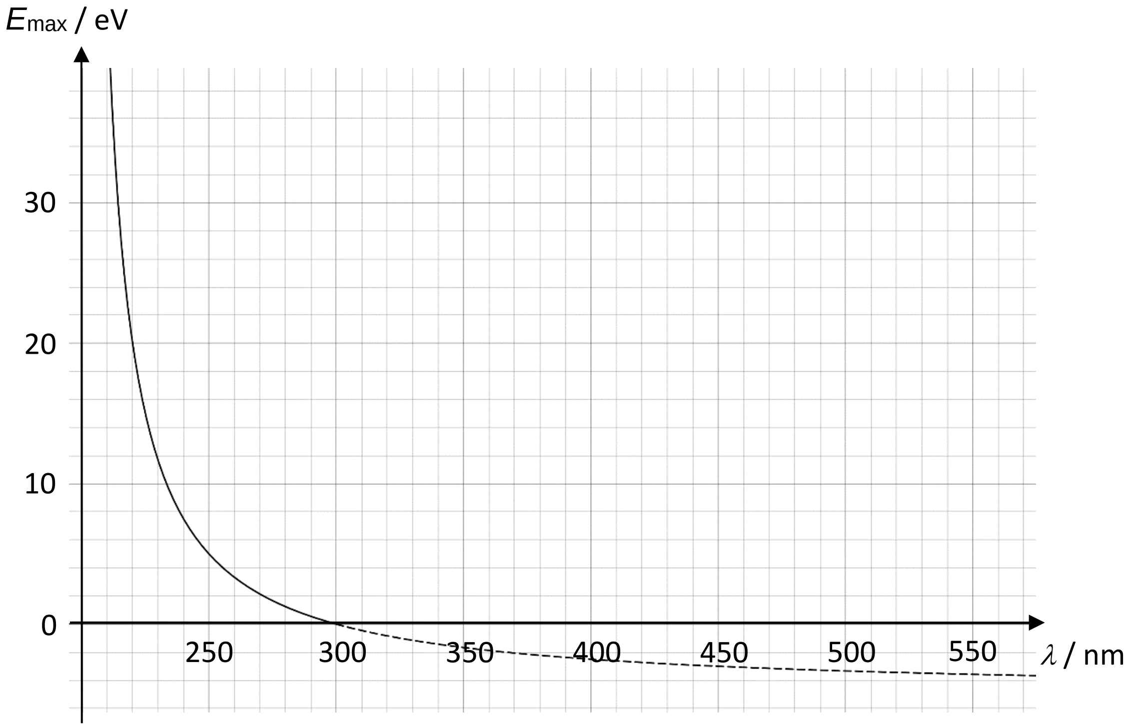


Fig. 9.4

Using Fig. 9.4, determine

1. the work function of the metal,

work function = ………………………………. eV [2]

2. the threshold frequency of the metal, and threshold frequency = …………………………….. Hz [1]

3. the stopping potential when λ = 220 nm.

stopping potential = ……………………………. V [2]

(iii) On Fig. 9.4, sketch a curve to show the variation with λ of E_{max} for a metal with a higher work function.

[2]

[Total: 20]