

TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

CIVICS GROUP

H2 PHYSICS**9749/01****Paper 1 Multiple Choice****25 September 2025****1 hour**

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST**You do not need to submit this Booklet at the end of the examination.**

Write in soft pencil.

Do not use paper clips, glue or correction fluid.

Write your name, class and centre/index number on the Multiple Choice Answer Sheet in the spaces provided.

Shade the last four digits of your centre/index number on the Multiple Choice Answer Sheet. (e.g. if your centre/index number is 30541234, shade 1234).There are **thirty** questions on this paper. Answer **all** questions.For each question there are four possible answers **A, B, C, D**.Choose the **one** you consider correct and record your choice in **soft pencil** on the Multiple Choice Answer Sheet.**Read the instructions on the Multiple Choice Answer Sheet.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $= (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$



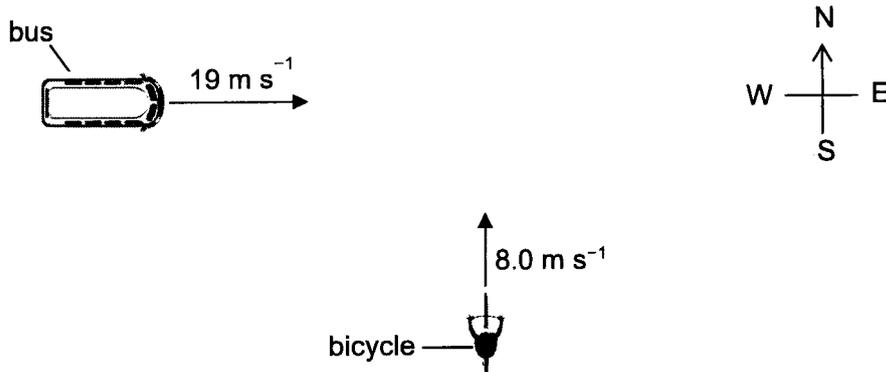
Formulae

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	$T/K = T/^{\circ}\text{C} + 273.15$
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.	$v = v_0 \cos \omega t$ $= \pm \omega \sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \dots$
electric potential	$V = \frac{Q}{4\pi\epsilon_0 r}$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$



4

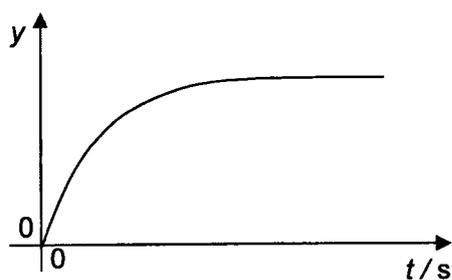
- 1 A bicycle moves at 8.0 m s^{-1} due north. A bus moves at 19 m s^{-1} due east.



At this instant, which arrow represents the velocity of the bicycle relative to the bus?



- 2 The graph below shows the variation with time t of a quantity y for a falling object released from rest.

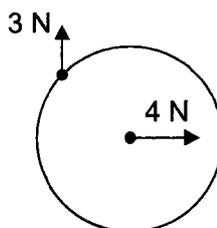


Which of the following is correct?

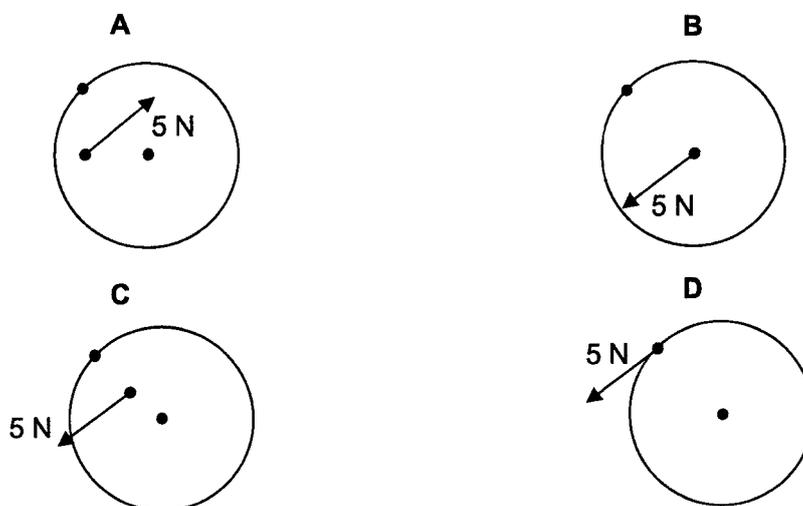
	quantity y	presence of air resistance
A	velocity	no
B	velocity	yes
C	displacement	no
D	displacement	yes

5

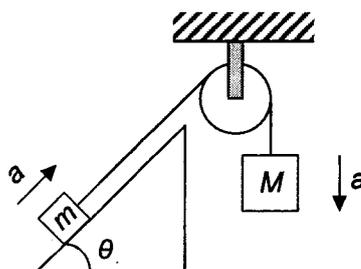
- 3 Two forces act on a circular disc as shown.



Which diagram shows the third force that must be applied such that the circular disc is in equilibrium?



- 4 Two blocks of masses M and m are joined by a light inextensible string through a frictionless pulley as shown. Mass m lies on a smooth slope of angle θ .



The acceleration of free fall is g .

What is the acceleration a of the two blocks?

A $\frac{(M + m \cos \theta)}{(M + m)} g$

B $\frac{(M + m \sin \theta)}{(M + m)} g$

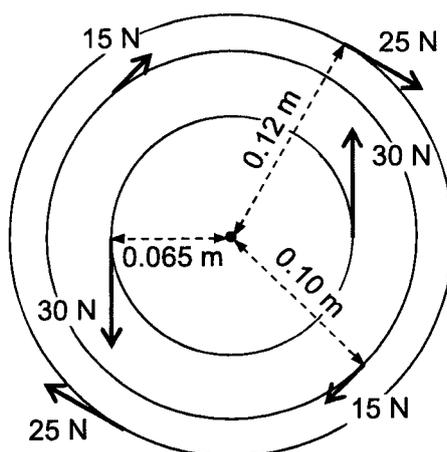
C $\frac{(M - m \cos \theta)}{(M + m)} g$

D $\frac{(M - m \sin \theta)}{(M + m)} g$



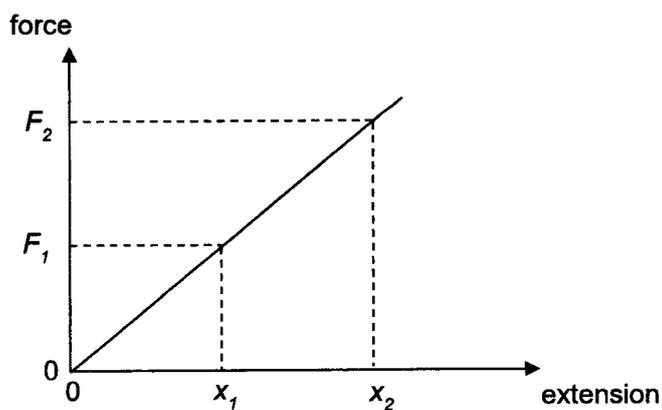
6

- 5 In a machine, many couples act on a rotating object as shown.



What is the resultant torque acting on the rotating object?

- A 2.6 N m B 5.1 N m C 6.5 N m D 12.9 N m
- 6 The force-extension graph of a spring is as shown.

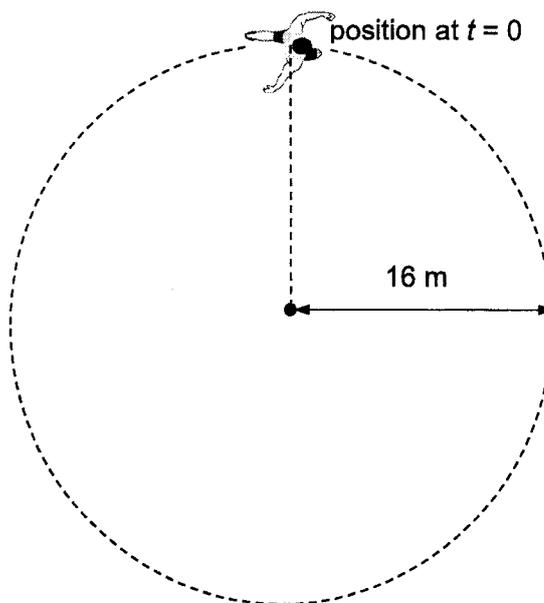


What is the change in elastic potential energy when the extension of the spring is increased from x_1 to x_2 ?

- A $F_2x_2 - F_1x_1$ B $0.5(F_2x_2 - F_1x_1)$
 C $F_2x_2^2 - F_1x_1^2$ D $0.5(F_2x_2^2 - F_1x_1^2)$

7

- 7 A man runs around a circular track of radius 16 m. His position at $t = 0$ s is as shown. It may be assumed that he maintained a constant speed of 8.4 m s^{-1} throughout the run.



What is the angular displacement of the man at $t = 8.0$ s?

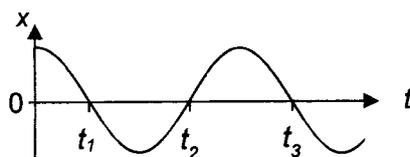
- A** 2.1 rad **B** 4.2 rad **C** 5.8 rad **D** 8.4 rad
- 8 A stone tied to a string is moving in a circular path. The speed of rotation is increased. Which statement is correct?
- A** The increase in angular speed causes the linear speed to increase.
B The increase in linear speed causes the angular speed to increase.
C The increase in angular speed causes the force applied to increase.
D The increase in force applied causes the angular speed to increase.
- 9 The International Space Station (I.S.S.) and a satellite orbit around the Earth at radii of $6.8 \times 10^3 \text{ km}$ and $4.2 \times 10^4 \text{ km}$ from the centre of Earth respectively.

If the satellite has a speed of 3.1 km s^{-1} , what is the speed of the I.S.S.?

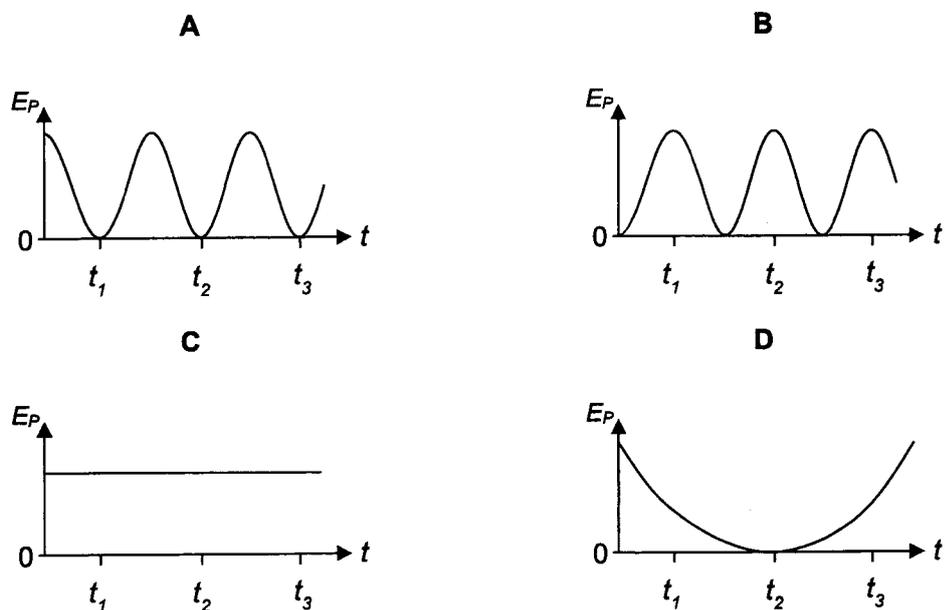
- A** 0.20 km s^{-1} **B** 1.2 km s^{-1} **C** 7.7 km s^{-1} **D** 19 km s^{-1}



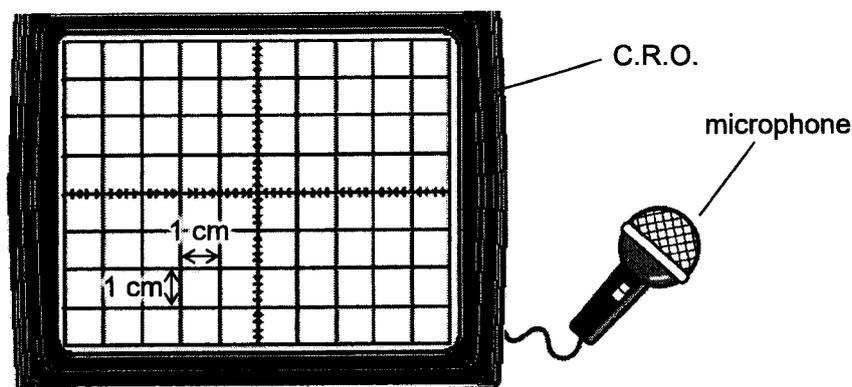
- 10 The oscillations of a mass suspended on a spring are simple harmonic. The variation with time t of the displacement x of the mass is shown.



Which graph shows the variation with time t of the potential energy of the oscillation E_P of the mass?



- 11 A student is investigating the frequency of a sound wave by using a microphone connected to a cathode-ray oscilloscope (C.R.O.) as shown below.

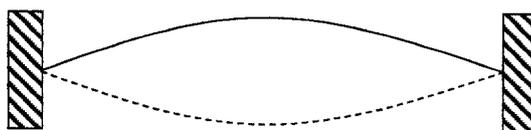


The frequency of the sound is 2 kHz.

Which time-base setting on the oscilloscope will be appropriate?

- A 10 ms cm^{-1} B 0.1 ms cm^{-1} C $1 \mu\text{s cm}^{-1}$ D 10 ns cm^{-1}

- 12 A wire is stretched between two supports and plucked. A stationary wave is formed as shown.



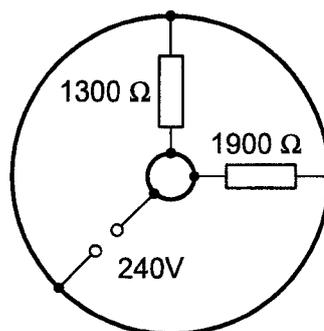
Given that the frequency of the stationary wave shown above is f , what is the next possible frequency for a stationary wave to be formed in the setup?

- A $2f$ B $3f$ C $\frac{1}{2}f$ D $\frac{3}{2}f$
- 13 Two monochromatic radiations X and Y of wavelengths λ_X and λ_Y respectively, are incident normally on a diffraction grating. The third order intensity maximum for X coincides with the fifth order intensity maximum for Y.

What is the ratio of $\frac{\lambda_X}{\lambda_Y}$?

- A $\frac{1}{2}$
- B $\frac{3}{5}$
- C $\frac{5}{3}$
- D Not able to determine with given information.
- 14 Which statement is true for an ideal gas undergoing compression in an insulated container?
- A Internal energy remains constant.
- B Temperature increases.
- C Heat is supplied to the gas.
- D Negative work is done on the gas.

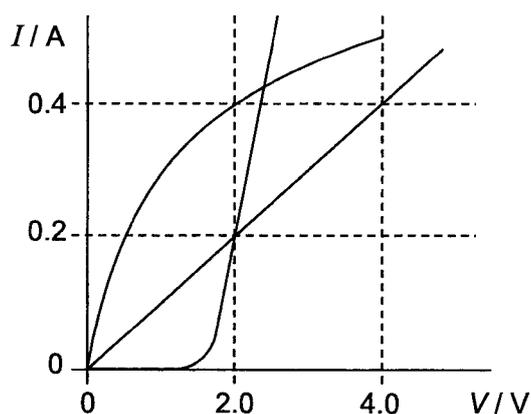
- 18 The diagram shows two resistors connected to a 240 V power supply of negligible internal resistance.



What is the current supplied by the power supply and total power dissipated by the resistors?

	current / A	total power dissipated / W
A	0.075	18
B	0.075	75
C	0.31	18
D	0.31	75

- 19 The graph shows the I - V characteristics of three electrical components, a diode, a filament lamp and a resistor, plotted on the same axes.



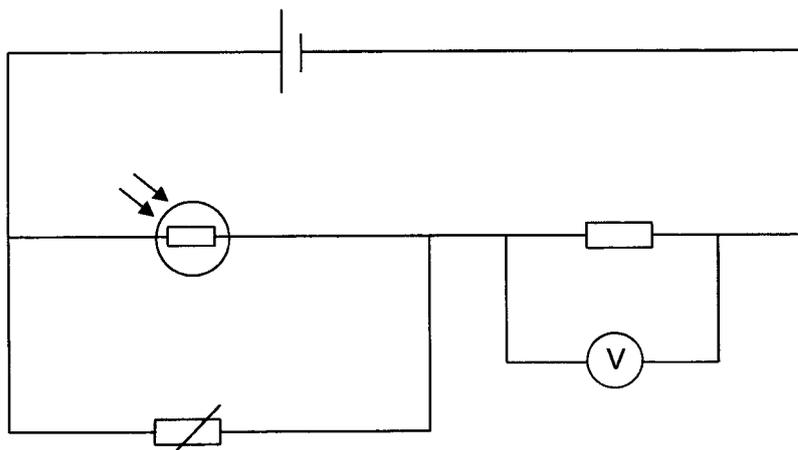
Which statement is correct?

- A** The resistance of the diode is constant above 1.8 V approximately.
- B** The resistance of the lamp is twice that of the resistor at 2.0 V.
- C** The resistance of the lamp is equal to that of the diode at approximately 2.4 V.
- D** All three components have the same resistance at one particular V .

12

- 20 NTC thermistors and light-dependent resistors (LDR) are often used in circuits which requires resistance to vary according to temperature and light intensity respectively.

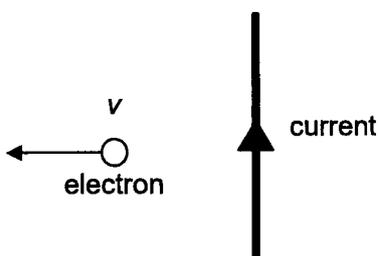
Below shows such a circuit.



What conditions will produce the highest reading on the voltmeter?

	brightness	temperature
A	high	low
B	high	high
C	low	low
D	low	high

- 21 An electron is moving with speed v beside a current carrying wire as shown.



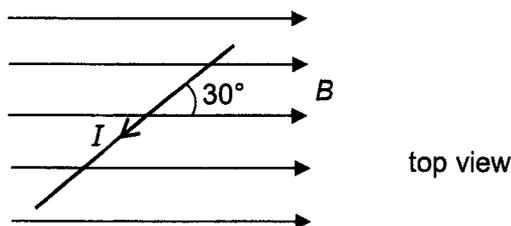
What is the direction of the magnetic force acting on the electron?

- A** into paper
- B** out of paper
- C** vertically downwards
- D** vertically upwards

13

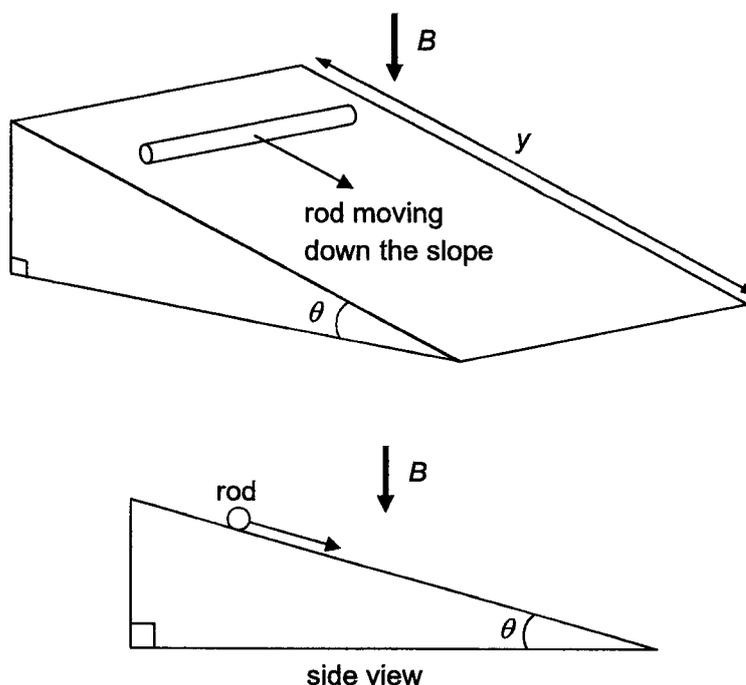
- 22 A wire 30 cm long with a mass of 4.0 g, is placed on a horizontal platform in a magnetic field of flux density 0.040 T. The diagram shows the top view of the set-up.

The current I in the wire is slowly increased until the wire starts to lift off from the platform when $I = I_0$.



What is value of I_0 ?

- A 3.3 A B 6.5 A C 33 A D 65 A
- 23 A conducting rod of length L is released from rest at the top of a smooth sloping surface. The surface has a fixed length y , but the angle θ of the slope to the horizontal can be varied. There is a uniform magnetic field of flux density B throughout the region of the sloping surface directed vertically downwards.

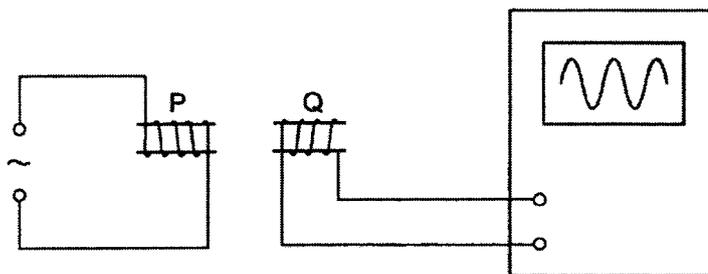


Which value of θ will induce the largest e.m.f. in the rod when it reaches the bottom of the slope?

- A 35° B 40° C 45° D 50°

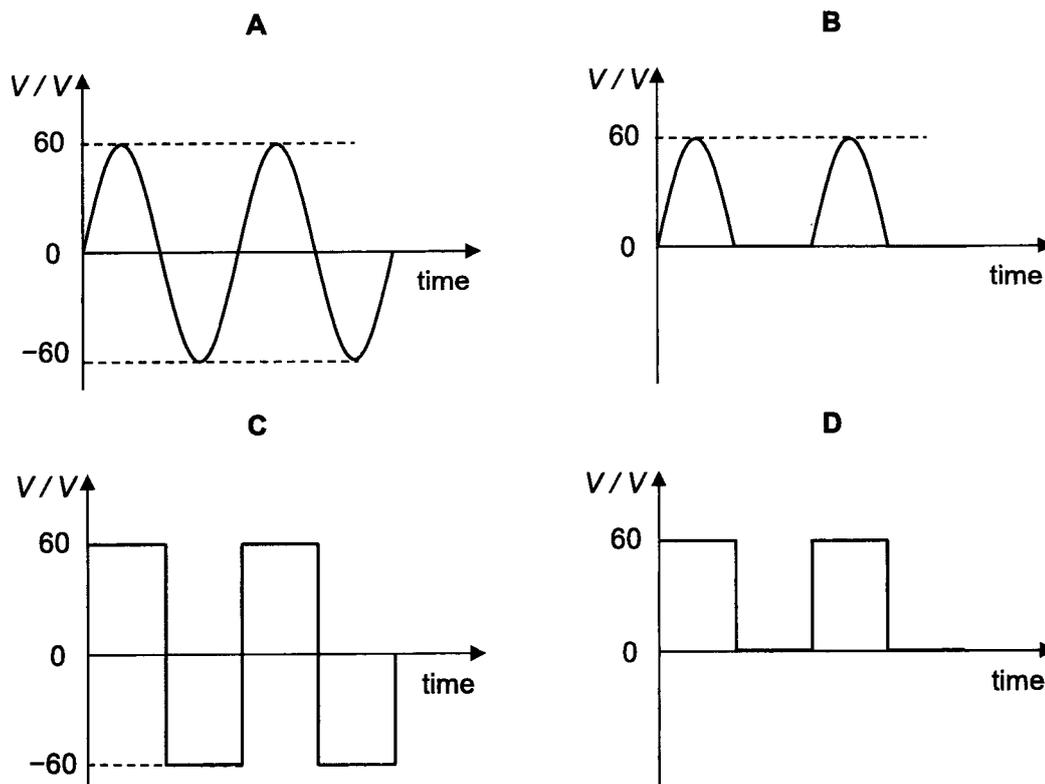
14

- 24 A coil P is connected to a 50 Hz alternating supply of constant peak voltage. Coil P lies close to a separate coil Q which is connected to the Y-input terminals of a cathode-ray oscilloscope. A sinusoidal trace appears on the screen of the oscilloscope.

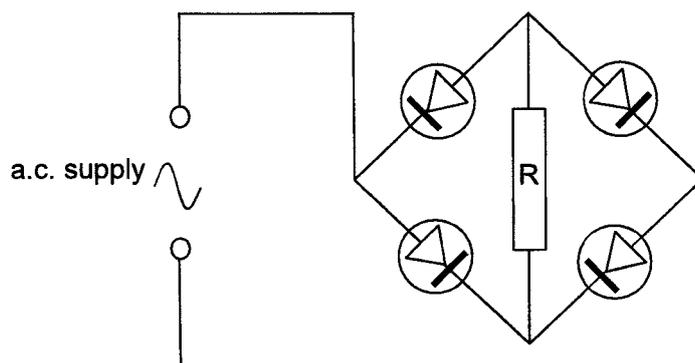


Which change will cause the trace to have a larger amplitude while the number of cycles per unit time remains unchanged?

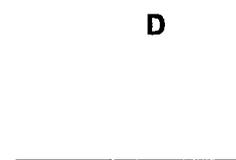
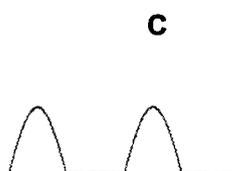
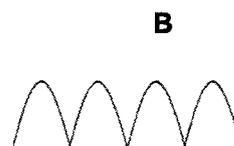
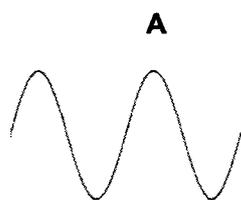
- A increase the frequency of the alternating supply
 B decrease the cross-sectional area of coil P
 C decrease the number of turns in coil Q
 D insert an iron core through both coils
- 25 When a varying voltage is connected across a resistor of resistance 8.0Ω , the mean power dissipated in the resistor is 450 W .
- Which graph shows a possible variation of the voltage with time?



- 26 A circuit is made up of a number of ideal diodes and a load R, as shown below. It is connected to an a.c. supply.



Which of the following traces would be seen on an oscilloscope connected across R?

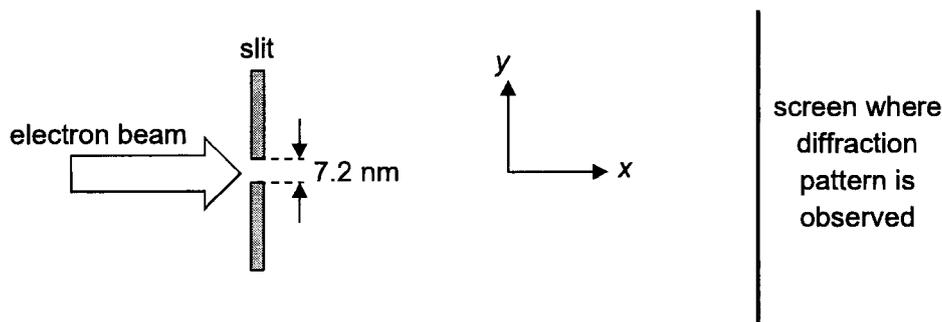


- 27 An electron is accelerated from rest through a potential difference to achieve a final kinetic energy of 9.3×10^{-16} J.

What is the de Broglie wavelength of the electron after being accelerated through this potential difference?

- | | | | |
|----------|-------------------------|----------|-------------------------|
| A | 5.1×10^{-10} m | B | 1.6×10^{-11} m |
| C | 5.1×10^{-12} m | D | 3.6×10^{-19} m |

- 28 When an electron beam passes through a slit, a diffraction pattern is observed on a suitable screen. This phenomenon can be explained using Heisenberg position-momentum uncertainty principle.



The slit width is 7.2 nm.

For an electron passing through the slit, what is the uncertainty in the momentum of the electron and its direction that best relates to the phenomenon?

	uncertainty in momentum / kg m s^{-1}	direction
A	9.2×10^{-35}	x
B	9.2×10^{-35}	y
C	9.2×10^{-26}	x
D	9.2×10^{-26}	y

- 29 It is observed that α -particles incident on a thin gold foil are mostly undeflected, while a small proportion of them are deflected at very large angles. Which statement provides the explanation for these observations?

- A** The α -particles are scattered by electrons.
- B** The α -particles are diffracted by the crystal lattice.
- C** The α -particles collide with small but massive nuclei.
- D** The α -particles undergo nuclear fission.

- 30 A radioactive sample is placed in a vacuum together with a Geiger Muller (GM) tube. The GM tube is placed 10 cm from the sample and the initial count rate is 1000 s^{-1} . Several materials are then placed between the sample and GM tube, and the results are shown below.

material	count rate / s^{-1}
0.1 mm aluminium sheet	500
7 mm aluminium sheet	500
10 cm of lead	near zero

What radiation is being emitted by the sample?

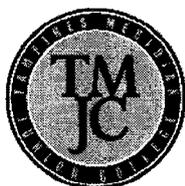
- A alpha radiation only
- B beta radiation only
- C beta and gamma radiation
- D alpha and gamma radiation

End of Paper



BLANK PAGE





TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

CIVICS GROUP

H2 PHYSICS

9749/02

Paper 2 Structured Questions

17 September 2025

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.

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 staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

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

For Examiners' Use	
1	/ 8
2	/ 9
3	/ 8
4	/ 8
5	/ 9
6	/ 8
7	/ 10
8	/ 20
Deduction	
Total	/ 80

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $= (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$



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

$$T / K = T / ^\circ C + 273.15$$

pressure of an ideal gas

$$p = \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle$$

mean translational kinetic energy of an ideal gas

$$E = \frac{3}{2} kT$$

molecule

displacement of particle in s.h.m.

$$x = x_0 \sin \omega t$$

velocity of particle in s.h.m.

$$v = v_0 \cos \omega t$$

$$= \pm \omega \sqrt{x_0^2 - x^2}$$

electric current

$$I = Anvq$$

resistors in series

$$R = R_1 + R_2 + \dots$$

resistors in parallel

$$1/R = 1/R_1 + 1/R_2 + \dots$$

electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

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

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$



4

Answer **all** the questions in the spaces provided.

- 1 A circuit is set up to measure the resistance of an unknown resistor X as shown in Fig. 1.1.

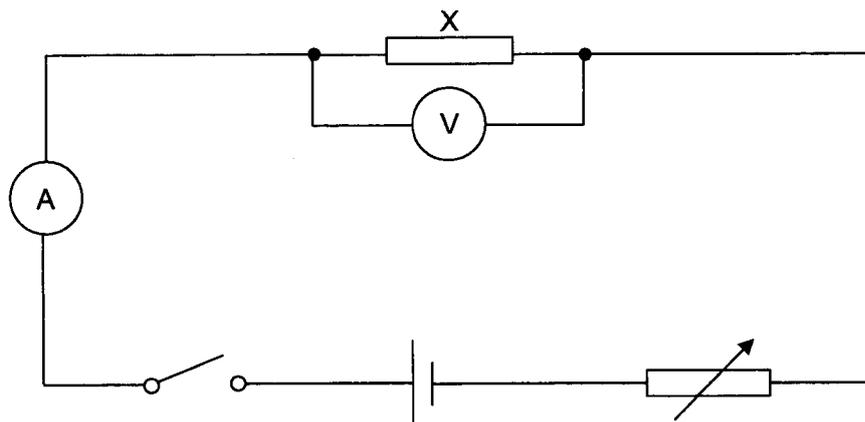


Fig. 1.1

- (a) When the switch is closed, the average drift velocity v of electrons moving through a wire is given by the equation,

$$v = \frac{\mu F}{e}$$

where e is the charge on an electron,
 F is a force acting on the electron, and
 μ is a constant.

Determine the SI base units of μ .

SI base units = [2]

(b) An analogue voltmeter is used to take measurements of the potential difference across X.

For these measurements, state one example of

(i) a systematic error,

..... [1]

(ii) a random error.

..... [1]

(c) The variable resistor is adjusted to give a new set of readings which, when repeated, give average values of potential difference V and current I of 3.00 ± 0.03 V and 4.9 ± 0.1 mA respectively.

(i) Show that the resistance of X is 612Ω .

[1]

(ii) Determine the actual uncertainty in the value of resistance of X showed in (i). Hence state the value of resistance of X with its actual uncertainty to an appropriate number of significant figures.

resistance of X = \pm Ω [2]

(d) When an experiment such as this is performed, it is common practice to adjust the variable resistor to obtain several sets of values of potential difference and current. These sets of values are then plotted on a graph from which the resistance of X may be deduced.

Discuss one advantage of this procedure compared with the determination of resistance of X from a single set of readings.

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



6

- 2 An object of mass 0.25 kg is launched with an initial speed, u , at an angle of 40° from the top of a cliff 100 m tall, as shown in Fig. 2.1.

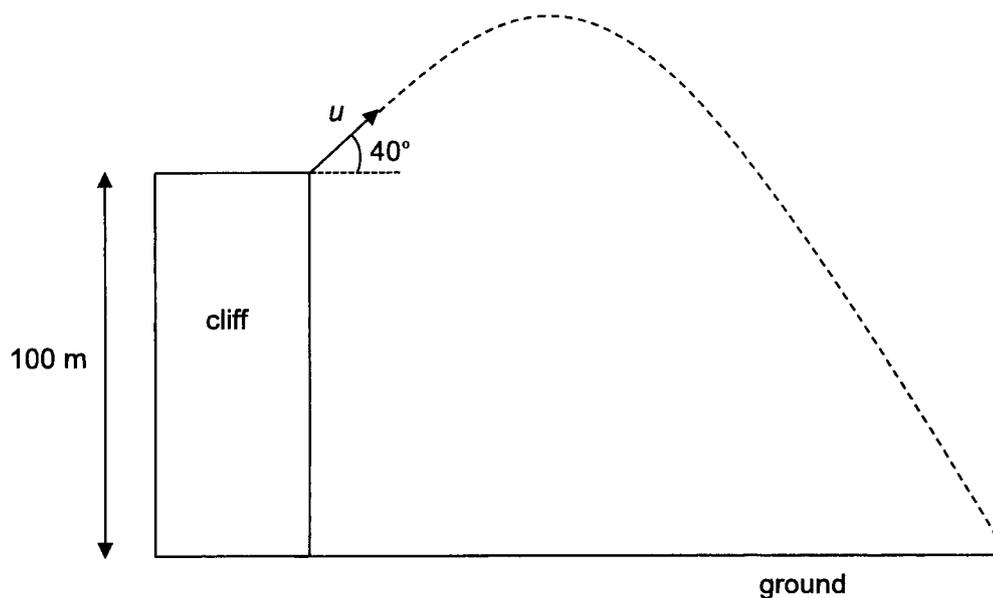


Fig 2.1

The minimum kinetic energy of the object during the trajectory is 12.5 J. Assume that air resistance is negligible.

- (a) Explain why kinetic energy is minimum at the top of the trajectory.

.....
 [1]

- (b) Show that u is 13 m s^{-1} .

[2]



7

(c) The object was in the air for a duration of time t before hitting the ground.

(i) Determine time t .

$t = \dots\dots\dots$ s [2]

(ii) Calculate the horizontal distance travelled by the object before hitting the ground.

horizontal distance = $\dots\dots\dots$ m [1]

(iii) Determine the magnitude and direction of the velocity of the object just before it hits the ground.

magnitude of velocity = $\dots\dots\dots$ m s⁻¹

direction: $\dots\dots\dots$ [3]



- 3 An object of density ρ_o , and volume V_o , is placed in a fluid of density ρ_f , as shown in Fig 3.1. The acceleration of free fall is g .

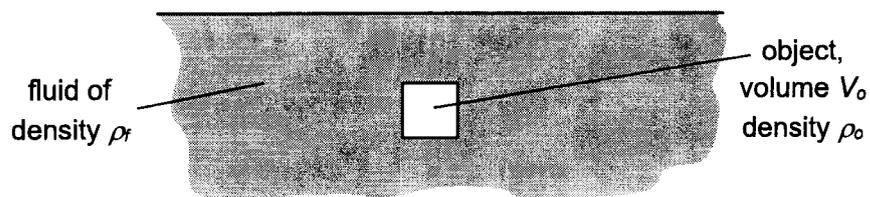


Fig. 3.1

- (a) State the origin of upthrust.

.....
 [1]

- (b) State an expression, in terms of ρ_o , V_o , ρ_f and g where appropriate, for

- (i) weight of the object, W

..... [1]

- (ii) upthrust acting on the object, U

..... [1]

- (c) The object starts to sink from rest in the fluid.

With suitable working, show whether ρ_o is greater, lesser, or equal to ρ_f .

[2]

9

- (d) The object sinks for a long time.

Describe and explain how the motion of the object changes until it reaches terminal velocity.

.....

.....

.....

..... [3]



- 4 The "Round Up" is a hollow cylindrical ride with radius 8.0 m, as shown in Fig. 4.1. When it spins about its axis at sufficient angular speed, riders are pinned to the inner wall. The cylinder then tilts while spinning, creating the illusion of defying gravity as riders remain pinned to the wall.

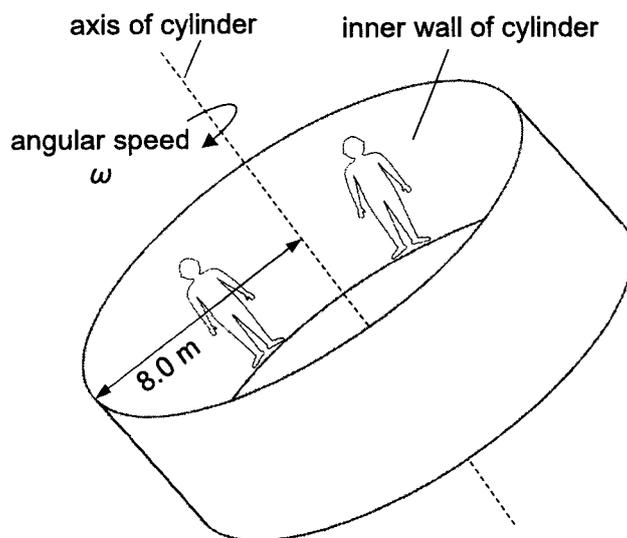


Fig 4.1

Fig. 4.2 shows the side view of the cylinder when it is tilted at an angle of 50° to the horizontal.

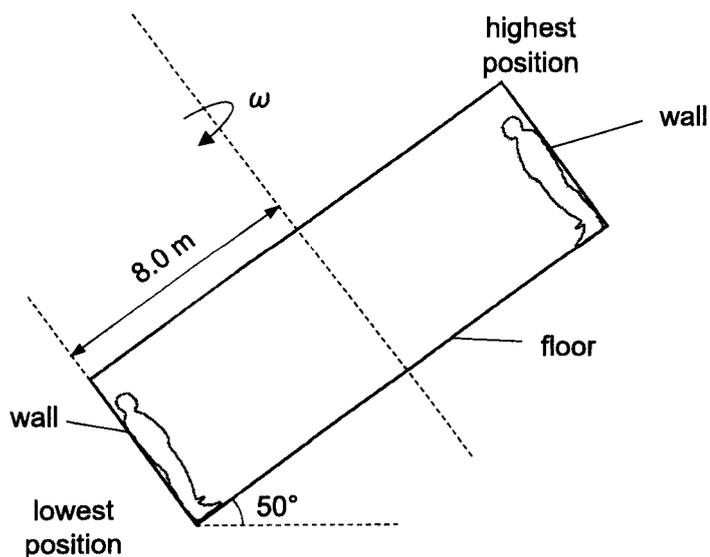


Fig 4.2

11

The cylinder is rotating at a constant angular speed ω that is sufficient for a rider of mass 65 kg to be just in contact with the wall at the highest position.

At the highest and lowest positions shown, the rider experiences no friction from the wall and floor of the cylinder.

- (a) By considering the forces acting on the rider at the highest position, show that ω is 0.97 rad s^{-1} . Explain your working.

[2]

- (b) Calculate the magnitude of normal contact force exerted by the wall of the cylinder on the rider at the lowest position.

magnitude of normal contact force = N [2]

- (c) Calculate the gain in gravitational potential energy when the rider is moved from the lowest position to the highest position.

gain in potential energy = J [2]



12

- (d) Hence, calculate the average power required to bring the rider from the lowest position to the highest position.

average power = W [2]



13

- 5 A pendulum consists of a sphere suspended from a fixed point by an inelastic light string. When the sphere is set in motion, it oscillates with simple harmonic motion. At its lowest position, it has kinetic energy of 0.86 J and momentum of 0.72 N s.

(a) Define *simple harmonic motion*.

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

(b) Show that the mass of the sphere is 0.30 kg.

[2]



- (c) The simple pendulum is now placed in front of a screen. A vertical rod is fixed near the rim of a horizontal turntable which is rotating at a frequency of 0.55 Hz. A horizontal beam of light casts a shadow of the rod onto the screen in front of which the simple pendulum is suspended, as shown in Fig. 5.1. The shadow of the rod also oscillates with simple harmonic motion.

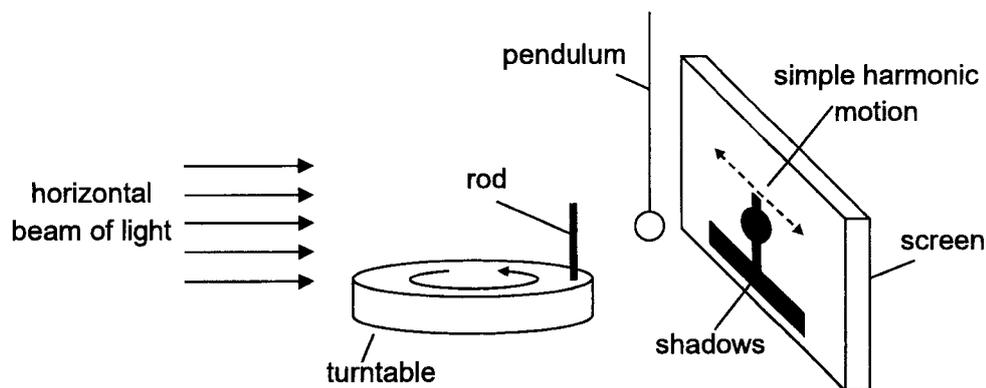


Fig. 5.1

- (i) The period T of a pendulum is related to its length L by the expression $T = 2\pi\sqrt{\frac{L}{g}}$, where g is the acceleration of free fall.

The pendulum is now set in motion, and it is observed that the shadows of the rod and the pendulum sphere move in phase on the screen.

Calculate the length of the pendulum, L .

$$L = \dots\dots\dots \text{ m} \quad [2]$$

- (ii) The pendulum is then held stationary and set in motion again. Now it is observed that shadow of the sphere passes the equilibrium position 0.50 s later than the shadow of the rod.

Calculate the phase difference between their motions.

$$\text{phase difference} = \dots\dots\dots \text{ rad} \quad [1]$$



- (d) The pendulum is next placed in water and set into motion. Fig. 5.2 shows the variation of displacement from its equilibrium position, x of the pendulum with time, t , for the first half oscillation.

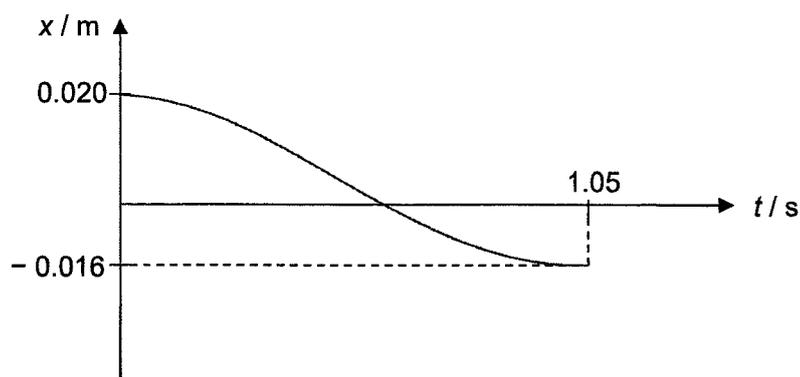


Fig. 5.2

- (i) Explain why the maximum negative displacement of the pendulum is not equal to its maximum positive displacement.
-
- [1]
- (ii) Determine the decrease in energy of the oscillation for the first half of the oscillation.

decrease in energy = J [2]

- 6 A battery of e.m.f. 6.0 V and internal resistance of $0.70\ \Omega$ is connected to 4 different components as shown in Fig. 6.1.

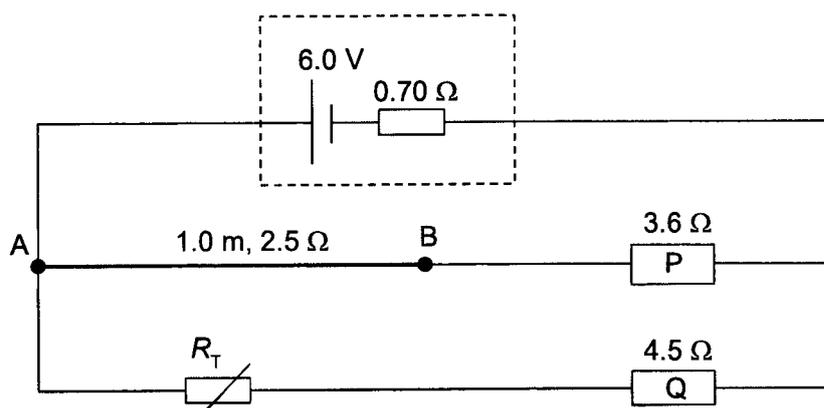


Fig. 6.1

Wire AB is a uniform resistance wire of length 1.0 m and resistance $2.5\ \Omega$.

P and Q are fixed resistors of resistances $3.6\ \Omega$ and $4.5\ \Omega$ respectively.

R_T is a thermistor, and the variation with temperature θ of its resistance is shown in Fig. 6.2.

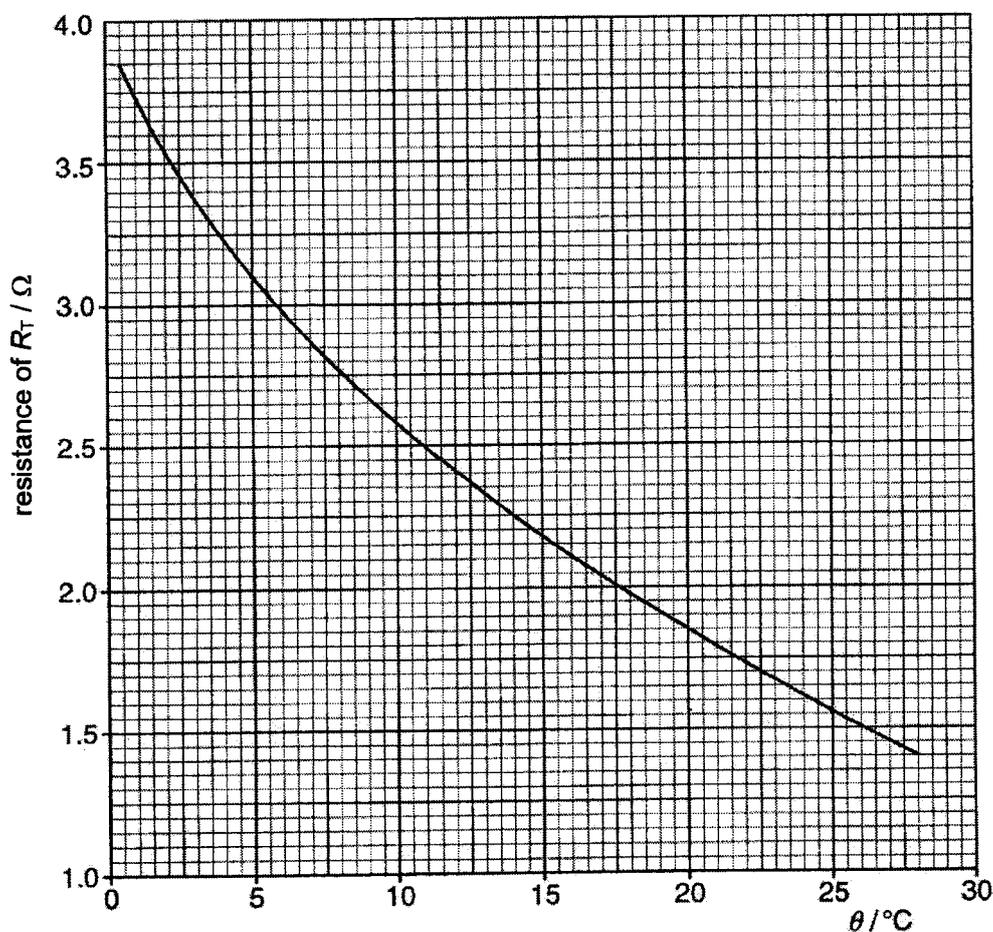


Fig. 6.2

17

The temperature of the thermistor is maintained at 20 °C.

- (a) Using Fig. 6.2, determine the resistance of R_T .

resistance = Ω [1]

- (b) Show that the terminal potential difference across the battery is 4.9 V.

[2]

- (c) Determine the current flowing through the thermistor.

current = A [2]

- (d) Hence, or otherwise, determine the potential difference across the thermistor.

potential difference = V [1]



18

- (e) A galvanometer is now connected to point C on wire AB, and point D between the thermistor and Q, as shown in Fig. 6.3.

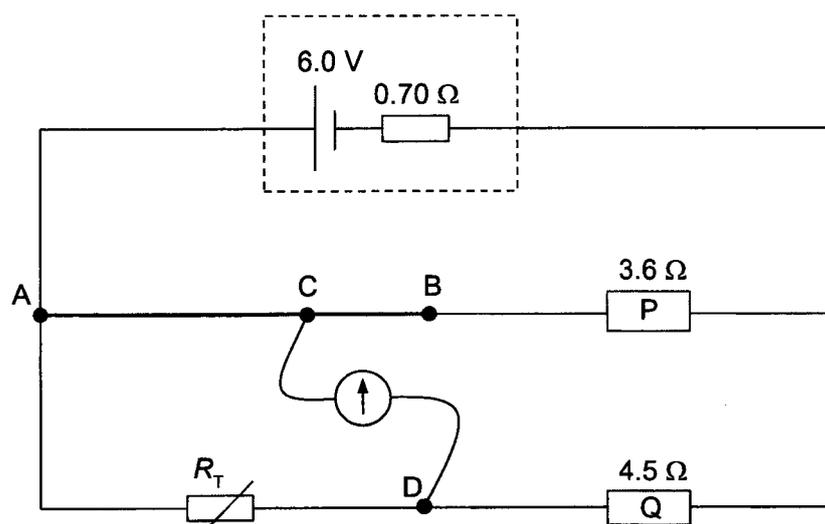


Fig. 6.3

Determine the length of wire between points A and C, such that the reading on the galvanometer is zero.

length of AC = m [2]

- 7 (a) The masses of some nuclei are shown in Fig. 7.1.

	mass / u
proton (${}^1_1\text{p}$)	1.007
neutron (${}^1_0\text{n}$)	1.009
lanthanum-141 (${}^{141}_{57}\text{La}$) nucleus	140.911

Fig. 7.1

- (i) Determine the number of neutrons in the lanthanum-141 nucleus.

number of neutrons = [1]

- (ii) Use data from Fig. 7.1 to show that the binding energy of a nucleus of lanthanum-141 is 1162 MeV.

[3]

- (iii) A plutonium-239 (${}^{239}_{94}\text{Pu}$) nucleus has binding energy of 1807 MeV.
By comparing the binding energy per nucleon of lanthanum-141 and plutonium-239, state and explain whether lanthanum-141 or plutonium-239 is more likely to undergo nuclear fission.

.....

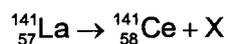
 [3]



20

- (b) Lanthanum-141 (${}^{141}_{57}\text{La}$) undergoes radioactive decay to form cerium-141 (${}^{141}_{58}\text{Ce}$) and a particle X. Particle X deflects as it moves through a magnetic field.

The decay can be represented by the equation



- (i) State what particle X is.

..... [1]

- (ii) According to conservation laws of energy and momentum, when lanthanum-141 nuclide of fixed initial energy undergoes decay, the emitted particle X should have a specific energy value. However, experimental observations show that particle X are emitted with a range of energies from different lanthanum-141 nuclides.

Explain the experimental observations.

.....

 [2]



- 8 In 1814, Joseph von Fraunhofer studied the light from the Sun. He made a crucial discovery when he observed dark lines on a continuous spectrum of white light, known as the solar absorption spectrum, shown in Fig. 8.1. These lines, now known as Fraunhofer lines, were later found to be absorption lines caused by elements in the Sun's outer gas layers.

The thickness of the lines shows the amount of absorption that happens for a particular wavelength. Thicker lines indicate a higher amount of absorption by the gases in the outer gas layers.

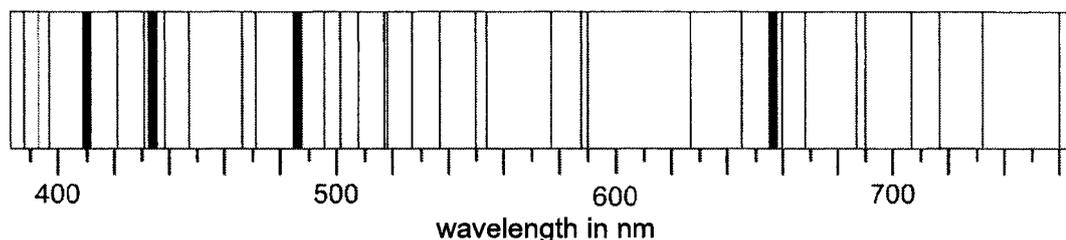


Fig 8.1: Solar absorption spectrum

By the early 20th century, scientists had established that each element produces a unique line spectrum when excited. This occurs because electrons in atoms can only occupy specific energy levels, and when they transit between these levels, they emit or absorb light of precise wavelengths, known as an emission or absorption spectrum. This principle has enabled astronomers to determine the chemical composition of distant celestial objects, such as the Sun, simply by analysing the light they emit. The emission spectrum for hydrogen and helium are shown in Fig. 8.2 and Fig 8.3 respectively.

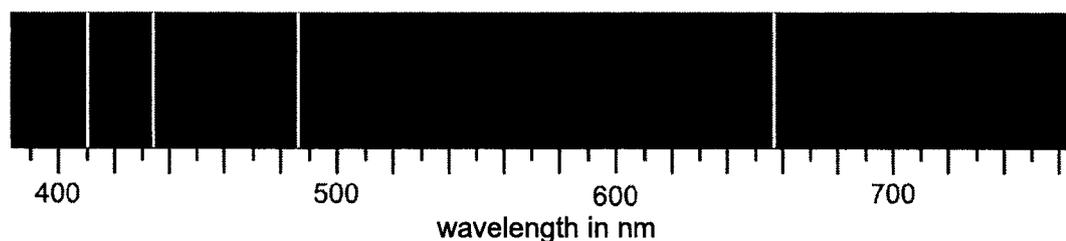


Fig 8.2: Hydrogen emission spectrum

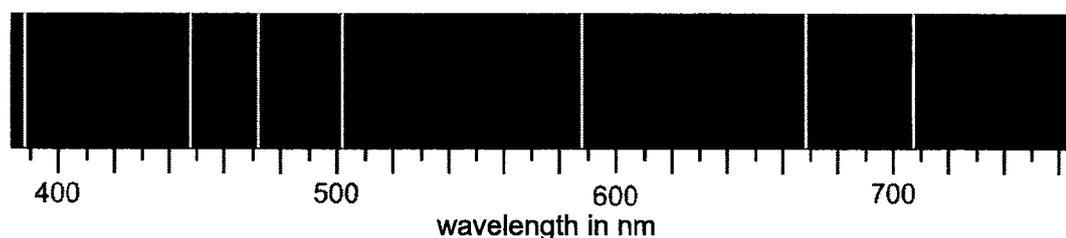


Fig 8.3: Helium emission spectrum

In 1929, Edwin Hubble made a groundbreaking observation while studying the line spectra of distant galaxies at Mount Wilson Observatory. He noticed that the spectral lines from these galaxies were systematically shifted towards longer wavelengths compared to the same spectral lines measured from a stationary source such as a hydrogen lamp in the laboratory. For instance, the hydrogen absorption spectrum from a distant galaxy J1030 is shown in Fig. 8.4.

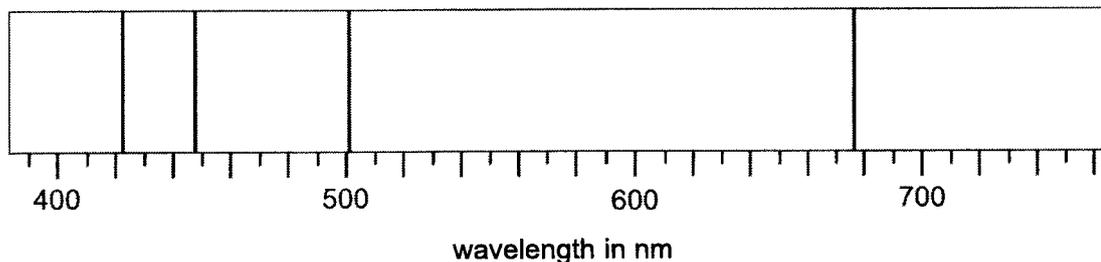


Fig. 8.4: Hydrogen absorption spectrum from galaxy J1030

This can be explained by the Doppler effect. The effect, first described by Christian Doppler in 1842, explains how light waves change wavelength when their source moves relative to an observer. When a light source moves away from an observer, the wavelength increases. Conversely, when the source moves towards the observer, the wavelength decreases. This effect is quantified in the equation

$$z = \frac{\lambda_{\text{moving}} - \lambda_o}{\lambda_o} = \frac{v}{c}$$

where z is a quantity known as “red-shift”,

λ_{moving} represents the wavelength from the moving light source,

λ_o represents the wavelength from a stationary source,

v is the speed of the moving source, and

c is the speed of light.

This discovery led to one of the most important methods in cosmology: using the wavelength of emitted light from a galaxy to determine if it is stationary or moving relative to Earth.

- (a) The Sun is modelled to have a hot dense core, surrounded by an outer layer of cooler gases. Explain how Fig. 8.1 supports this model.

.....

 [2]

- (b) Using Fig. 8.1, Fig. 8.2 and Fig. 8.3, compare whether there is more hydrogen or helium in the gas layer. Explain your answer.

.....

 [2]



- (c) Using Fig. 8.1, Fig. 8.2 and Fig. 8.3, state and explain whether only hydrogen and helium are present in the outer gas layer of the Sun.

.....

 [2]

- (d) (i) Show that the highest frequency of light in the hydrogen emission spectrum is 7.3×10^{14} Hz.

[1]

- (ii) Calculate the energy of the photon in d(i).

energy = J [2]

- (e) A distant galaxy GN-Z11 is found to be moving away from Earth and is a moving light source.

Fig. 8.5 compares certain wavelengths of the line spectra of hydrogen obtained from a stationary source on Earth and GN-Z11. Some values of z and v are also included.

Hydrogen spectral wavelengths from GN-Z11 / nm	Hydrogen spectral wavelengths from stationary source on Earth / nm	z	$v / \text{m s}^{-1}$
676	656	0.0305	9.15×10^6
500	485		

Fig 8.5

- (i) Complete the table in Fig. 8.5. [2]



- (ii) Suggest why the shift in wavelengths is called "red shift".

.....
 [1]

- (iii) The hydrogen spectral wavelengths from another galaxy, the Andromeda Galaxy, were instead discovered to be shorter than the wavelengths from a stationary source on Earth.

State what this implies about the motion of the Andromeda Galaxy relative to Earth.

.....
 [1]

- (f) Fig. 8.6 below shows the z values of four galaxies, and their distance from Earth d .

Galaxy	z	d / million light-years
Perseus	0.018	250
NGC 4889	0.022	308
Coma	0.023	321
Hercules Cluster	0.037	500

Fig. 8.6

- (i) One *light-year* is defined as the distance travelled by light in one year. Express one light-year in metres.

one light-year = m [1]

- (ii) Using the data in Fig 8.6, describe qualitatively the relationship between the distance of a galaxy and the speed with which it is moving away from Earth.

.....
 [1]



25

(iii) Fig. 8.7 shows the variation of z with distance d .

Plot the data for the Hercules Cluster on Fig 8.7.

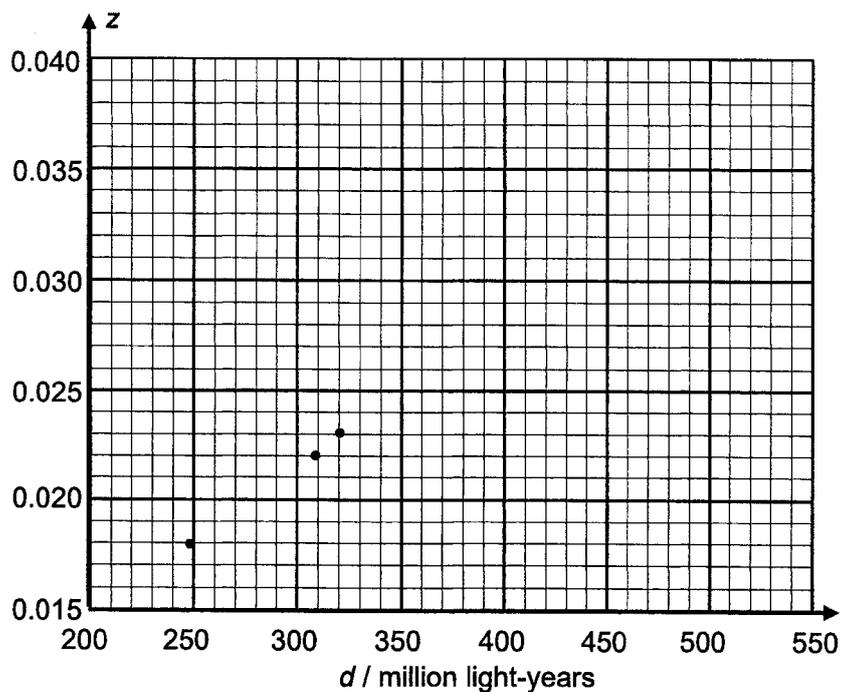


Fig. 8.7

[1]

(iv) Add a line of best fit in Fig. 8.7.

[1]

(v) z is related to d by the equation

$$z = \frac{H_0 d}{c}$$

where H_0 is the Hubble constant and c is the speed of light.

Using the line of best fit in (iv), determine H_0 .

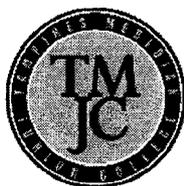
$$H_0 = \dots\dots\dots \text{s}^{-1} \quad [3]$$

End of Paper



Blank Page





TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

 ()

CIVICS GROUP

H2 PHYSICS

9749/03

Paper 3 Longer Structured Questions

24 September 2025

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.

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 staples, paper clips, 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.

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

For Examiner's Use		Percentage
Subtotal P1	/ 30	/ 15
Subtotal P2	/ 80	/ 30
Paper 3		
1	/ 8	
2	/ 6	
3	/ 9	
4	/ 7	
5	/ 9	
6	/ 10	
7	/ 11	
8	/ 20	
9	/ 20	
Deduction		
Subtotal P3	/ 80	/ 35
Subtotal P4	/ 55	/ 20
Grand total		/ 100

This document consists of **30** printed pages and **2** blank pages.

2

Data

speed of light in free space	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $= (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
elementary charge	$e = 1.60 \times 10^{-19} \text{ C}$
the Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27} \text{ kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27} \text{ kg}$
molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
acceleration of free fall	$g = 9.81 \text{ m s}^{-2}$



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

$$T / K = T / ^\circ C + 273.15$$

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.

$$v = v_0 \cos \omega t$$

$$= \pm \omega \sqrt{x_0^2 - x^2}$$

electric current

$$I = Anvq$$

resistors in series

$$R = R_1 + R_2 + \dots$$

resistors in parallel

$$1/R = 1/R_1 + 1/R_2 + \dots$$

electric potential

$$V = \frac{Q}{4\pi\epsilon_0 r}$$

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

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$



4

Section A

Answer **all** questions in this section in the spaces provided.

- 1 Object A of mass m is projected with a velocity of 2.4 m s^{-1} on a frictionless surface, directly towards a stationary object B of mass $4m$, as shown in Fig. 1.1.
- A spring of negligible mass is fixed on object B such that the collision with object A is elastic and head-on.

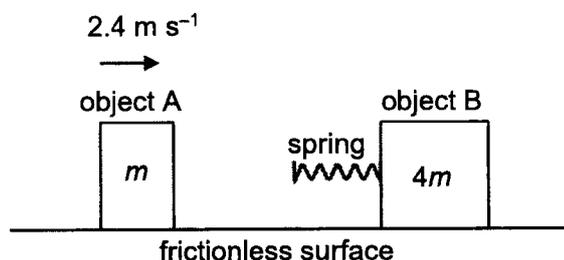


Fig. 1.1

- (a) Explain what is meant by an *elastic collision*.

.....
 [1]

- (b) Calculate the speed of object A after collision.

speed of object A = m s^{-1} [3]



5

- (c) At one instant during the collision, the two particles have a common speed v_0 .

Show that v_0 is 0.48 m s^{-1} .

[1]

- (d) On the axes in Fig. 1.2, sketch two graphs to show the variation with time t of the velocities v of object A and object B. Label the graphs A and B respectively.

Numerical labels are not required.

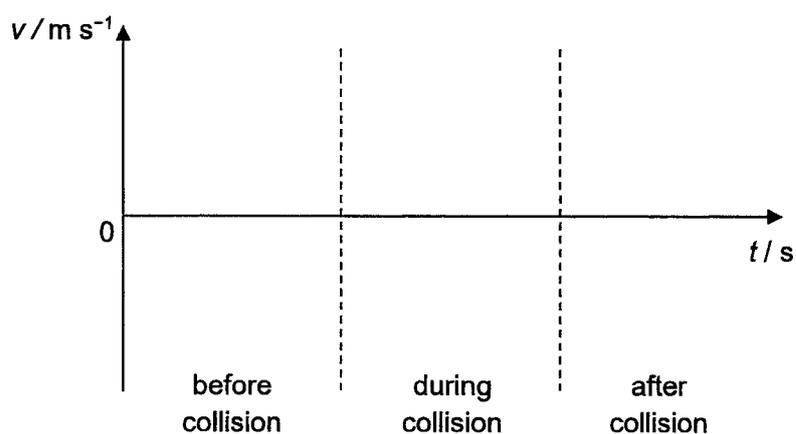


Fig. 1.2

[3]

6

- 2 A child slides down a slope PQ of height 7.0 m, as shown in Fig. 2.1.

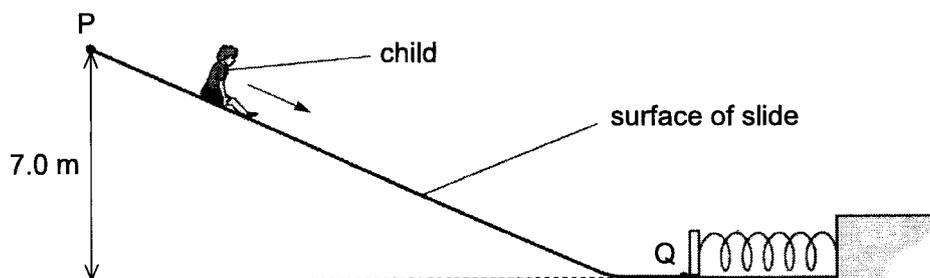


Fig. 2.1 (not drawn to scale)

She started from rest at P and reaches a speed of 4.8 m s^{-1} at Q. A resistive force opposes the motion of the child as she slides down.

- (a) Determine the ratio $\frac{\text{kinetic energy of the child at Q with resistive force}}{\text{kinetic energy of the child at Q if there is no resistive force}}$.

ratio = [2]

- (b) At Q, the child, of mass 20 kg, makes contact with a soft board attached to a spring. The spring compresses and the child is eventually brought to rest, as shown in Fig. 2.2.

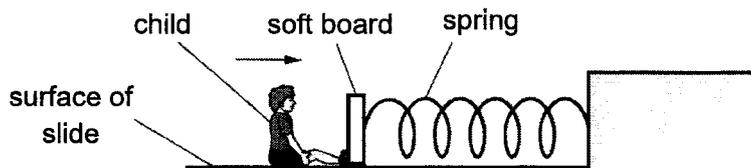


Fig. 2.2

The spring has a spring constant of 54 N m^{-1} . The maximum compression of the spring is 2.1 m.

Calculate the efficiency of the transfer of the kinetic energy of the child at Q to the elastic potential energy of the spring.

efficiency = % [2]

- (c) Suggest two reasons why the efficiency in (b) is not 100%.

1

.....

2

..... [2]

3 (a) Define *gravitational field strength*.

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

(b) Explain why for a satellite in orbit around a planet, the gravitational field strength g at the position of the satellite must have the same magnitude and direction as the centripetal acceleration a of the satellite.

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



- (c) At a distance r away from the centre of a planet X, the gravitational field strength due to the planet is given by g .

It is given that g obeys the inverse square law, where $g \propto \frac{1}{r^2}$.

Fig. 3.1 shows the variation with $\lg r$ of $\lg g$.

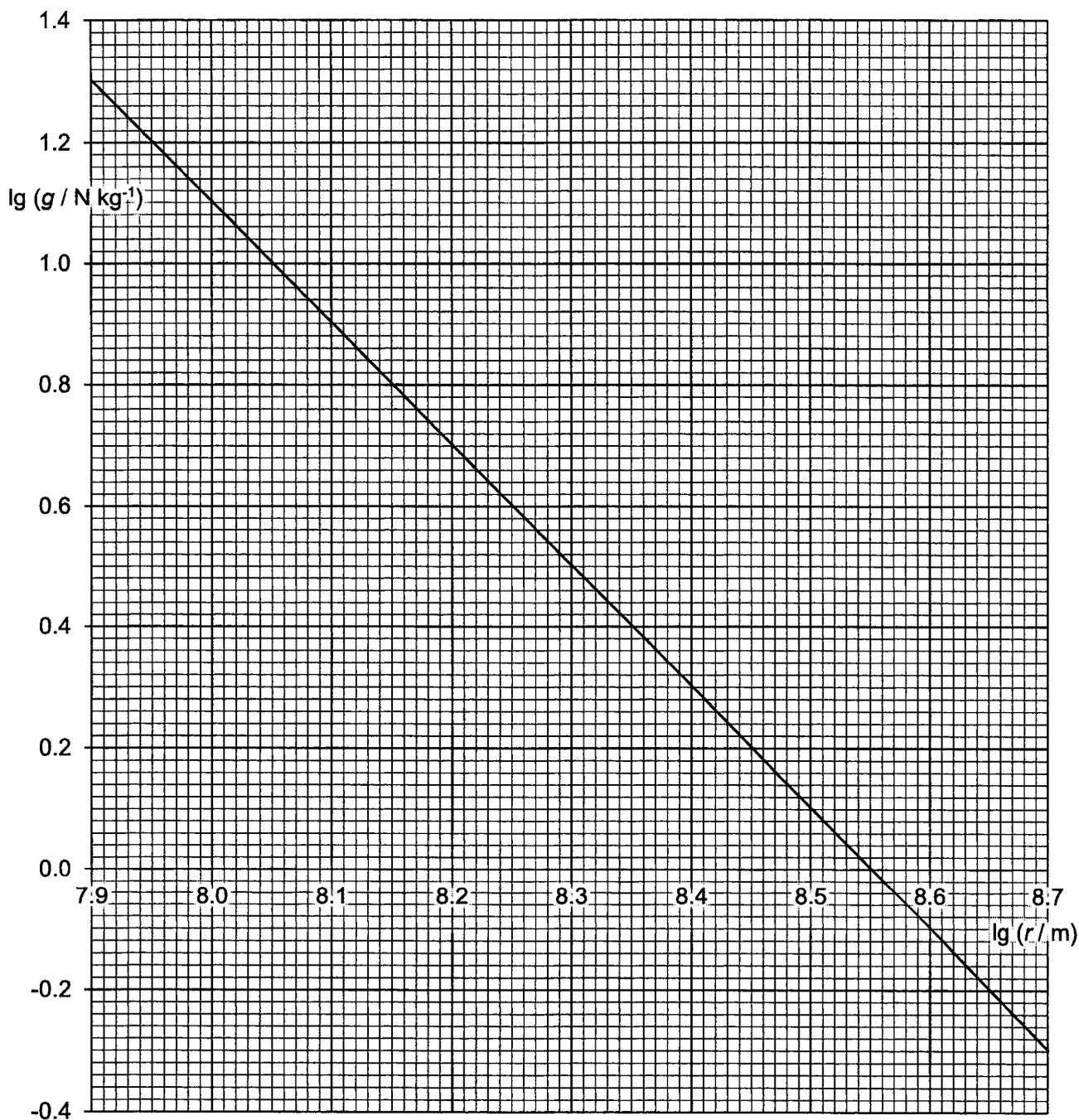


Fig. 3.1

10

- (i) Use data from Fig. 3.1 to show that the gravitational field strength of the planet obeys the inverse square law.

[2]

- (ii) A satellite is in an orbit of radius 4.18×10^8 m around the planet.
Using Fig. 3.1, determine the speed of the satellite.

speed = m s⁻¹ [3]

- (iii) Another planet Y has a smaller mass than planet X.

On Fig. 3.1, sketch the graph for planet Y.

[1]



11
BLANK PAGE



- 4 (a) (i) State what is meant by *plane polarisation* of waves.

.....
 [1]

- (ii) State why a sound wave cannot be polarised

.....
 [1]

- (b) A beam of unpolarised light is shone through two polarising filters X and Y, as shown in Fig. 4.1.

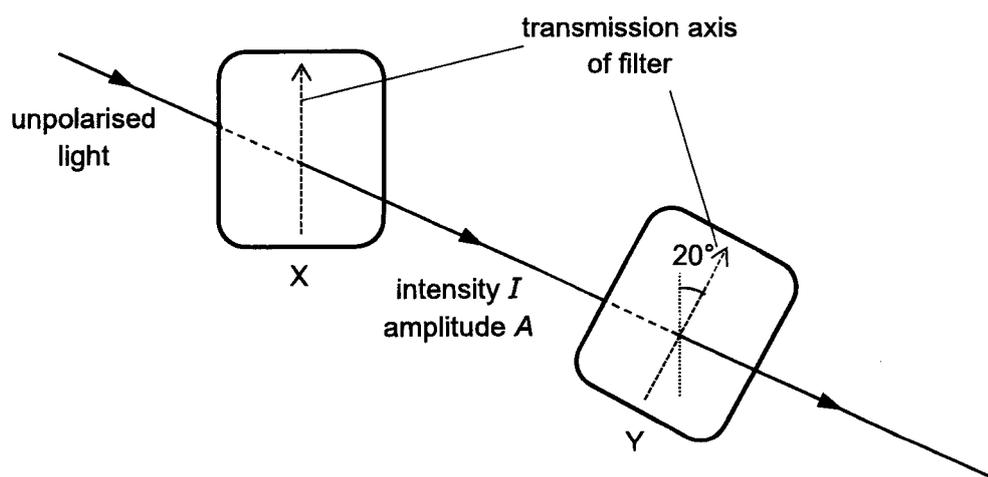


Fig. 4.1

The intensity and amplitude of the light after passing through polarising filter X is I and A respectively.

Polarising filter Y is positioned with its transmission axis at an angle of 20° to that of polarising filter X.

- (i) For the unpolarised light before passing through polarising filter X, state

1. its amplitude, in terms of A .

amplitude = [1]

2. its intensity, in terms of I ,

intensity = [1]

- (ii) Calculate the intensity of light, in terms of I , after passing through polarising filter Y.

intensity = [2]

- (iii) Polarising filter Y is now rotated about the direction of the light beam, from its starting position shown in Fig. 4.1. The direction of rotation is such that the angle of the transmission axis to the vertical initially increases as shown in Fig. 4.2.

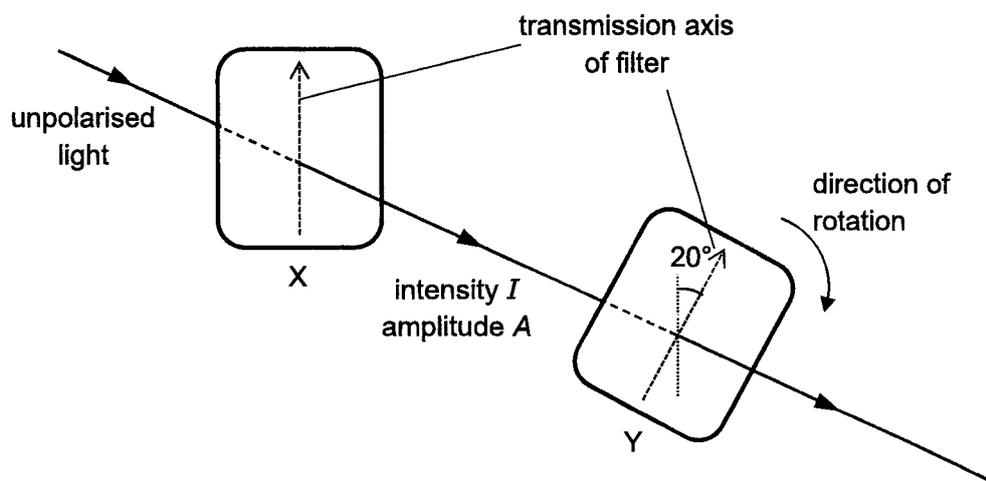


Fig. 4.2

Calculate the minimum angle through which filter Y must be rotated by so that the intensity of the light after passing through polarising filter Y returns to the value that it had when the filter was at its starting position.

angle = ° [1]

5 (a) State the *principle of superposition*.

.....

 [1]

(b) A double slit consists of two parallel slits. The separation of the slits is 1.5 mm.

Coherent light of wavelength 590 nm is incident normally on the double slits as shown in Fig. 5.1. A screen is placed 3.2 m away from the double slit. Fringes are observed on the screen.

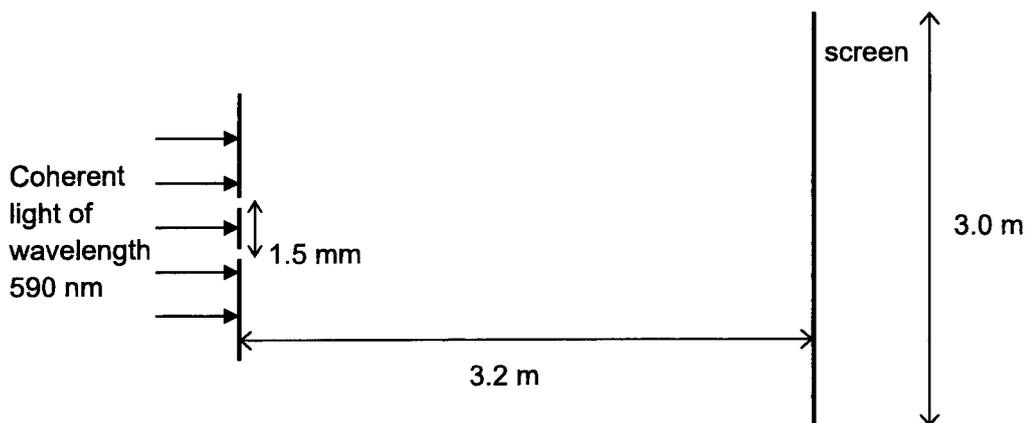


Fig. 5.1 (not to scale)

(i) Calculate the separation between the fringes.

separation = m [2]

(ii) The widths of the two slits are then increased while their separation is kept constant. Fringes are no longer observed.

Explain why the fringes are no longer observed.

.....

 [2]



15

- (iii) The double slit is now replaced by a diffraction grating having 700 lines per millimetre. The same coherent light is now incident normally on the grating.

The screen is 3.0 m long as shown in Fig. 5.1.

Determine the maximum number of bright fringes that can be seen on the screen.

maximum number of bright fringes = [4]



16

- 6 A fixed mass of monatomic ideal gas has an initial volume of 0.075 m^3 at a pressure of $4.5 \times 10^5 \text{ Pa}$ and temperature of $60 \text{ }^\circ\text{C}$.
- (a) Calculate the number of moles of gas present.

number of moles = mol [2]

- (b) The gas is subsequently heated to $150 \text{ }^\circ\text{C}$. It expands at constant pressure.
- (i) Determine the new volume of the gas.

new volume of gas = m^3 [2]

- (ii) Calculate the change in internal energy of the gas.

change in internal energy = J [2]



17

(iii) Determine the external work done by the gas.

work done by gas = J [2]

(iv) Hence, determine the amount of heat supplied to the gas.

heat supplied to gas = J [2]



18

- 7 Two charged metal spheres A and B of diameter 10 cm and 20 cm respectively, are situated in a vacuum. Their centres are separated by a distance of 50 cm, as shown in Fig. 7.1. x is the distance from the centre of sphere A to any arbitrary point along the line joining the centres of the two spheres.

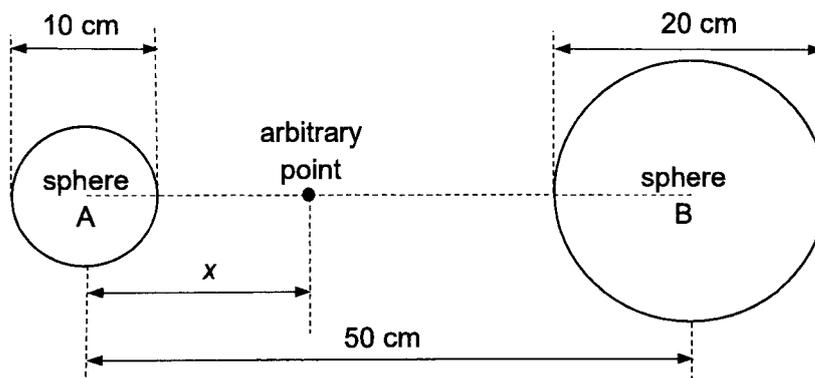


Fig. 7.1 (not to scale)

The variation with x of the electric potential V is shown in Fig. 7.2.

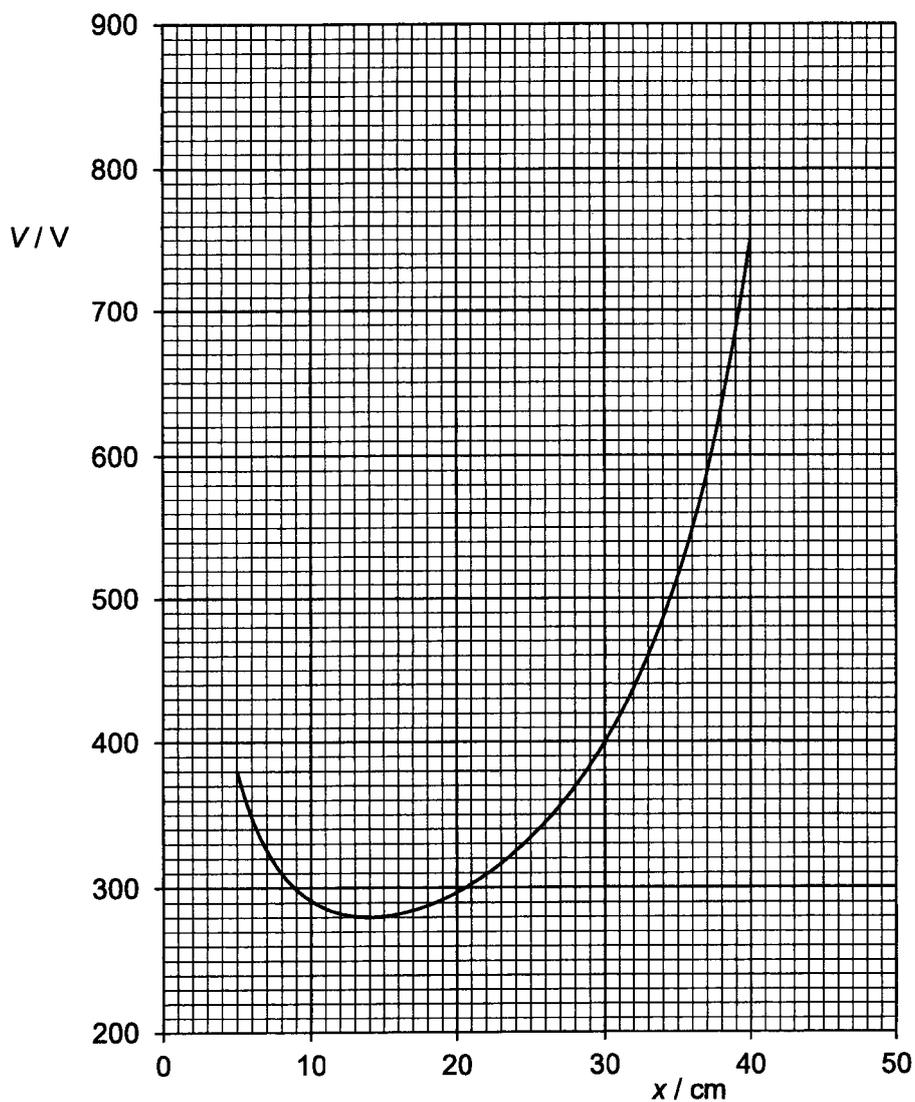


Fig. 7.2



(a) On Fig. 7.2, complete the graph for between $x = 0$ cm to $x = 5.0$ cm and between $x = 40.0$ cm and $x = 50.0$ cm. [1]

(b) Describe how the resultant electric force on an electron will vary as it is moved from the surface of sphere A to the surface of sphere B, along the line joining their centres.

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

(c) State and explain which sphere has a smaller magnitude of charge.

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

(d) The charge on each sphere may be considered to be a point charge at its centre. The magnitude of charge of sphere A is 1.2 nC.
Estimate the magnitude of charge of sphere B, leaving your answer in nC.

magnitude of charge = nC [2]



20

- (e) An electron is ejected from the surface of sphere A at a speed of $9.7 \times 10^6 \text{ m s}^{-1}$. It moves towards sphere B along the line joining the centre of the two spheres.

Determine, with suitable calculations, whether the electron is able to reach the surface of sphere B.

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



Section B

Answer **one** question from this Section in the spaces provided.

- 8 (a) A rigid rectangular metal loop has resistance R . It has dimensions L and W , and moves with a constant speed v to the right, as shown in Fig. 8.1.

It enters a region of uniform magnetic field with field strength B directed into the page. The region extends a distance of $3W$ in the horizontal direction.

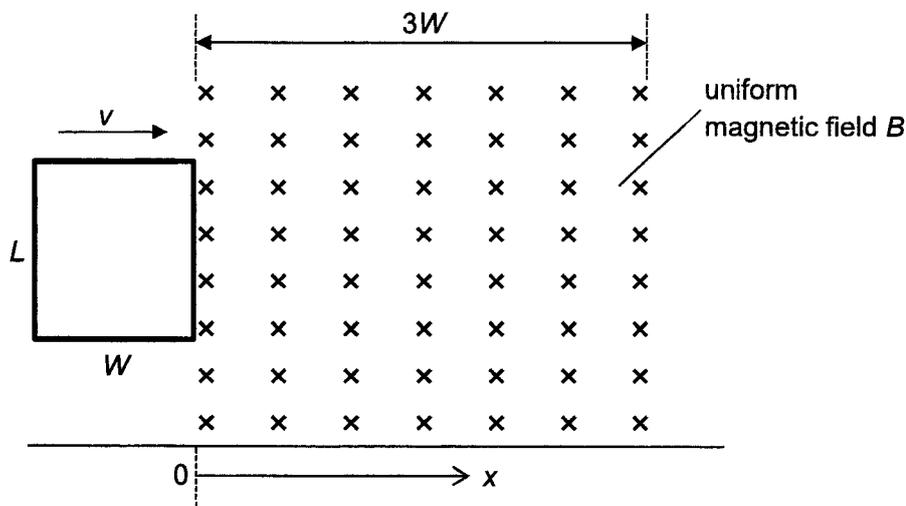
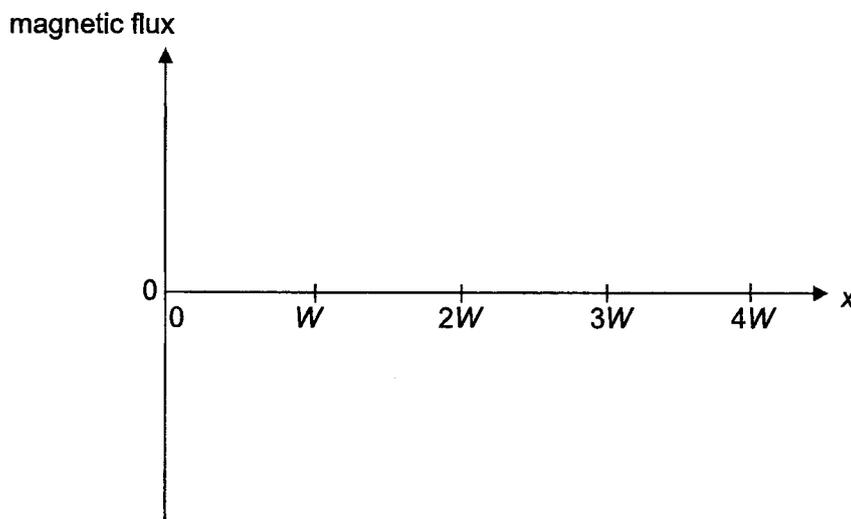


Fig. 8.1

Sketch for the entire duration from the point where the loop enters till it completely leaves the magnetic field,

- (i) the variation of the magnetic flux through the loop with horizontal distance x from the left edge of the uniform magnetic field.

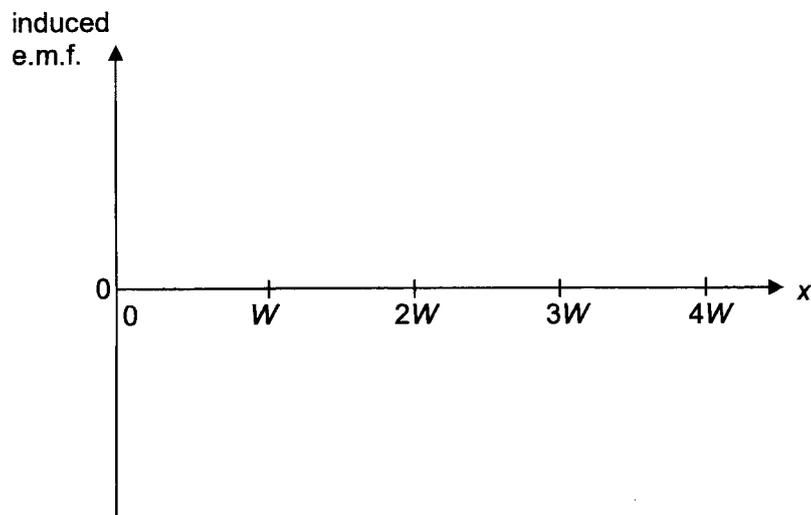
Include in your sketch, an appropriate expression for the maximum magnetic flux, in terms of B , L , W , v and R where appropriate.



[2]

- (ii) the variation of the induced electromotive force (e.m.f.) in the loop with distance x .

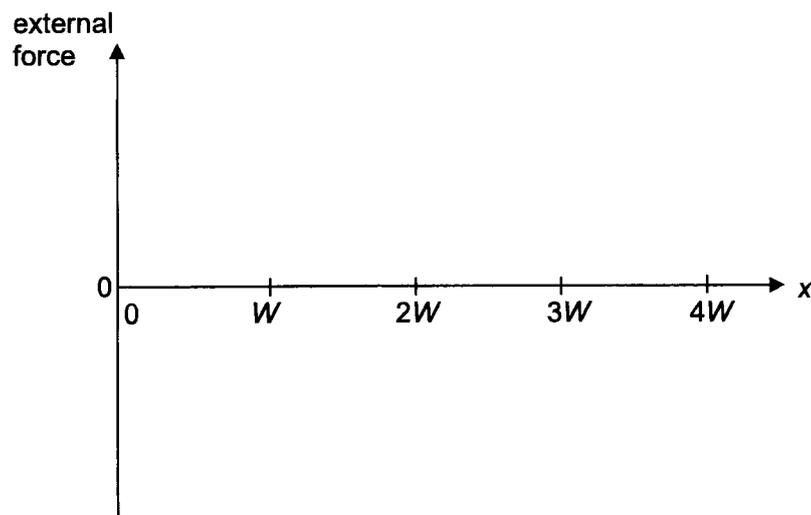
Include in your sketch, an appropriate expression for the maximum induced e.m.f., in terms of B , L , W , v and R where appropriate.



[2]

- (iii) the variation of the external force applied to the loop to keep v constant with distance x .

Include in your sketch, an appropriate expression for the maximum external force applied, in terms of B , L , W , v and R where appropriate.



[2]

- (b) Fig. 8.2 shows a simple generator where a metal coil rotates at a constant angular velocity about a vertical axis in a uniform magnetic field.

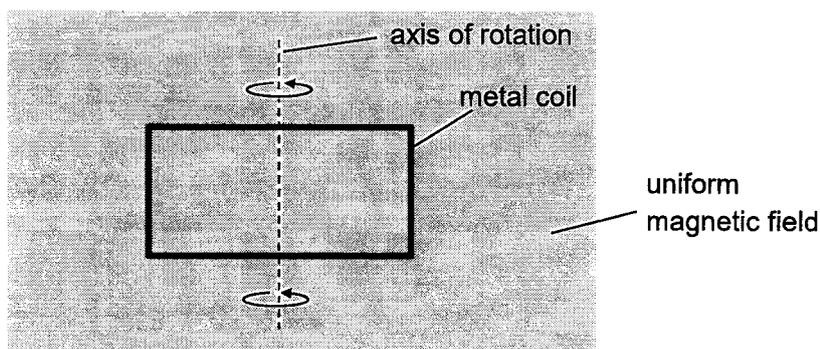


Fig. 8.2

- (i) State Faraday's law of electromagnetic induction.

.....
 [2]

- (ii) State two factors that affects the magnitude of the maximum induced e.m.f.

.....

 [2]

- (iii) Explain why the e.m.f. induced is sinusoidal.

.....

 [3]

24

- (c) A rigid metal coil with 50 turns measuring 11.0 cm by 9.0 cm is suspended from a sensitive newton-meter, as shown in Fig. 8.3. The metal coil is initially above a region of uniform magnetic field of flux density B .

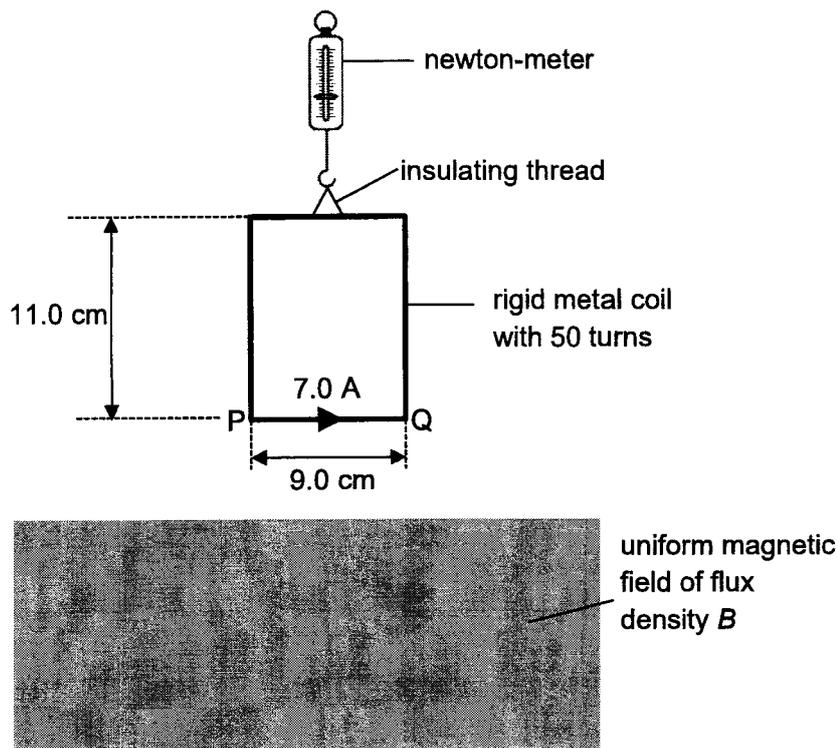


Fig. 8.3

The coil is connected to a power supply so that there is a current of 7.0 A in the direction indicated in Fig. 8.3.

The coil is then slowly lowered at a constant speed into the uniform magnetic field until all of side PQ enters the field. The magnetic field lines are in the horizontal plane and at an angle of 62° to PQ. The top view is shown in Fig. 8.4.

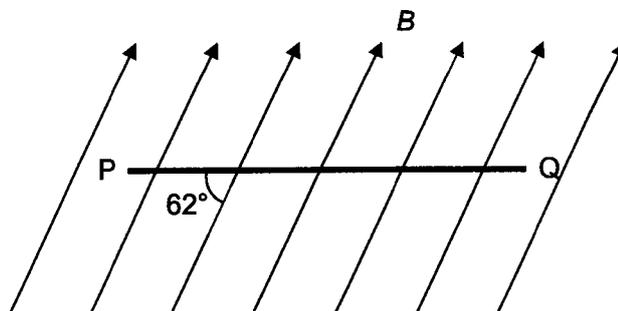


Fig. 8.4 (top view)

25

When side PQ of the coil first enters the magnetic field, the reading on the newton-meter changes by 0.35 N.

- (i) Determine the magnetic flux density B .

$$B = \dots\dots\dots \text{ T} \quad [2]$$

- (ii) State and explain if the change in the reading on the newton-meter is an increase or decrease from its initial value before the coil enters the magnetic field.

.....
 [1]

- (iii) The rigid coil is slowly lowered further so that the vertical sides start to enter the magnetic field.

State what additional motion will be observed.

.....
 [1]



26

- (d) An alternating current (a.c.) supply is connected to a laminated iron-cored transformer. The transformer consists of a primary coil of 30 turns and a secondary coil of 600 turns, as shown in Fig. 8.5.

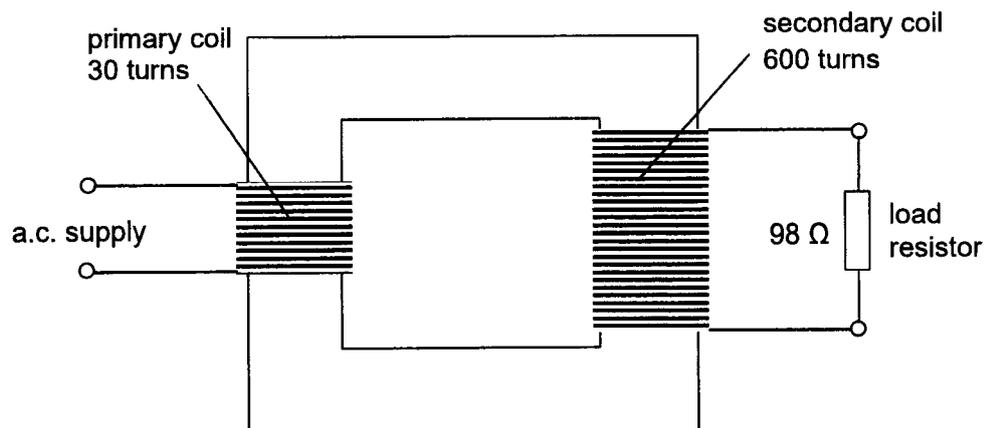


Fig. 8.5

The a.c. supply is a sinusoidal alternating voltage of peak value 102 V. The output from the transformer is connected to a load resistor of resistance 98 Ω .

- (i) Suggest why the iron core is laminated.

.....
 [1]

- (ii) Calculate the peak value of the output potential difference.

peak output potential difference = V [1]

- (iii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

r.m.s. current = A [1]



- 9 (a) (i) State a *phenomenon* each that demonstrates the particulate nature and wave nature of light.

particulate nature:

wave nature: [2]

- (ii) Explain how the existence of discrete electron energy levels in atoms gives rise to a line emission spectrum.

.....

.....

.....

..... [2]



- (b) To produce electromagnetic radiation in a gas lamp, cool gas atoms in the lamp are excited by bombarding them with energetic electrons.

Fig. 9.1 shows some electron energy levels of an isolated gas atom of such a lamp.

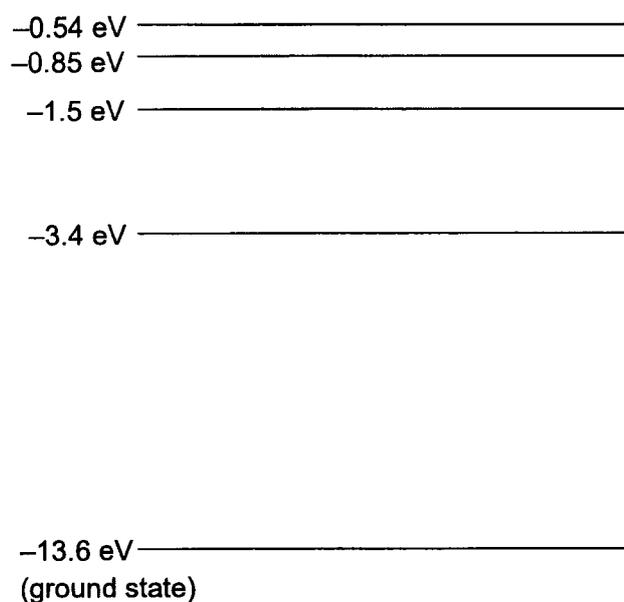


Fig. 9.1

The gas atoms are bombarded by electrons with energy of 12.8 eV, resulting in photons of different energies being emitted.

- (i) On Fig. 9.1, draw clearly all the possible transitions which lead to the emission of photons. [2]
- (ii) Show that lowest wavelength of the photons emitted is 9.8×10^{-8} m.

[2]

- (c) The electromagnetic radiation emitted from the gas lamp in (b) is now incident on metal Z used in a photoelectric experiment.

Fig. 9.2 shows the setup of the photoelectric experiment.

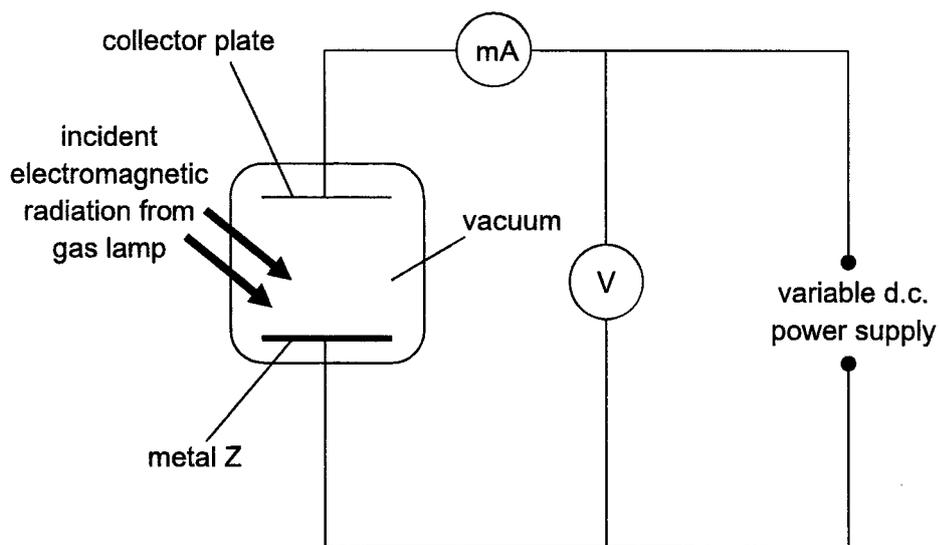


Fig. 9.2

The potential of the collector plate is varied gradually from positive to negative with respect to metal Z.

The variation of the current I with the potential difference V is shown in Fig. 9.3.

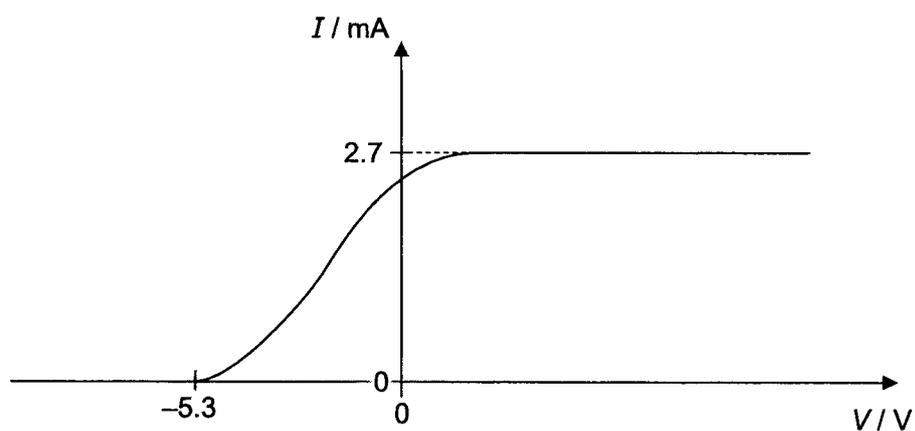


Fig. 9.3

30

- (i) Explain why I decreases gradually as the potential of the collector plate is made more and more negative with respect to metal Z.

.....

 [2]

- (ii) Calculate the maximum rate of emission of photoelectrons.

rate of emission = s^{-1} [2]

- (iii) Show that the work function energy of metal Z is $1.2 \times 10^{-18} \text{ J}$.

work function energy = J [2]

- (iv) Hence, calculate the threshold wavelength of metal Z, leaving your answer in nm.

threshold wavelength = nm [1]



- (v) The gas lamp is now replaced with a new electromagnetic radiation source, and the experiment is repeated.

Graph R in Fig. 9.4 shows the results of the new experiment.

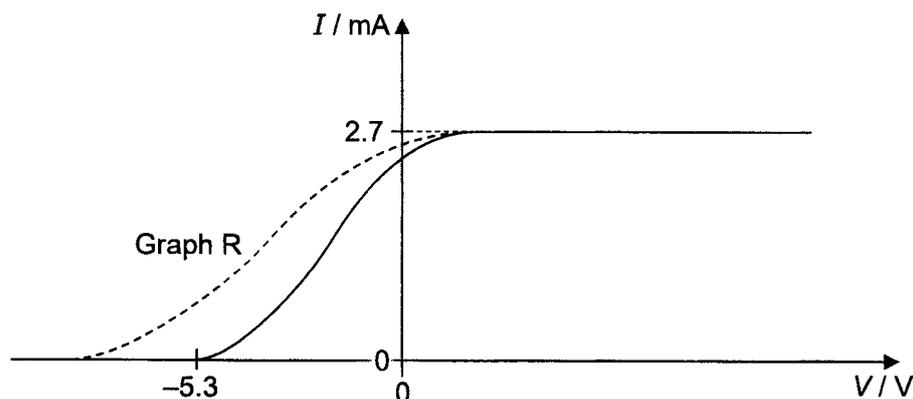


Fig. 9.4

State and explain one difference between this new electromagnetic radiation source and the gas lamp.

.....

.....

..... [2]

- (vi) Photoelectric effect is applied in the manufacture of light meters.

Light meters are typically used by photographers to check the intensity of ambient visible light so that they can make adjustments before taking any photographs.

Explain briefly how photoelectric effect is used for such a purpose in a light meter.

.....

.....

..... [2]

- (vii) Using your answer in (iv), explain why metal Z is not suitable to be used in the manufacture of light meters.

.....

.....

..... [1]

End of paper

BLANK PAGE

