



RIVER VALLEY HIGH SCHOOL

JC2 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749

PAPER 1

26 SEP 2025

1 HOUR

CANDIDATE
NAME

CENTRE
NUMBER

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INDEX
NUMBER

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CLASS

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INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.

Write your name, class and index number above.

There are **thirty** questions in this section. Answer **all** questions. For each question, there are four possible answers, **A, B, C** and **D**. Choose the **one** you consider correct and shade your choice in **soft pencil** on the separate **Optical 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 on the Question Paper.

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

Hand in the Optical Answer Sheet.

This document consists of 17 printed pages and 1 blank page.

Data

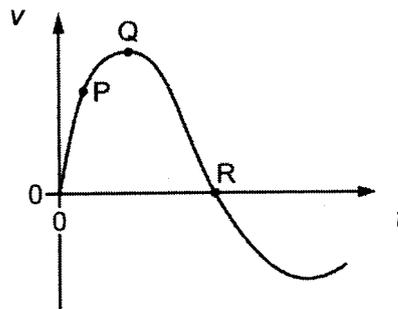
speed of light in free space,	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space,	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
elementary charge,	$e = 1.60 \times 10^{-19} \text{ C}$
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,	$m_e = 9.11 \times 10^{-31} \text{ kg}$
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molar gas constant,	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
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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	$\phi = -Gm/r$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

For each question, there are four possible answers, **A**, **B**, **C** and **D**. Choose the **one** you consider correct and shade your choice in **soft pencil** on the separate **Answer Sheet**.

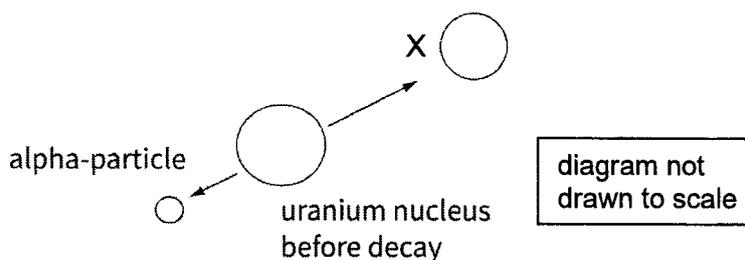
- 1 Which of the following quantities has a unit that can be expressed in terms of just two different SI base units?
- A** area
B charge
C current
D force
- 2 Which of the following experimental techniques reduces the systematic error of the quantity being investigated?
- A** measuring several distances between adjacent nodes on a standing wave to find the mean distance
B measuring the diameter of a wire repeatedly and calculating the average
C adjusting an analogue ammeter to remove its zero error before measuring a current
D timing a large number of oscillations to find a period
- 3 The graph shows how velocity v varies with time t for a bungee jumper.



At which point is the bungee jumper momentarily at rest and at which point does she have zero acceleration?

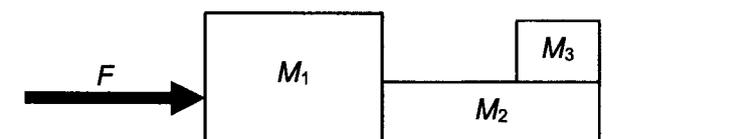
	jumper at rest	jumper with zero acceleration
A	P	Q
B	Q	R
C	R	Q
D	R	R

- 4 A stationary uranium nucleus disintegrates, emitting an alpha-particle of mass 6.65×10^{-27} kg and another nucleus X of mass 3.89×10^{-25} kg.



Which of the following gives the ratio $\frac{\text{speed of alpha-particle}}{\text{speed of nucleus X}}$?

- A 0.017
 B 0.98
 C 1.0
 D 58
- 5 A force F acts on a system of masses M_1 , M_2 and M_3 on a frictionless floor as shown.



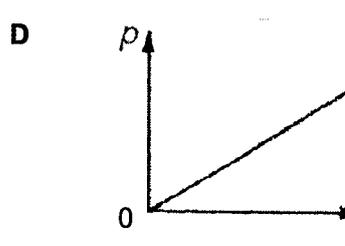
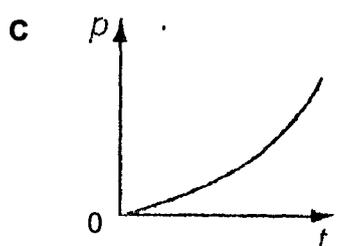
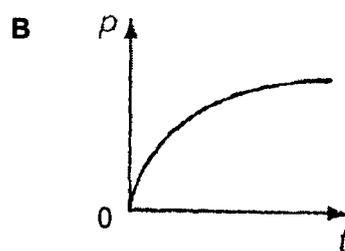
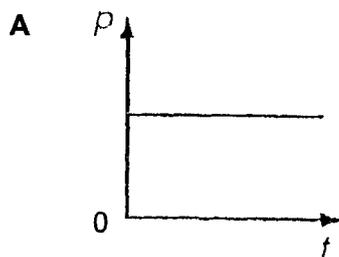
The structure of the system of the masses remains unchanged as it accelerates.

Which of the following gives the magnitude of the frictional force on M_3 ?

- A F
 B $F \left(\frac{M_3}{M_2} \right)$
 C $F \left(\frac{M_3}{M_1 + M_2} \right)$
 D $F \left(\frac{M_3}{M_1 + M_2 + M_3} \right)$

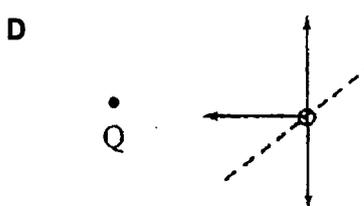
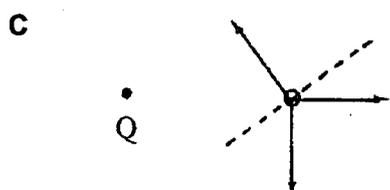
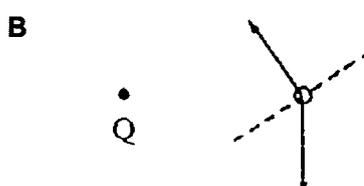
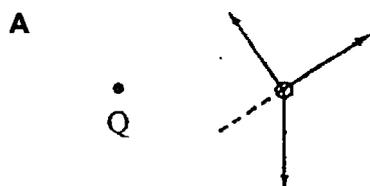
- 8 A constant force is applied to a body which is initially stationary but free to move in the direction of the force.

Assuming that the effects of friction are negligible, which of the following graphs best represents the variation of p , the power supplied, with time t ?

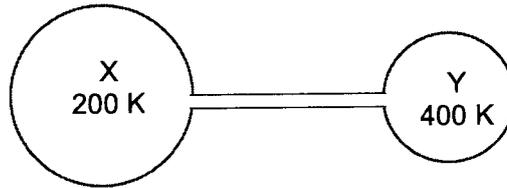


- 9 An aircraft is travelling at constant speed in a horizontal circle, centre Q. Each diagram shows a tail-view of the aircraft, the dotted line representing the orientation of the wings and the circle representing the centre of gravity of the aircraft.

Which diagram correctly shows the direction of forces acting on the aircraft?



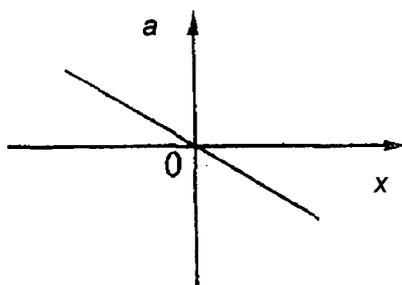
- 10 In the diagram, the volume of bulb X is twice that of bulb Y. The system is filled with an ideal gas and a steady state is established with the bulbs X and Y at temperature 200 K and 400 K respectively.



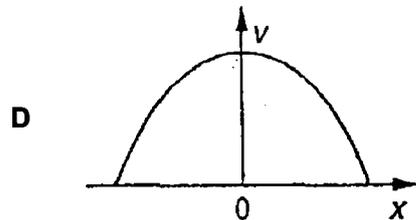
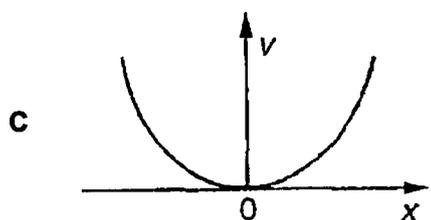
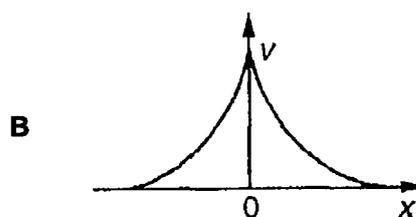
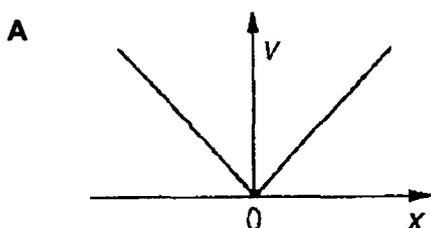
If the mass of gas in X is m , what is the mass of gas in Y?

- A $\frac{m}{4}$
- B $\frac{m}{2}$
- C m
- D $4m$
- 11 One mole of ideal gas is contained within a cylinder by a frictionless piston and is initially at temperature T . The pressure of the gas is kept constant while it is heated and its volume doubles.
- If R is the molar gas constant, what is the work done by the gas in increasing its volume?
- A $\frac{1}{2}RT$
- B RT
- C $\frac{3}{2}RT$
- D $2RT$
- 12 Which of the following statements about internal energy is correct?
- A The internal energy of a system depends only on its temperature.
- B When the internal energy of a system is increased, its temperature always rises.
- C The internal energy of a system can be increased without transfer of energy by heating.
- D When two systems have the same internal energy, they must be at the same temperature.

- 16 A particle moves such that its acceleration a is related to its displacement x from a fixed position as shown in the graph below.



Which of the following best illustrates how the speed v varies with x ?

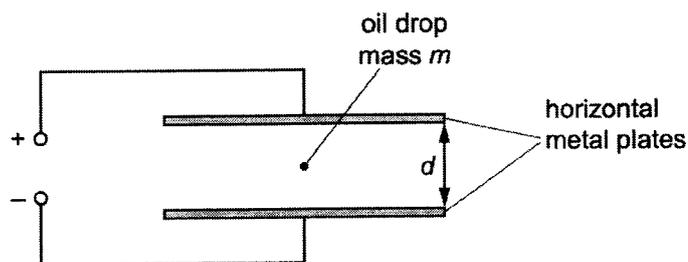


- 17 Which one of the following effects provides direct evidence that light is a transverse, rather than a longitudinal wave?
- A The brightness of the illuminated smartphone screen changes when looking at it through a polarising sheet.
 - B Light is diffracted in a Young's Double slit experiment.
 - C Lightning is seen before thunder is heard.
 - D Light can cause emission of electrons from the surface of a metal.

- 21 In a wire, the drift velocity of electrons is $2.0 \times 10^{-4} \text{ m s}^{-1}$ when a current of 3.0 A flows. If the cross-sectional area of the wire is doubled and the current remains the same, what is the new drift velocity?

- A $4.0 \times 10^{-4} \text{ m s}^{-1}$ B $1.0 \times 10^{-4} \text{ m s}^{-1}$
 C $2.0 \times 10^{-4} \text{ m s}^{-1}$ D $0.5 \times 10^{-4} \text{ m s}^{-1}$

- 22 A negatively charged oil drop of mass m is between two horizontal parallel metal plates a distance d apart.



When the potential difference (p.d.) between the plates is V_1 the oil drop rises at a constant speed. When the p.d. is decreased to a value V_2 the oil drop falls at the same constant speed.

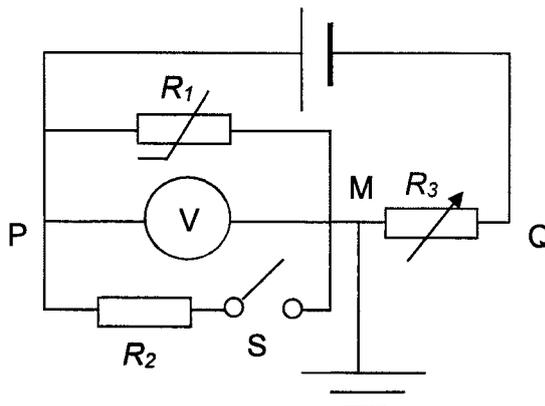
Air resistance acts on the drop when it is moving. The upthrust on the drop is negligible.

The acceleration of free fall is g .

What is the charge on the oil drop?

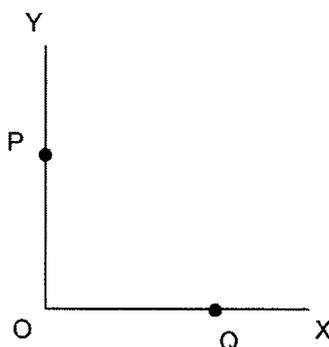
- A $\frac{mdg}{V_1 - V_2}$
 B $\frac{mdg}{V_1 + V_2}$
 C $\frac{2mdg}{V_1 - V_2}$
 D $\frac{2mdg}{V_1 + V_2}$

- 23 A thermistor R_1 is connected to a battery of constant e.m.f. with negligible internal resistance as shown in the figure.



Which of the following actions will cause an increase in the potential difference measured by the voltmeter? Assume that the voltmeter has infinite resistance.

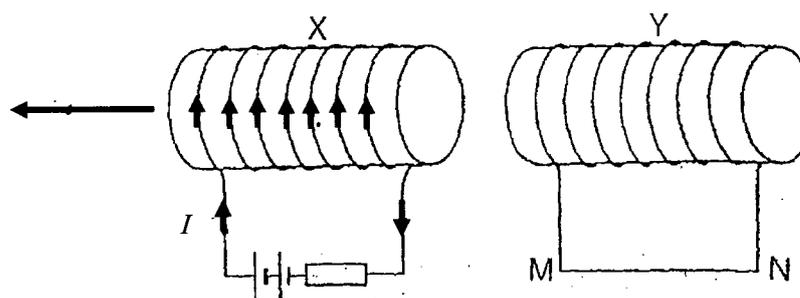
- A Increase the temperature of the thermistor with S open.
 - B Remove the earth connection at M with S open.
 - C Close switch S.
 - D Decrease resistance R_3 with S open.
- 24 The diagram shows a plane OXY with axes OX and OY at right angles.



Which of the following currents in a straight conductor will produce a magnetic field at O in the direction OX?

- A at P into the plane of the diagram
- B at P out of the plane of the diagram
- C at Q into the plane of the diagram
- D at Q out of the plane of the diagram

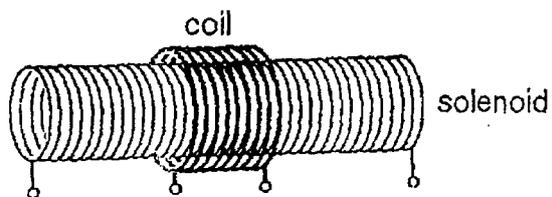
- 25 X and Y are solenoids wound on cardboard tubes. X carries constant current I as shown below and moves with constant speed away from Y along the common axis of the two tubes.



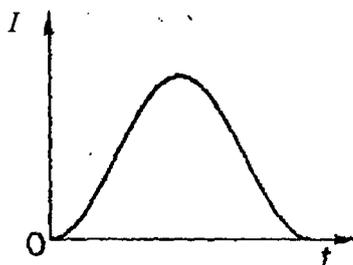
As a result of electromagnetic induction, a current will flow in the straight wire MN and there will be a force between X and Y. Which one of the following correctly describes both the current and the force?

	Nature and direction of current in straight wire MN	Nature of force
A	diminishing, N to M	attraction
B	diminishing, M to N	repulsion
C	constant, N to M	attraction
D	constant, M to N	repulsion

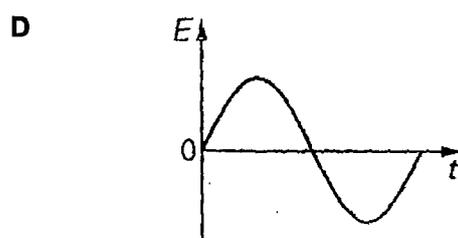
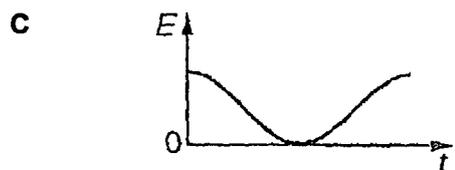
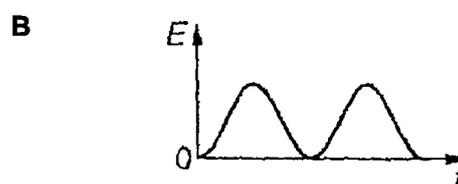
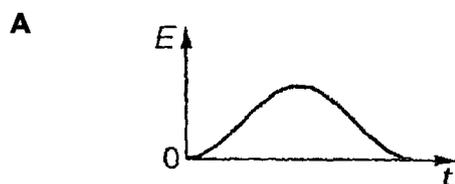
- 26 The diagram shows a short coil wound over the middle part of a long solenoid.



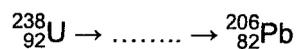
The solenoid current I is varied with time t as shown in the sketch graph.



Which graph shows how the e.m.f. E induced in the short coil varies with t ?



- 30 A nucleus of uranium-238, ${}^{238}_{92}\text{U}$, decays in a series of steps to form a nucleus of lead-206, ${}^{206}_{82}\text{Pb}$ as shown.



An α -particle or a β^- particle is emitted during each step.

What is the total number of β^- particles that are emitted?

- A 6
- B 8
- C 10
- D 16

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RIVER VALLEY HIGH SCHOOL

JC 2 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 2

PAPER 2

18 SEPTEMBER 2025

2 HOURS

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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.

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

Answer all questions.

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

FOR EXAMINERS' USE	
Paper 2	
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Deduction	
Paper 2	/ 80

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pressure of an ideal gas

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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,

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radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

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

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

- 1 (a) The kinetic theory of gases is based on some simplifying assumptions. Molecules of the gas are assumed to behave as hard elastic identical spheres.

State the assumption about ideal gas molecules based on

- (i) the nature of their movement,

.....
 [1]

- (ii) their volume.

.....
 [1]

- (b) The pressure of an ideal gas is given by

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

where N is the number of gas molecules

m is the mass of a gas molecule

V is the volume of the gas

$\langle c^2 \rangle$ is the mean square speed of the molecules

- (i) Explain the significance of the “ $\frac{1}{3}$ ” in the equation.

.....
 [1]

- (ii) Density of nitrogen gas is found to be 1.25 kg m^{-3} at $0 \text{ }^\circ\text{C}$ and 101 kPa .

Assuming nitrogen gas behaves like an ideal gas, determine its root-mean-square speed.

root-mean-square speed = m s^{-1} [2]

- (iii) Use your answer in (b)(ii) to determine the root-mean-square speed of the nitrogen gas at $127 \text{ }^\circ\text{C}$.

root-mean-square speed = m s^{-1} [2]

2 (a) Define simple harmonic motion.

.....

 [1]

(b) Calculate the gain in potential energy when a mass of 150 g is raised vertically through 1.0 mm.

gain in potential energy = J [2]

(c) A simple pendulum consists of a light inextensible string and a bob of mass 150 g attached. The variation of the potential energy V_p with the horizontal displacement of the bob x is shown in Fig. 2.1.

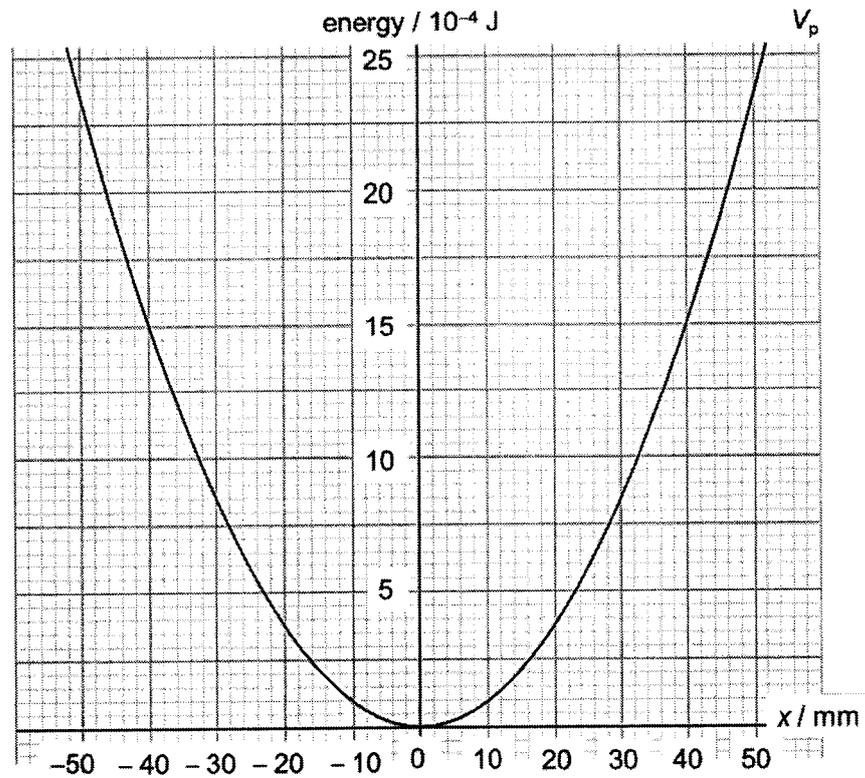


Fig. 2.1

To set the pendulum into oscillation, the bob is displaced sideways (keeping the string taut) until its centre of mass is raised vertically through 1.0 mm and then released. Using your answer in (b), sketch labelled graphs on the axis of Fig. 2.1 to show the variation, as the pendulum oscillates ideally, of x with

(i) the total energy. Label it TE. [1]

(ii) the kinetic energy. Label it KE. [2]

(d) By reference to Fig. 2.1, or otherwise, write down the amplitude of oscillation of the pendulum.

amplitude of oscillation = mm [1]

(e) The pendulum achieves velocity v in the horizontal direction during its oscillation. Using the axis of Fig. 2.2, sketch the variation as the pendulum oscillates, of v with x , as air resistance is no longer negligible, starting from initial release position until the pendulum comes to a rest, after 2 cycles.

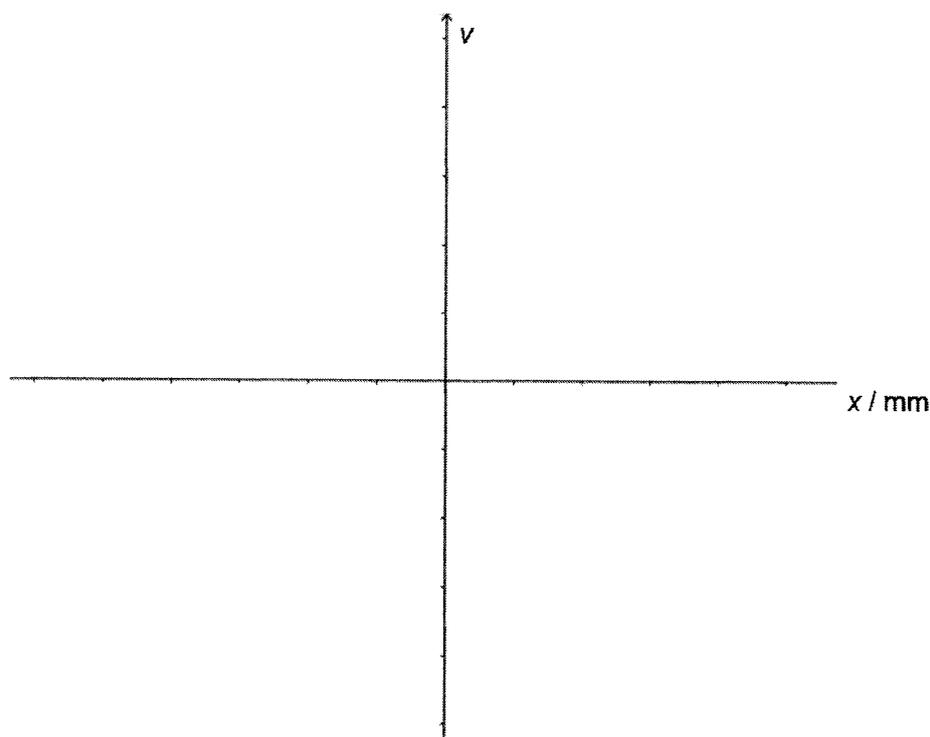


Fig. 2.2

[2]

- 3 Fig. 3.1 shows two coherent loudspeakers S_1 and S_2 placed 4.0 m apart in an open field. D is a detector placed in the same horizontal plane as the loudspeakers. D is placed 12.0 m away from S_2 .

When the loudspeakers are switched on, sound of frequency 1780 Hz is emitted from the two loudspeakers in **antiphase**. The lines S_1S_2 and S_2D are perpendicular to each other.

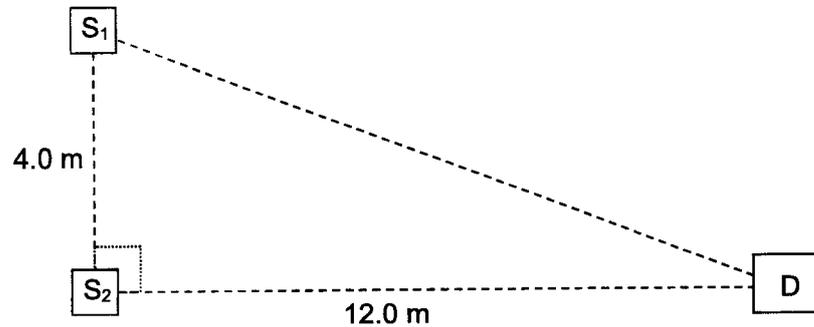


Fig. 3.1

- (a) Given that the speed of sound in air is 330 m s^{-1} , calculate the wavelength λ of the sound emitted from S_1 and S_2 .

$$\lambda = \dots\dots\dots \text{ m} \quad [1]$$

- (b) Calculate the path difference, in terms of λ , between the sound waves reaching D from S_1 and S_2 .

You may assume that the two loudspeakers and the detector are point objects.

$$\text{path difference} = \dots\dots\dots \lambda \quad [2]$$

- (c) By considering the phase difference between the sound waves reaching D from S_1 and S_2 , explain whether D would detect a minimum or maximum intensity.

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

- (d) As the frequency of the sound from S_1 and S_2 is gradually increased from 1780 Hz to a value f_1 , the resultant intensity at D goes through a series of maxima and minima. It eventually detects 2 complete cycles of change in sound intensity.

Calculate the frequency f_1 at which the second complete cycle of change in sound intensity is detected.

$f_1 = \dots\dots\dots$ Hz [3]

- 4 (a) State what is meant by *resistivity* of a material.

.....

 [1]

- (b) A student attempts to measure the resistivity of soil using two parallel copper plates driven into the ground as shown in Fig. 4.1.

Each copper plate has a height of 1.040 m, a width of 0.210 m and a thickness of 0.050 m. The copper plates are driven to a depth of $d = 0.800$ m and separated by a distance $x = 0.900$ m.

When the switch is open, the student obtained a steady voltmeter reading of +0.281 V. When the switch is closed, the student obtained a voltmeter reading of +1.398 V and an ammeter reading of 0.31 mA.

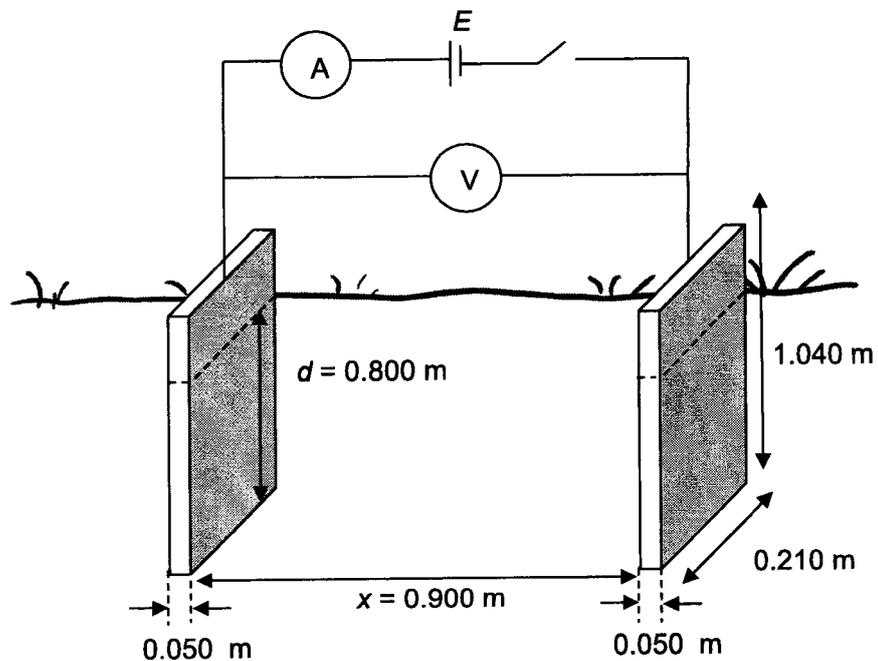


Fig. 4.1

- (i) Show that the resistance of the soil between the copper electrodes is $3.6 \text{ k}\Omega$.

[1]

- (ii) Hence, find the resistivity of the soil.

resistivity = $\Omega \text{ m}$ [2]

- (iii) A student suggested using a more precise ammeter to measure the current.

By using the same apparatus, suggest and explain another procedure how the value in (b)(i) could be determined to a higher significant figure.

.....

 [2]

- (c) A heating device is designed to operate on an a.c. power supply. The device has a resistance of 6.0Ω .

- (i) Calculate the average power dissipated in the device when operating at an a.c. supply of voltage 12.0 V , 50 Hz .

average power dissipated = W [1]

- (ii) On Fig. 4.2, draw a graph to show the variation with time t of the change in power P dissipated in the device for the a.c. supply in (i). Mark values on both axes.

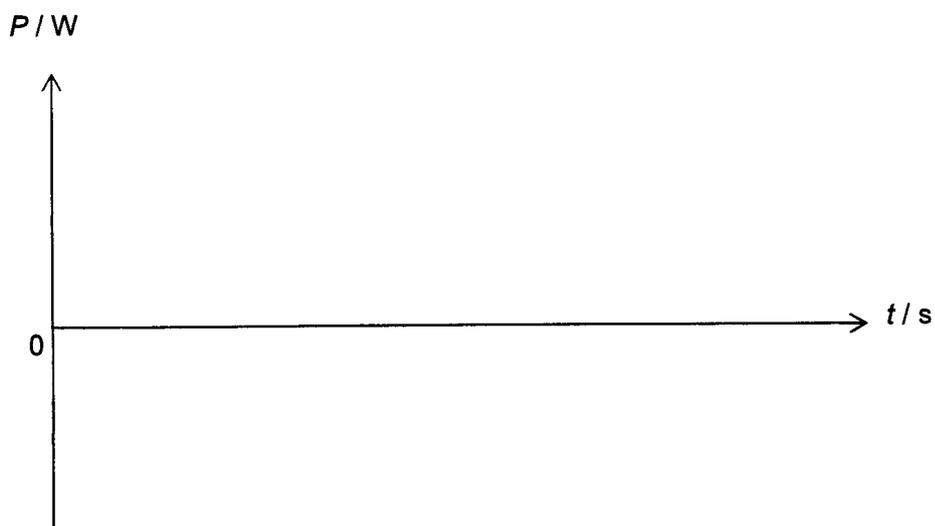


Fig. 4.2

[2]

- (iii) The alternating supply of voltage 12.0 V, 50 Hz is derived from the mains supply of voltage 230 V, 50 Hz using a transformer, assuming 30% of the input energy is lost in the transformer.

Calculate the primary r.m.s. current when the heating device is in use.

primary r.m.s. current = A [2]

- (iv) State an advantage of using alternating current for the transmission of electrical energy.

.....
 [1]

- 5 Two point charges of $+2.4 \mu\text{C}$ and $-2.9 \mu\text{C}$ are placed at points A and B respectively in a vacuum. The distance AB is 0.15 m as shown in Fig. 5.1.

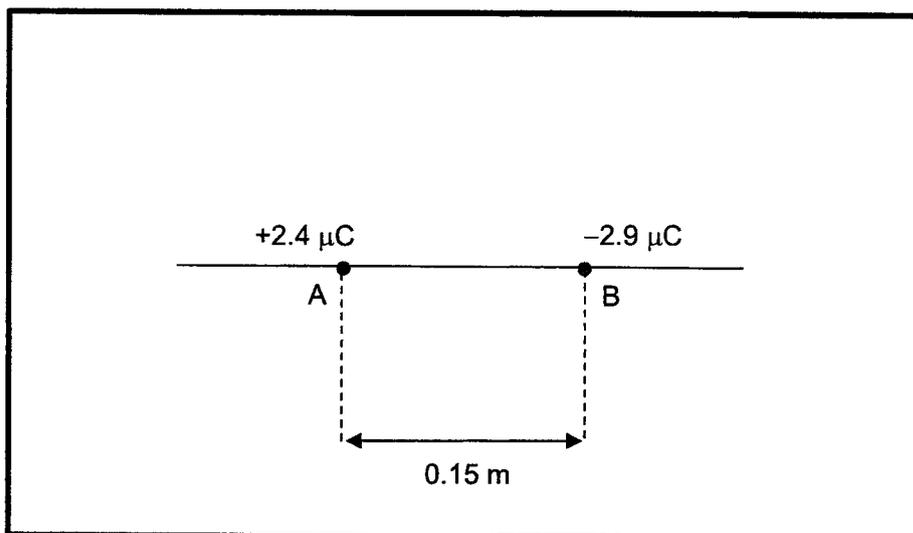


Fig. 5.1

It is required to find a point P at which the resultant electric field due to these two point charges is zero.

- (a) By considering the electric field strength due to the point charges, explain why point P must lie along the straight line with points A and B on it.

.....

 [2]

- (b) Determine the position of point P from A. Show your working clearly.

distance from A = m

direction from A = [4]

- (c) On Fig. 5.1, sketch the equipotential line of potential = 0 V. [2]

- 6 (a) Two long wires X and Y, separated by a distance $r = 3.0$ m, are at right angles to the plane of the paper. X has current $I_1 = 5.0$ A and Y has current $I_2 = 7.0$ A, both pointing out of the plane of the paper as shown in Fig. 6.1.

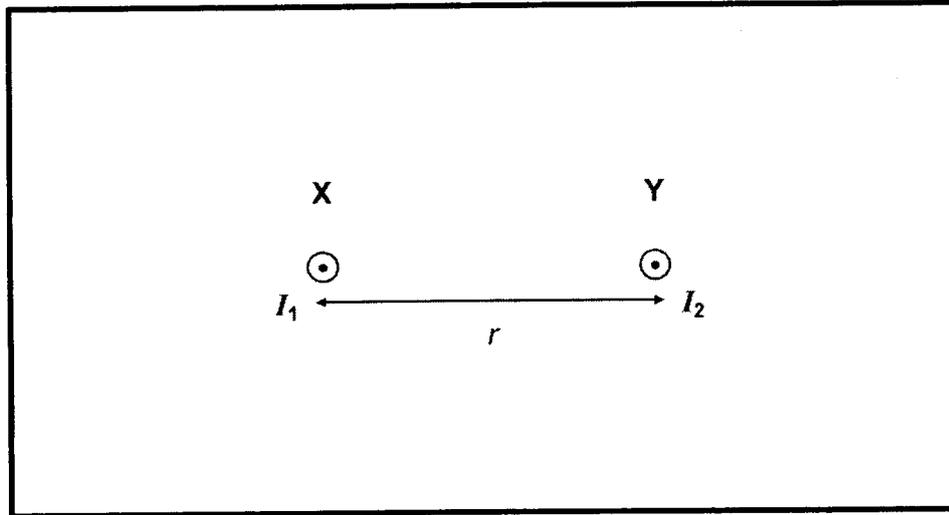


Fig. 6.1

- (i) Show on Fig. 6.1 the direction of the magnetic field B which I_1 causes at Y. Label it B . [1]
- (ii) Show on Fig. 6.1 the direction of the force F which I_1 causes on wire Y. Label it F . [1]
- (iii) Determine the value of the force per unit length of wire which I_1 causes on wire Y.

force per unit length = N m⁻¹ [2]

- (b) State Faraday's Law.

.....

 [1]

Wires X and Y are now coiled into a solenoid, of 10-turns per cm, and search coil, respectively. The current-carrying solenoid is placed near to the search coil as shown in Fig. 6.2.

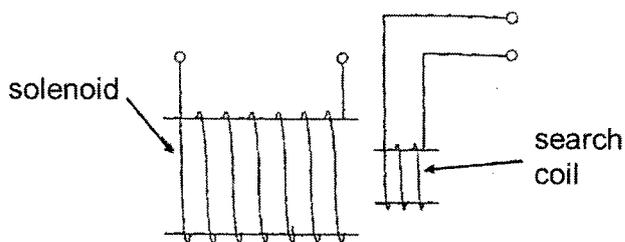


Fig. 6.2

The variation with time t of the current I in the solenoid is shown in Fig. 6.3.

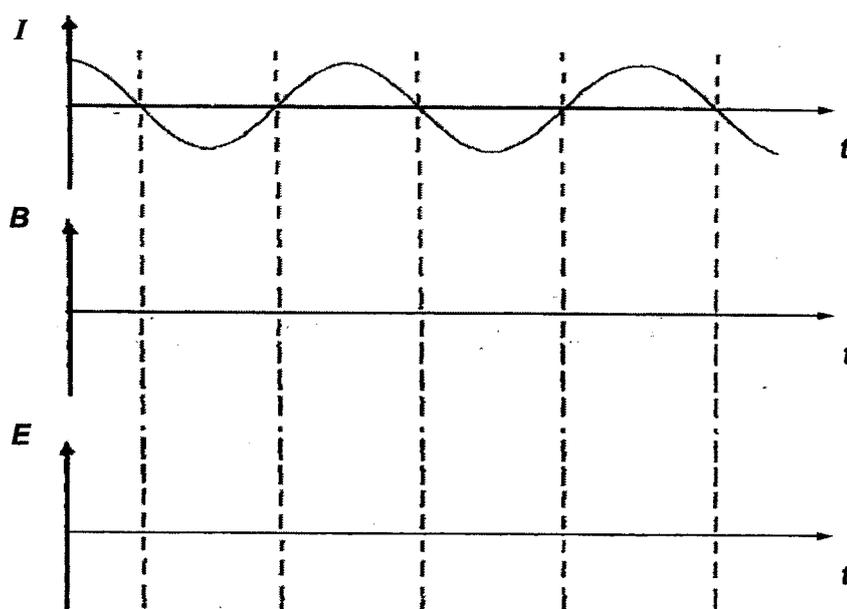


Fig. 6.3

- (i) Sketch on Fig. 6.3 the variation with t of the magnetic flux density B in the solenoid. [1]
- (ii) Sketch on Fig. 6.3 the variation with t of the e.m.f. E induced in the search coil. [1]
- (iii) Calculate the current flowing in the solenoid to generate a maximum magnetic flux density B of 1.0 mT. [2]

current = mA [2]

7 (a) State what is a *photon*.

.....
 [1]

(b) Two metal electrodes A and B are sealed into an evacuated glass envelope and a potential difference V , measured using the voltmeter, is applied between them as shown in Fig. 7.1.

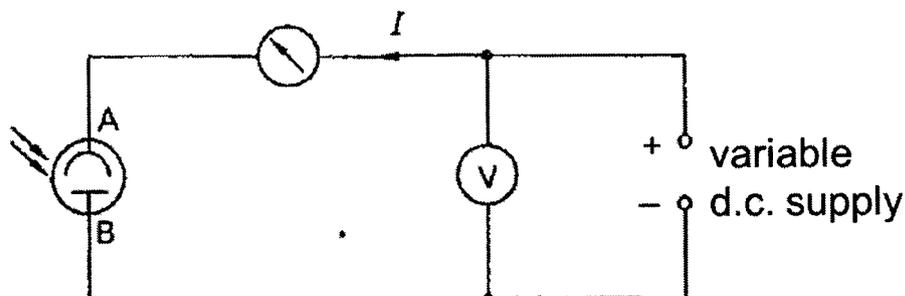


Fig. 7.1

B is then illuminated with monochromatic light of wavelength 365 nm and I , the photocurrent in the circuit, is measured for various values of V . The results are shown in Fig. 7.2.

(i) Using Fig. 7.2, determine the change in electric potential energy required to reduce the photocurrent to zero.

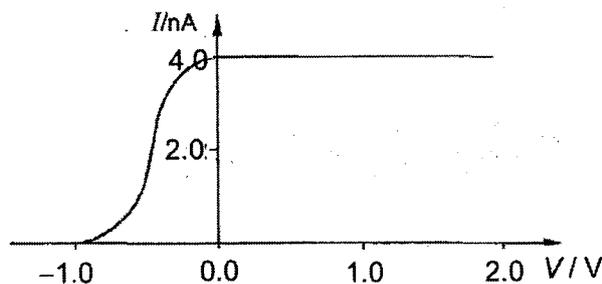


Fig. 7.2

change in electric potential energy = J [1]

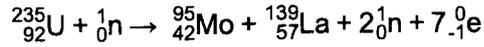
(ii) Calculate the maximum speed of the photoelectrons.

maximum speed = km s^{-1} [2]

(iii) Hence determine the work function energy of B.

work function = eV [2]

8 One possible reaction taking place in the core of a reactor is



	mass
${}_{92}^{235}\text{U}$	235.123 u
${}_{42}^{95}\text{Mo}$	94.945 u
${}_{57}^{139}\text{La}$	138.955 u
proton	1.007 u
neutron	1.009 u

(a) Explain why large nuclei such as uranium-235 are used in nuclear fission reactor in a power plant.

.....
 [1]

Ignore the mass of electron. Using the data above,

(b) show that the energy released per fission of uranium is 200 MeV,

[3]

(c) calculate the energy available from the complete fission of 1.00 g of uranium-235, and

energy = J [2]

- (d) the mass of uranium-235 used by a 500 MW nuclear power station in one hour, assuming 30% efficiency.

mass = g [2]

9 Passenger loading of a European Airbus Aeroplane

Fig. 9.1 shows data concerning a European Airbus aeroplane to answer the following questions.

Mass of aeroplane, including crew and all equipment	42 000 kg
Maximum number of passengers	150
Average mass of a passenger and baggage	100 kg
Capacity of fuel tanks	18 000 kg
Average fuel consumption	5.0 kg km ⁻¹
Safety reserve of fuel at end of journey	3 000 kg
Take-off speed	75 m s ⁻¹
Length of runway used	1 500 m

Fig. 9.1

Average fuel consumption is a measure of how much the plane uses to travel a certain distance. This is typically expressed as mass of fuel per unit distance travelled. The capacity of fuel carried at the start of a plane journey includes the safety reserve fuel. The safety reserve fuel is the extra fuel carried beyond what is needed for the planned flight. It should not be used unless during unexpected situations such as delays, diversions or changes in flight conditions.

- (a) For a plane carrying maximum capacity of fuel, calculate the maximum safe distance travelled of the aeroplane.

distance travelled = km [1]

- (b) Calculate how much further could the aeroplane travel, if at the end of its scheduled flight in (a), the airport it intended to land at was closed due to poor weather conditions.

distance travelled = km [1]

- (c) Determine the maximum total mass of the aeroplane, passengers and fuel at the start of a flight.

total mass = kg [1]

- (d) Fig. 9.2 shows the variation with time of the lift force on the aeroplane during taking off.

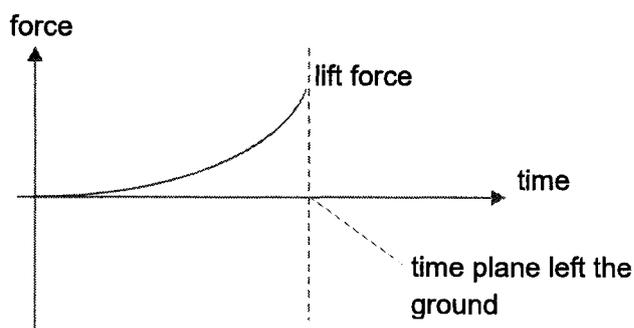


Fig. 9.2

On Fig. 9.2 sketch the variation with time,

- (i) the weight of the plane, label the graph **W**, and [1]
- (ii) the normal contact force by the ground on the plane, label the graph **N**. [1]
- (e) Determine the horizontal acceleration of the aeroplane while it is on the runway when it is taking off.

Assume that the acceleration of the aeroplane is constant.

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

- (f) Hence determine the force required to cause the acceleration.

force = N [1]

- (g) Sometimes aeroplanes find it necessary to take off from shorter than normal runways.

They then have to reduce the number of passengers they carry or the amount of fuel carried. But they are not allowed to reduce their safety margin of reserve fuel.

- (i) Assume that your answer in (f) remains constant, show that the total mass that can be accelerated to the take-off speed in a distance of 1200 m is 60 000 kg.

mass = kg [1]

- (ii) Complete Fig. 9.3 showing the maximum safe distance the aeroplane can travel when carrying different number of passengers.

Length of take-off / m	1500	1200	1200	1200
Number of passengers	150	130	110	90
Mass of aeroplane / kg	42 000			
Mass of passengers / kg	15 000	13 000	11 000	9 000
Total mass of fuel /kg	18 000			
Total mass / kg		60 000	60 000	60 000
Mass of fuel in reserve / kg	3 000			
Usable mass of fuel / kg	15 000			
Maximum safe distance / km				

Fig. 9.3 Data for Airbus with different operating conditions

[2]

- (h) For most commercial aeroplane, the *maximum landing weight* is lower than the *maximum take-off weight*.

Hence if an aeroplane needs to return for an emergency landing shortly after take-off, it may need to dump fuel before landing.

Suggest a reason why the maximum landing weight of an aircraft is lower than its maximum take-off weight.

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

END OF PAPER

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RIVER VALLEY HIGH SCHOOL

JC 2 PRELIMINARY EXAMINATIONS

H2 PHYSICS 9749 / 3

PAPER 3

19 SEPTEMBER 2025

2 HOURS

CANDIDATE NAME

CENTRE NUMBER

INDEX NUMBER

CLASS

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.

Write your name, centre number, index number and class in the spaces at the top of this page and on all work you hand in.

Candidates answer on the Question Paper.

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.

You are advised to spend one and half hours on Section A and half an hour on Section B.

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

PAPER	1	2	3	4	TOTAL
SCORE	/30	/80	/80	/55	/245

FOR EXAMINERS' USE

Section A – do all questions

1	/ 6
2	/ 6
3	/ 7
4	/ 6
5	/ 6
6	/ 7
7	/ 14
8	/ 8
Section B – do ONE question only	
9	/ 20
10	/ 20
Deduction	
TOTAL	/ 80

This document consists of 27 printed pages and 1 blank page

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	$\phi = -GM/r$
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,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

Answer all the questions in this Section in the spaces provided.

- 1 (a) Distinguish between a *systematic* and a *random* error in the measurement of a physical quantity.

.....

 [2]

- (b) A travelling microscope fitted with a vernier scale is used to measure the internal diameter of a capillary tube. Fig. 1a and Fig. 1b show the vernier when the microscope is adjusted so that the cross-wires are aligned at opposite ends of a diameter.

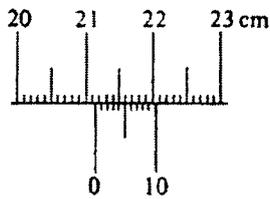


Fig. 1a

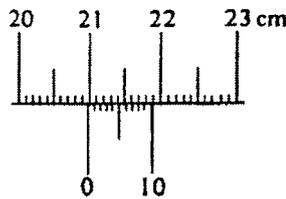


Fig. 1b

- (i) Write down the two vernier readings.

Fig. 1a = cm

Fig. 1b = cm [1]

- (ii) State the absolute uncertainty in a single reading of the vernier.

absolute uncertainty = cm [1]

- (iii) Hence determine the percentage uncertainty in the cross-sectional area of the capillary tube that could arise if it were calculated using these two readings.

percentage uncertainty = % [2]

- 2 A small ball of mass 34 g is thrown horizontally with a speed of 4.0 m s^{-1} . It falls through a vertical height of 1.96 m before bouncing off a smooth horizontal plate as shown in Fig. 2.1.

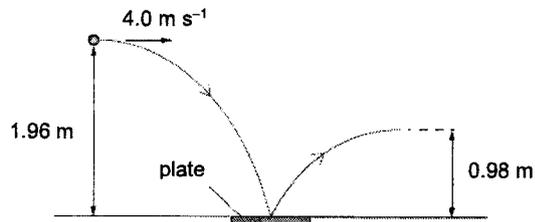


Fig. 2.1

Air resistance is negligible.

- (a) Calculate the vertical component of the velocity of the ball when it hits the plate.

vertical component of the velocity = m s^{-1} [2]

- (b) State and explain the change, if any, in the horizontal component of the velocity of the ball before and after the collision with the plate.

.....

 [2]

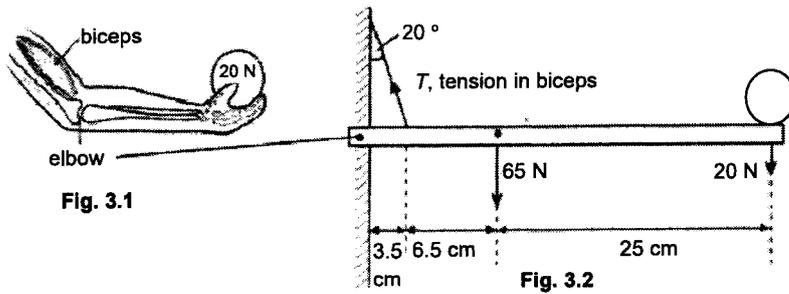
- (c) Determine the impulse of the ball during the collision.

impulse = N s [2]

3 (a) Define *moment of a force*.

.....
 [1]

(b) A person supports a load of 20 N in his hand as shown in Fig. 3.1. The system of the hand and load is represented by Fig. 3.2. The rod represents the forearm and T represents the tension exerted in the biceps. The forearm weighs 65 N.



Given that $T = 410$ N, determine the magnitude and direction of the force acting at the elbow.

force acting at the elbow = N
 direction of the force = [4]

- (c) In order to break a stack of wooden boards, a karate expert has to move his arm and hand swiftly against it with considerable speed as shown in Fig. 3.3.



Fig. 3.3

Using Newton's laws of motion, explain why he has to execute the karate strike very quickly.

.....

.....

.....

..... [2]

- 4 (a) A small metal sphere of mass m is moving vertically downwards through a viscous liquid.

When it reaches a constant downward velocity v , the kinetic energy achieved is given by $\frac{1}{2}mv^2$.

Explain why the kinetic energy reached a constant value.

.....

 [2]

- (b) Consider a constant horizontal applied force F acting on an object of mass m travelling with initial velocity u , achieving a final velocity of v , over a displacement of s as shown in Fig. 4.1.

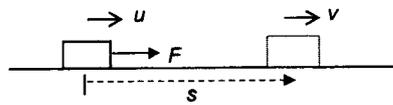


Fig. 4.1

By considering Newton's Laws and equations of motion, derive an expression for the kinetic energy $\frac{1}{2}mv^2$.

State an assumption necessary for the derivation.

.....
 [4]

- 5 (a) Explain what is meant by *angular velocity*. State its SI unit.

.....

 [2]

- (b) A particle is suspended from a point A by an inextensible string of length L . It is projected from B with a velocity V , perpendicular to AB, which is just sufficient for it to reach point C, as shown in Fig. 5.1.

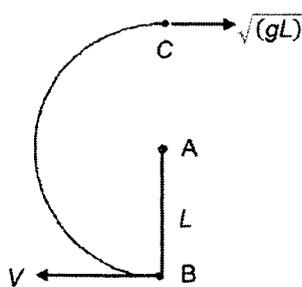


Fig. 5.1

- (i) Show that, if the string is just taut when the particle reaches C, its speed at C is \sqrt{gL} .

[2]

- (ii) Determine V if L is 1.0 m.

$V = \dots\dots\dots \text{ m s}^{-1}$ [2]

- 6 (a) Fig. 6.1 shows a uniform wire XY of length 150.0 cm and resistance 4.5Ω connected in series with a cell Z of electromotive force (e.m.f.) 3.0 V with internal resistance 0.50Ω .

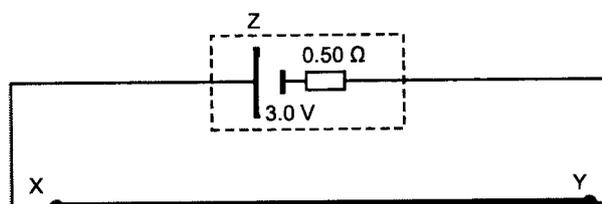


Fig. 6.1

- (i) State what is meant by *electromotive force* of a cell.

.....
 [1]

- (ii) Show that the potential difference between X and Y is 2.7 V.

[1]

- (b) Another circuit consisting of a cell W in series with $1.0\ \Omega$ and $2.0\ \Omega$ resistors is connected to positions X and P which are $80.0\ \text{cm}$ apart as shown in Fig. 6.2.

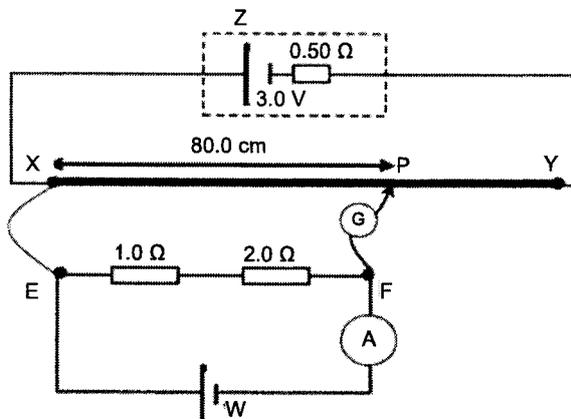


Fig. 6.2 (not drawn to scale)

If the galvanometer shows null deflection, determine the current reading shown on the ammeter.

current reading = A [2]

- (c) Wire XY is replaced with another wire of the same material and length but with a smaller cross-sectional area.

- (i) State and explain the changes, if any, in the balance length.

.....

 [2]

- (ii) Hence with reference to potential difference, explain the changes, if any, of the final ammeter reading at balance.

.....
 [1]

7 A simplified representation of the 5 lowest energy levels of the outermost electron in the sodium atom is shown in Fig. 7.1.

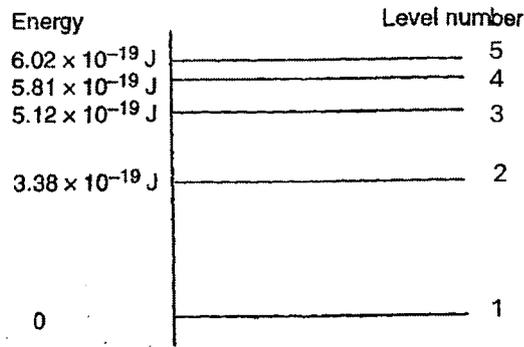


Fig. 7.1

(a) Considering transitions between only these levels,

(i) state the spectral emission transition that has the longest wavelength (give your answers in terms of level numbers),

level to [1]

(ii) state the number of emission lines that might be produced by transitions among these levels.

number of spectral emission lines [1]

(iii) Cool sodium vapour at low pressure is bombarded with electrons of kinetic energy E .

Commented [YKW(1)]: Change to (b).

Determine the number of emission transitions observed if E has the value 3.6 eV. Show your reasoning clearly.

number of observed transitions [3]

- (b) State the number of absorption lines that might be visible to the human eye, if the sodium atoms are initially at Level 1. Show your working clearly.

Continued on Page 2 of 2

number of visible absorption lines [2]

When electrons bombard heavier metals, the range of spectral lines detected could be very different. Fig. 7.2 shows a spectral graph of relative intensity against frequency of x-ray detected, conducted using two different accelerating voltages, V_1 and V_2 (not labelled).

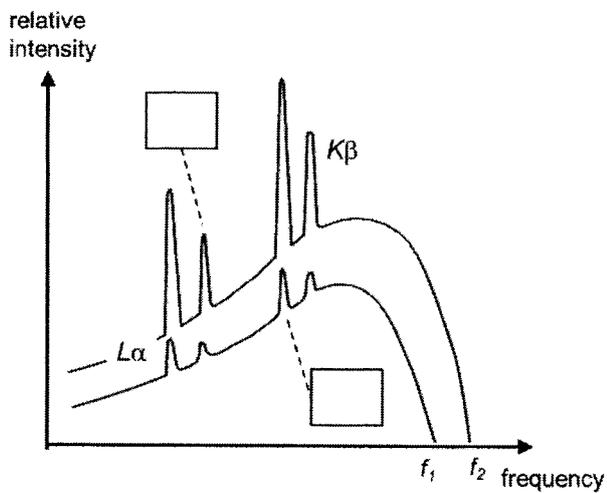


Fig. 7.2

Continued on Page 2 of 2

- (c) Fill in the boxes in Fig. 7.2 with appropriate notations for the characteristic lines. [1]

- (d) Explain briefly for the observation of characteristic peak K_{β} in Fig. 7.2.

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

- (e) Explain briefly for the observation of two distinct continuous spectra in Fig. 7.2, when experiments using two different accelerating voltages, V_1 and V_2 are conducted, where V_2 is larger than V_1 .

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

- (f) Explain briefly for the observation of characteristic peaks at the same frequency regardless of the voltages.

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

8 Stable isotope of gold has an atomic number of 79 and a mass number of 197. A sample of pure gold is irradiated with neutrons to produce a small proportion of the radioactive isotope of gold of mass number 198.

(a) If chemical analysis of the sample subsequently showed that it contained a trace of mercury of atomic number 80, state and explain what you would conclude from this analysis about the radiation of the radioactive gold.

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

(b) (i) The half-life of the radioactive isotope of gold is 2.69 days.

With reference to your answer in (a) or otherwise, suggest a possible use for radioactive gold. Explain your answer.

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

(ii) A sample of Gold-198 has an activity of 64 kBq when it was initially measured.

1. Calculate the mass of radioactive isotope of Gold-198 present in the sample.

mass = g [2]

2. Calculate the activity after 13.5 days.

activity = kBq [2]

Section B

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

- 9 (a) Sample of material A and sample of material B are at different initial temperatures when they are placed in a thermally insulated container and allowed to come to *thermal equilibrium*.

Fig. 9.1 gives the graph of variation with time t of their temperature θ . Sample A has a mass of 5.0 kg; sample B has a mass of 1.5 kg.

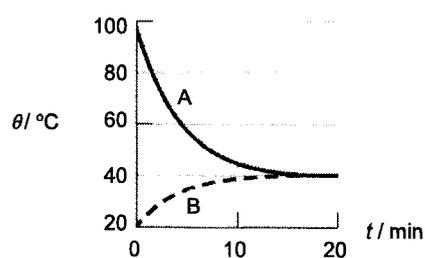


Fig. 9.1

Fig. 9.2 is a plot for material B. It shows the temperature change $\Delta\theta$ that the material undergoes when thermal energy Q is transferred to it. The change in temperature $\Delta\theta$ is plotted against the thermal energy Q per unit mass of the material.

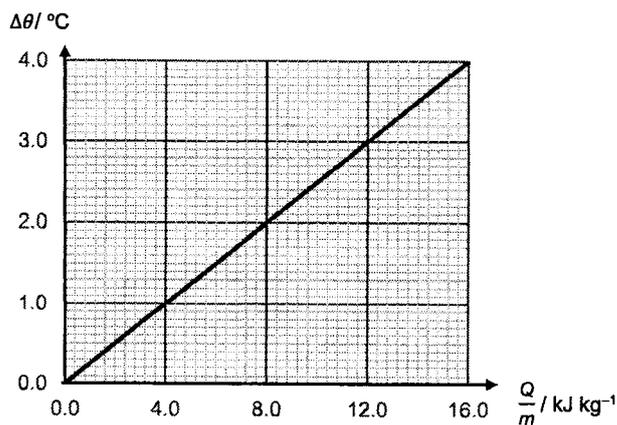


Fig. 9.2

- (i) Explain what is meant by sample A and sample B in thermal equilibrium and thus comment about their temperature.

.....

 [2]

- (ii) Use Fig. 9.2 to find specific heat capacity of material B.

specific heat capacity = $\text{J kg}^{-1} \text{K}^{-1}$ [2]

- (iii) Use your answer in (a)(ii) and Fig. 9.1 to find the specific heat capacity of material A.

specific heat capacity = $\text{J kg}^{-1} \text{K}^{-1}$ [2]

- (iv) Sketch on Fig. 9.2 the change in temperature $\Delta\theta$ versus the thermal energy Q per unit mass for material A. [1]

(b) Fig. 9.3 shows a cylinder containing ideal gas and closed by a movable piston. The cylinder is kept submerged in an ice-water mixture.

process 1: The piston is quickly pushed down from position 1 to position 2. The process occurs so fast that there is not enough time for heat to be transferred.

process 2: The piston is held at position 2 until the gas is again at the temperature of the ice-water mixture.

process 3: The piston then is slowly raised back to position 1.

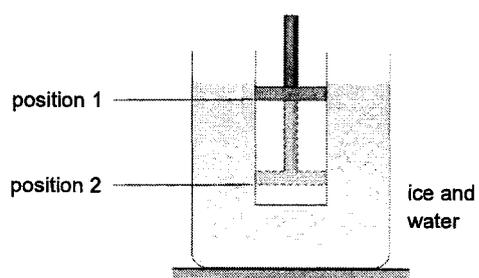


Fig. 9.3

Fig. 9.4 is a pressure-volume diagram for the processes.

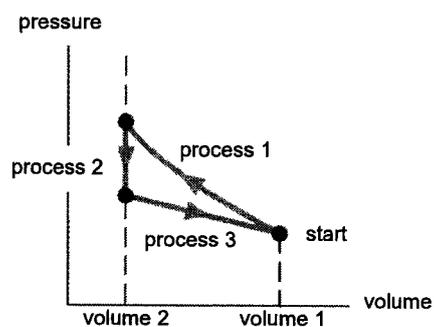


Fig. 9.4

- (i) The equation below describes first law of thermodynamics

$$\Delta u = q + w$$

Explain what each term means.

Δu :

q :

w :

[2]

- (ii) For process 1, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5.

[1]

	Δu	q	w
process 1			
process 2			
process 3			

Fig. 9.5

- (iii) For process 2, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

.....

[3]

- (iv) For process 3, fill in 'positive' or 'negative' or 'zero' for each term in Fig. 9.5. Explain your answer.

.....

[2]

- (v) If 100 g of ice is melted during the cycle, determine the work done on the gas?

Specific latent heat of fusion of water = 334 J g^{-1}

work done = J [2]

- (c) (i) A student uses a constant-volume gas thermometer to measure the pressure of a gas at different temperatures on a Celsius scale. The results are shown in Fig. 9.6.

Temperature / °C	Pressure / kPa
0	100
100	137

Fig. 9.6

Assuming that pressure is proportional to absolute temperature, estimate the temperature in °C at which the pressure of the gas would become zero.

temperature = °C [2]

- (ii) Experiments were carried out with different gases at different initial pressures. Fig. 9.7 shows that the thermometer readings tend to the same point nearly independent of the type of gas at low pressure.

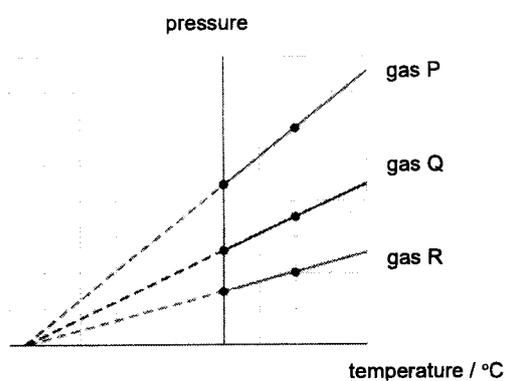


Fig. 9.7

Suggest a reason why different gases may agree only at low pressure.

.....

.....

.....

..... [1]

10 (a) Sound is propagated in a medium as a longitudinal progressive wave, in which there is a repeated sequence of displacements of the medium particles.

(i) Explain what is meant by a *longitudinal progressive wave*.

.....

 [2]

(ii) A loudspeaker emits 20 W of sound waves uniformly in all directions.

Calculate the intensity of the sound wave at 5.0 m from the loudspeaker.

intensity = W m^{-2} [2]

(iii) Directional loudspeakers are speakers that project sound in a specific direction.

Suggest why directional loudspeakers are preferred in large outdoor concerts, considering the audience and nearby residential areas.

.....
 [1]

- (b) Fig. 10.1 shows two small loudspeakers L_1 and L_2 separated by 15 cm. A sound sensor M is moved along a line XY parallel to the line joining the two loudspeakers and at a perpendicular distance 20 m away.

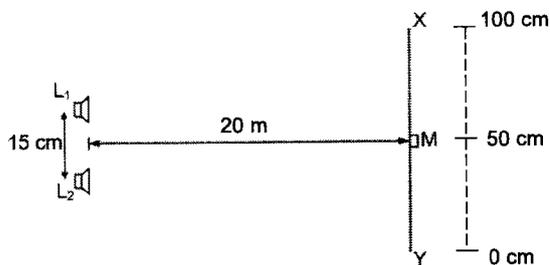


Fig. 10.1

The sound intensity detected by the sound sensor varies as shown in Fig. 10.2.

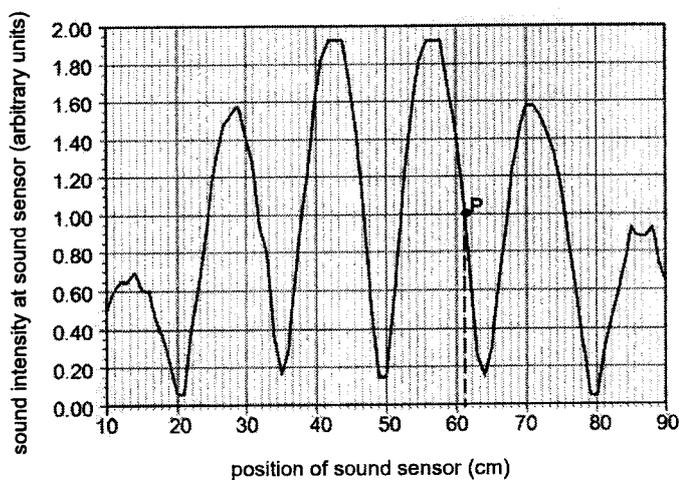


Fig. 10.2

- (i) Explain how it can be deduced that the loudspeakers are coherent sources of waves.

.....
 [1]

- (ii) By considering the phase difference of the waves from both speakers, explain how the central minimum in the pattern is formed.

.....

 [2]

- (iii) Calculate the approximate frequency at which the speakers were driven. Assume the speed of sound as 343 m s^{-1} .

approximate frequency = Hz [3]

- (iv) Estimate the phase angle between the waves from the loudspeakers when the waves meet to produce the intensity at point P on the pattern of Fig. 10.2.

phase angle = rad [2]

- (v) Suggest a reason why the maxima on Fig. 10.2 are not all of the same intensity.

.....
 [1]

- (c) Fig. 10.3 shows a narrow beam of coherent light of wavelength 589 nm falling normally on a diffraction grating having 500 lines per millimetre. The diffraction grating is situated at the centre of a circular scale.

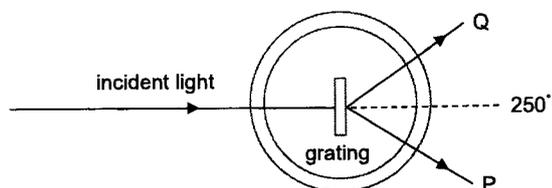


Fig. 10.3

The straight through direction is at the reading of 250° on the scale. A detector is placed at P, where the reading on the scale is 210° . The detector is then moved towards Q, where the reading on the scale is 290° .

- (i) Determine the number of maxima detected as the detector moves from P to Q.

number of maxima detected = [2]

- (ii) State how the angular separation between two maxima of the same order can be increased.

.....
 [1]

- (iii) State how the position of the central maximum will change if the light beam does not fall normally on the diffraction grating as shown in Fig. 10.4.

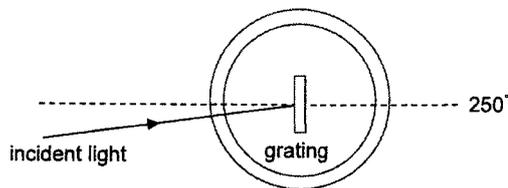


Fig. 10.4

.....
 [1]

- (iv) The light source used in the setup in Fig. 10.3 is replaced with an incident light of unknown wavelength.

Suggest one advantage and one disadvantage of obtaining the wavelength by using observations of the second-order diffracted light rather than the first-order diffracted light.

.....

 [2]

End of Paper

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