

Name: _____ ()

Class: 25 / _____



ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC2 Preliminary Examination

PHYSICS Higher 2

9749/01

Paper 1 Multiple Choice

Wednesday 3 September 2025

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name and class on the Multiple Choice Answer Sheet.

Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A, B, C** and **D**.

Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

Read the instructions on the Multiple Choice Answer Sheet very carefully.

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 question paper.

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

This document consists of **16** printed pages and **0** blank page.

9749/01/ASRJC/2025Prelim

[Turn over

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	$h = 6.63 \times 10^{-34} \text{ J s}$
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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

$$B = \mu_0 nI$$

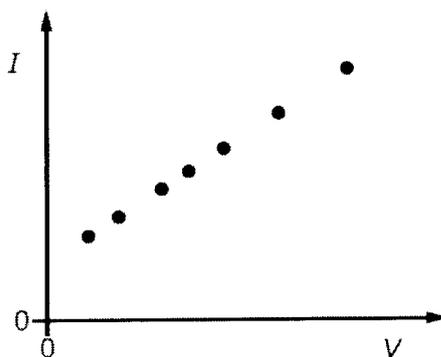
radioactive decay

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

decay constant

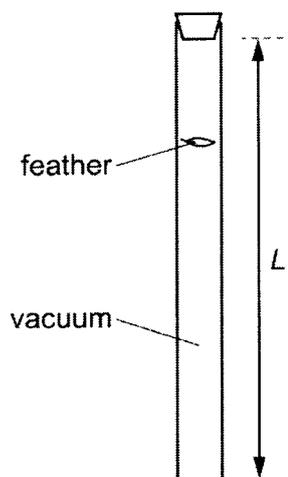
$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

- 1 What is a reasonable estimate of the kinetic energy of a car travelling at a speed of 30 m s^{-1} ?
- A 10^2 J B 10^4 J C 10^6 J D 10^8 J
- 2 Readings are made of the current I for different voltages V across a fixed resistor. The results are plotted on a graph to show the variation of I with V .



What is the best description of the errors in the readings?

- A random only
- B systematic only
- C both systematic and random
- D neither systematic nor random
- 3 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L .

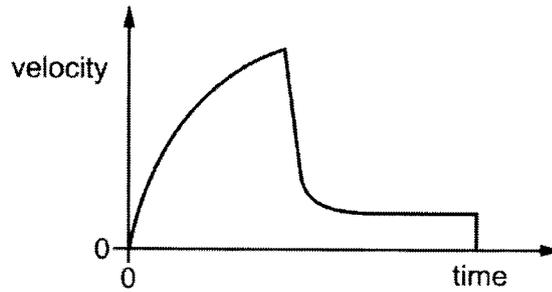


The feather takes time T to fall from the top to the bottom of the tube.

How far does the feather fall from the top of the tube in time $0.50T$?

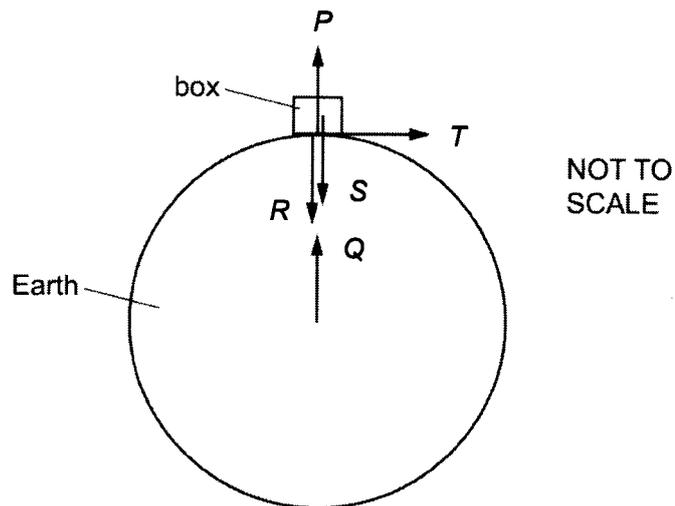
- A $0.13L$ B $0.25L$ C $0.38L$ D $0.50L$

- 4 The graph shows the variation of velocity with time for a stone that falls from a bridge into a lake and sinks to the bottom of the lake.



What can be deduced about the motion of the stone?

- A Terminal velocity was reached in air.
 B The distance travelled in water was greater than the distance travelled in air.
 C The acceleration in air was decreasing with increasing time.
 D The rate of change of velocity in air was constant.
- 5 A box rests on the Earth with forces P , Q , R , S and T acting on them as shown. Newton's third law describes how forces of the same type act in pairs.



Which of the following correctly identifies the pair of forces?

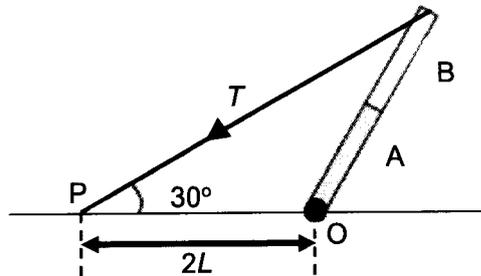
- A P and S
 B P and Q
 C P and R
 D R and Q

- 6 Water is pumped through a hosepipe at a rate of 90 kg per minute. It emerges from the hosepipe horizontally with a speed of 20 m s^{-1} .

Which force is required from a person holding the hosepipe to prevent it moving backwards?

- A 30 N B 270 N C 1800 N D 10800 N

- 7 A rod, made up of 2 uniform portions, A and B, is held in place by a cable under tension, T . The cable is at an angle of 30° to the horizontal.

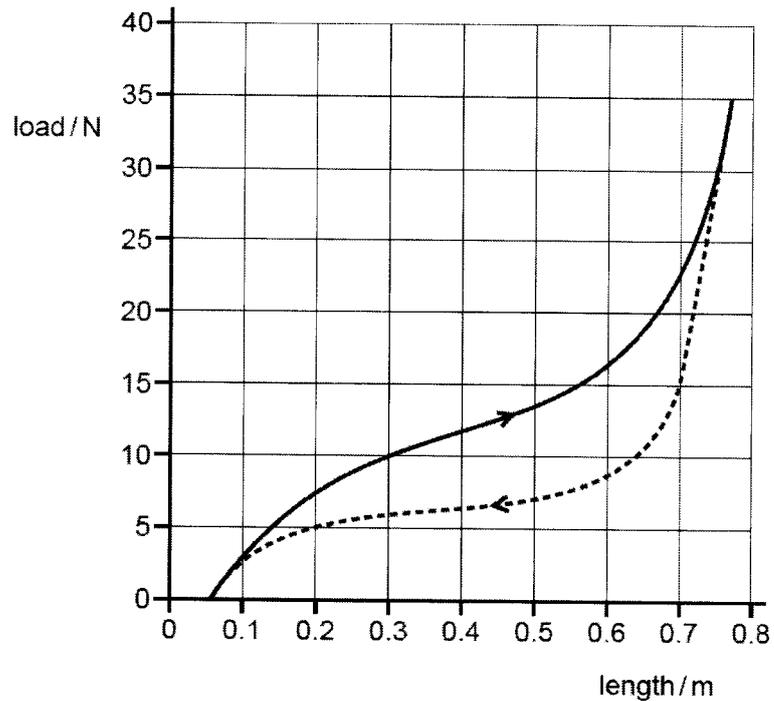


The portions A and B have masses of 20.0 kg and 30.0 kg respectively, and are of identical length, L .

What is the tension T in the cable?

- A 150 N B 190 N C 230 N D 270 N

- 8 The solid line on the graph shows how the length of a rubber band varies when an increasing load is applied. The dotted line shows how the length subsequently varies as the load is gradually decreased.

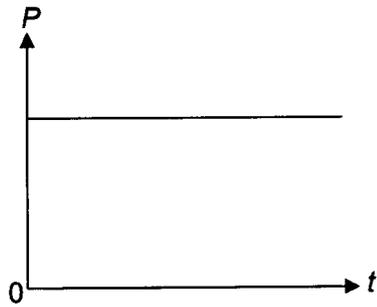


Which statement is correct?

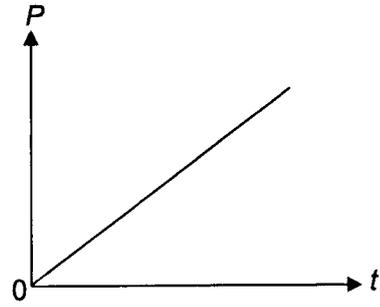
- A** The energy recovered when the load is removed is about 10 J.
- B** The energy remaining in the rubber band after one cycle of loading and unloading is about 3 J.
- C** The total work done on the rubber band during one cycle of loading and unloading is about 14 J.
- D** The work done in stretching the rubber band is about 5 J.

- 9 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 ?

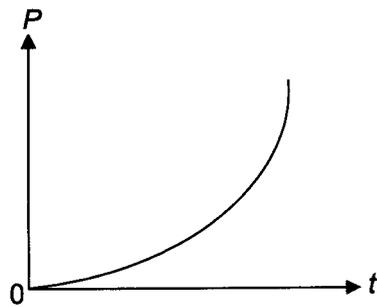
A



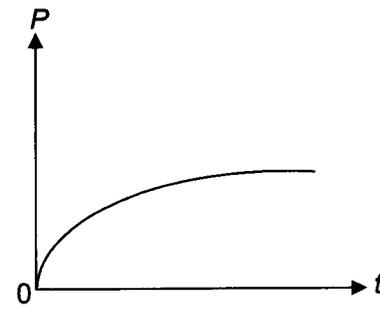
B



C



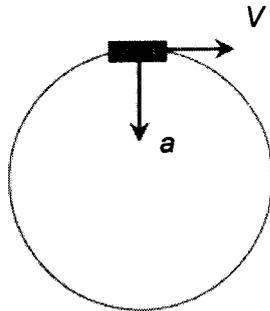
D



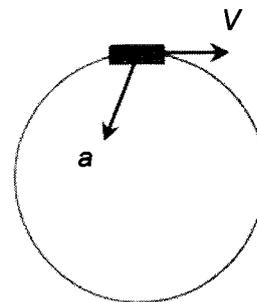
- 10 A drone is performing a vertical circular path stunt for its audience on the ground.

Which diagram shows the resultant acceleration a acting on the drone at the instant where its velocity is V and speeding up?

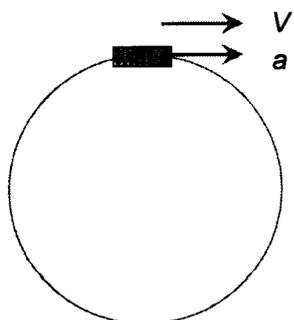
A



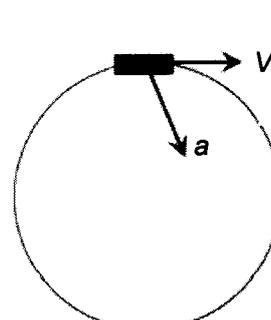
B



C



D



- 11 The gravitational field strength on the surface of planet P is one tenth of that on the surface of planet Q.

On the surface of P, a body has a mass of 1.0 kg and a weight of 1.0 N.

What are the mass and weight of the same body on the surface of planet Q?

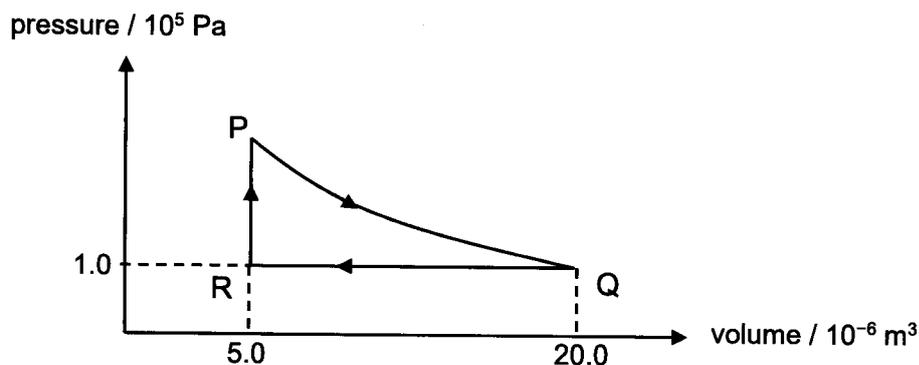
	mass on Q / kg	weight on Q / N
A	1.0	0.1
B	1.0	10
C	10	10
D	10	100

- 12 The density of an ideal gas is 1.2 kg m^{-3} at a pressure of $1.0 \times 10^5 \text{ Pa}$.

What is the root-mean-square (r.m.s.) speed of the molecules of the gas?

- A** 350 m s^{-1} **B** 500 m s^{-1} **C** 3700 m s^{-1} **D** $2.50 \times 10^5 \text{ m s}^{-1}$

- 13 A fixed mass of an ideal gas undergoes a cycle PQRP of changes, as shown below.



Work done by gas from P to Q is 4.2 J.

What is the overall heat gain in a cycle PQRP of changes?

- A** -5.7 J **B** -2.7 J **C** 2.7 J **D** 5.7 J

- 14 In order to check the speed of a camera shutter, the camera was used to photograph the bob of a simple pendulum moving in front of a horizontal scale. The extreme positions of the bob were at 600 mm and 700 mm marks. The photograph showed that while the shutter was opened, the bob moved from 650 mm to 675 mm mark.

If the period of the pendulum was 2.0 s, how long does the shutter remain open?

- A 0.17 s
 B 0.25 s
 C 0.50 s
 D 1.0 s
- 15 As the intensity of a single frequency sound wave travelling through the air is increased, how do the maximum speed of vibration of the air molecules and the speed of wave travel change?

	maximum speed of vibration of air molecules	speed of wave travel
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

- 16 Light of wavelength λ is emitted from two point sources R and S and falls onto a distant screen.



At point P on the screen, the light intensity is zero.

What could explain the zero intensity at P?

- A Light from the two sources is emitted 180° out of phase and the path difference to P is λ .
- B Light from the two sources is emitted 180° out of phase and the path difference to P is $\frac{1}{2}\lambda$.
- C Light from the two sources is emitted 90° out of phase and the path difference to P is λ .
- D Light from the two sources is emitted in phase and the path difference to P is λ .

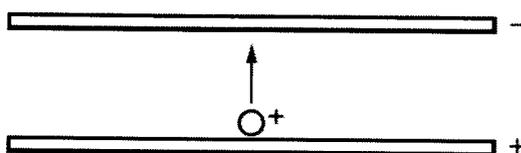
- 17 A beam of red light of wavelength 720 nm is incident normally on a diffraction grating and produces a diffraction pattern on a screen placed parallel to the grating.

The beam of red light is replaced with a beam of electromagnetic radiation of wavelength X , which is incident normally on the same diffraction grating.

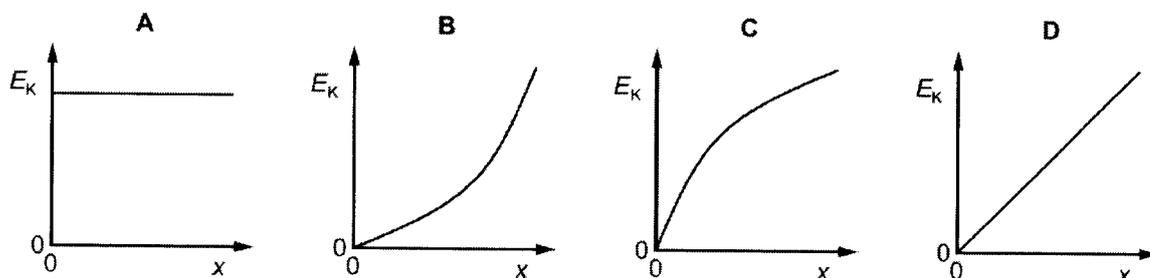
The third-order maximum for the electromagnetic radiation of wavelength X is at the same position on the screen as the second-order maximum for the red light.

What is wavelength X ?

- A 480 nm B 540 nm C 960 nm D 1100 nm
- 18 Two oppositely-charged horizontal metal plates are placed in a vacuum. A positively-charged particle starts from rest and moves from one plate to the other plate, as shown.



Which graph shows how the kinetic energy E_k of the particle varies with the distance x moved from the positive plate?

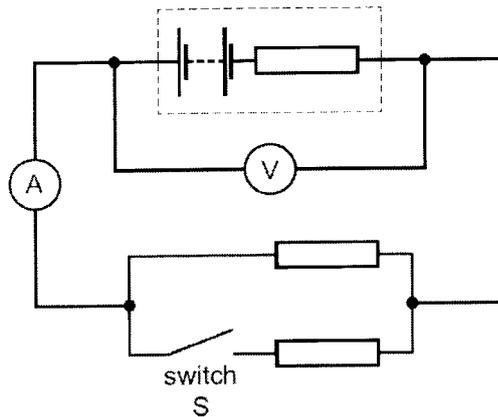


- 19 A resistor has resistance R . When the potential difference across the resistor is V , the current in the resistor is I . The power dissipated in the resistor is P . Work W is done when charge Q flows through the resistor.

What is **not** a valid relationship between these variables?

- A $I = \frac{PQ}{W}$ B $Q = \frac{W}{IR}$ C $R = \frac{V^2}{P}$ D $R = \frac{W}{PQ}$

- 20 A battery, with internal resistance, is connected to a parallel arrangement of two resistors and a switch S, as shown.

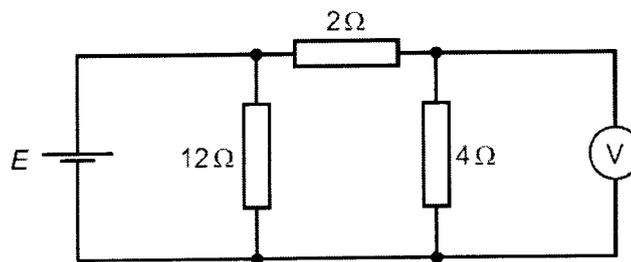


Initially switch S is open.

What happens to the voltmeter and ammeter readings when switch S is closed?

	voltmeter reading	ammeter reading
A	decreases	increases
B	decreases	decreases
C	increases	increases
D	increases	decreases

- 21 A cell of electromotive force (e.m.f.) E and negligible internal resistance is connected into a circuit, as shown.

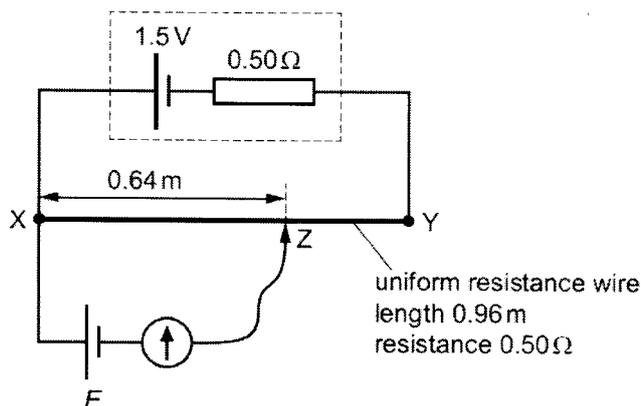


The voltmeter has a very high resistance and reads a potential difference V_{out} .

What is the ratio $\frac{V_{\text{out}}}{E}$?

- A** $\frac{1}{6}$ **B** $\frac{1}{3}$ **C** $\frac{1}{2}$ **D** $\frac{2}{3}$

- 22 A potentiometer circuit is used to determine the electromotive force (e.m.f.) E of a cell. The circuit includes a second cell of e.m.f. 1.5 V and internal resistance $0.50\ \Omega$ that is connected to a uniform resistance wire XY , as shown.

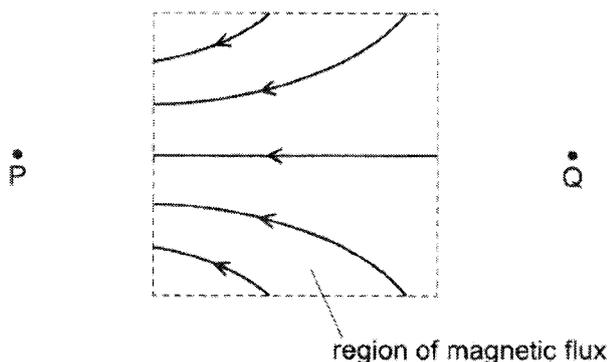


The resistance wire XY has a length of 0.96 m and a resistance of $0.50\ \Omega$.

The movable connection Z is moved along wire XY . The galvanometer reading is zero when length XZ is 0.64 m .

What is the value of e.m.f. E ?

- A 0.50 V B 0.75 V C 1.0 V D 1.1 V
- 23 The magnetic flux pattern formed in a region of space is shown.

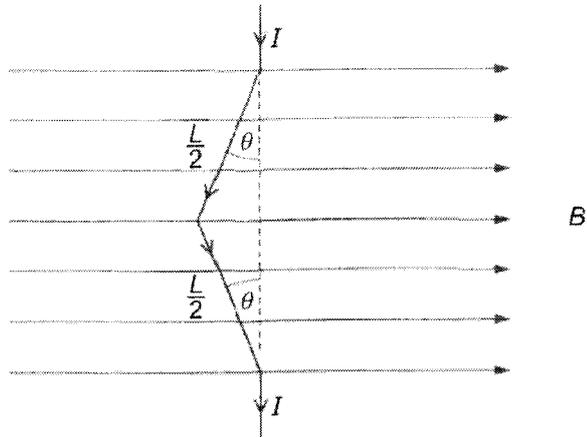


What could cause the magnetic flux pattern?

- A a current-carrying, flat, circular coil with a diameter along the line PQ
 B a current-carrying solenoid with one end at P
 C a long, straight, current-carrying wire along the line PQ
 D a south pole of a bar magnet at Q

- 24 The diagram shows a bent wire in a uniform magnetic field of flux density B .

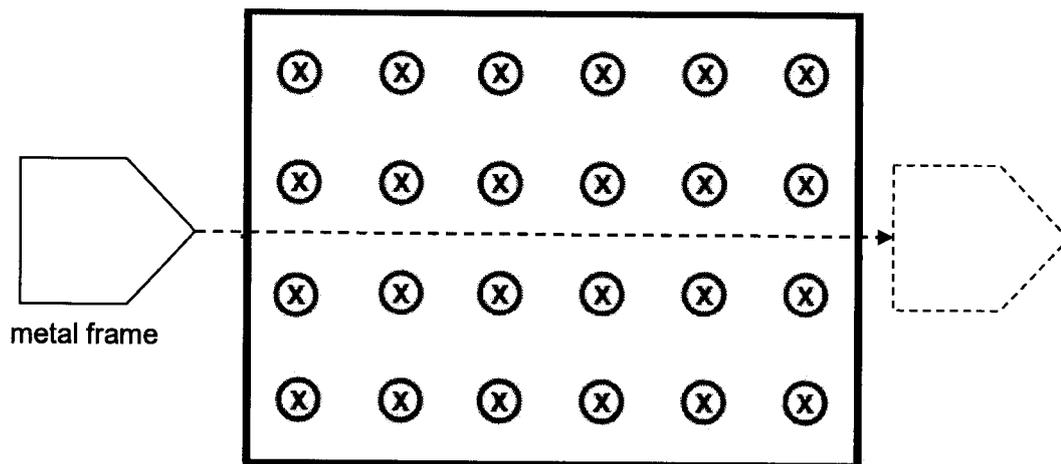
The length of wire in the field is L and each half of the wire is inclined at an angle θ normal to the field direction. There is a current I in the wire.



Which row gives the magnitude and the direction of the force acting on the wire?

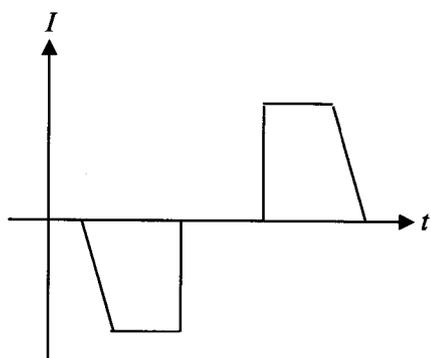
	magnitude	direction
A	$BIL \cos \theta$	out of the page
B	$BIL \cos \theta$	into the page
C	$BIL \sin \theta$	out of the page
D	$BIL \sin \theta$	into the page

- 25 The figure below shows a metal frame entering a region of uniform magnetic field. The plane of the metal frame is always normal to the magnetic field, and the metal frame moves at a constant speed.

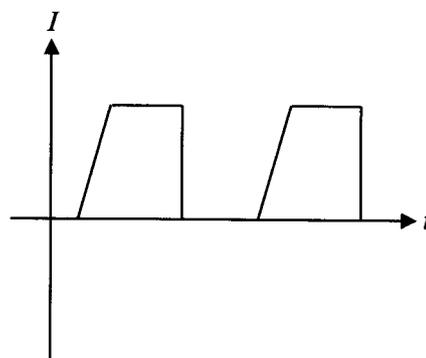


Which graph best shows the variation with time t of the current I induced in the frame?

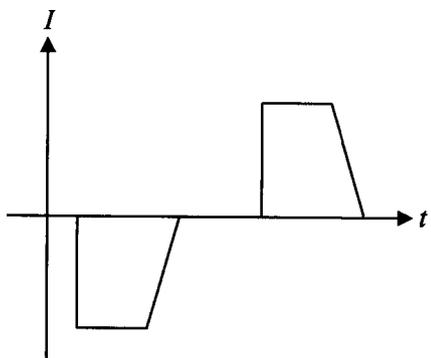
A



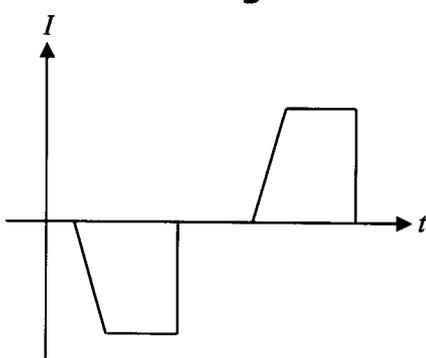
B



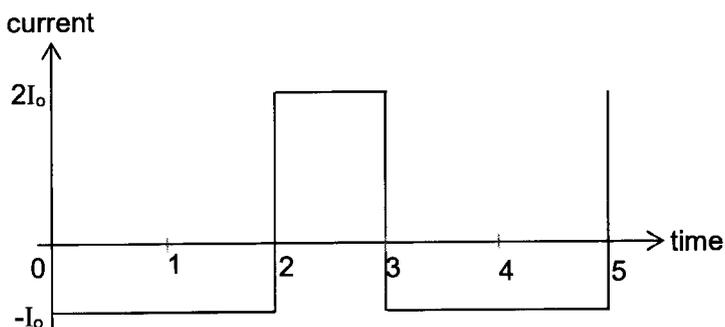
C



D



- 26 The graph shows the variation with time of a periodic current. What is the root-mean-square value of the current?



- A $\sqrt{2}I_0$ B $\frac{I_0}{\sqrt{2}}$ C $\frac{I_0}{2}$ D $2I_0$
- 27 What is the reasonable estimate, to one significant figure, of the energy of a photon of violet light?
- A 4 eV B 6 eV C 3×10^{-19} J D 5×10^{-19} J
- 28 The uncertainty in position of a particle in space is 2.00×10^{-20} m and the uncertainty in its momentum is 4.00×10^{-14} N s.
- What is the minimum percentage change in uncertainty of momentum when the uncertainty in position is halved?
- A -100 % B -66 % C 66 % D 100 %
- 29 Today, the activity of a sample of caesium-137 is 4.0×10^5 Bq. The half-life of caesium-137 is 33 years.
- What is the best estimate of the number of caesium-137 nuclei that will decay in the next two days?
- A 5.0×10^8 B 1.2×10^9 C 6.9×10^{10} D 9.5×10^{12}
- 30 A nucleus X decays into a nucleus Y by emitting an alpha particle followed by two beta particles.
- Which statement about this nuclear decay is correct?
- A Beta particle decay occurs when an orbital electron is emitted.
- B Nucleus Y has the same nucleon number as nucleus X.
- C Nucleus Y is an isotope of nucleus X.
- D The total mass of the products is equal to the mass of the initial nucleus X.

Name: _____ ()

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ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC2 Preliminary Examination

PHYSICS Higher 2

9749/02

Paper 2 Structured Questions

Friday 22 August 2025

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and class in the spaces at the top of this 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 Examiner's Use	
Paper 2 (80 marks)	
1	
2	
3	
4	
5	
6	
7	
Deductions	
Total	

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

9749/02/ASRJC/2025Prelim

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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

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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

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

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

- 1 (a) The acceleration of free fall g may be determined from an oscillating pendulum using the equation

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

where l is the length of the pendulum and T is the period of oscillation.

In an experiment, the measured values for an oscillating pendulum are

$$l = 1.50 \text{ m} \pm 2\%$$

and $T = 2.48 \text{ s} \pm 3\%$.

- (i) Calculate the acceleration of free fall g .

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

- (ii) Determine the actual uncertainty of the calculated value of g .

$$\text{actual uncertainty} = \dots\dots\dots \text{ m s}^{-2} \text{ [2]}$$

- (b) A trolley on a track is attached by springs to fixed blocks X and Y, as shown in Fig. 1.1. The track contains many small holes through which air is blown vertically upwards. This results in the trolley resting on a cushion of air rather than being in direct contact with the track.

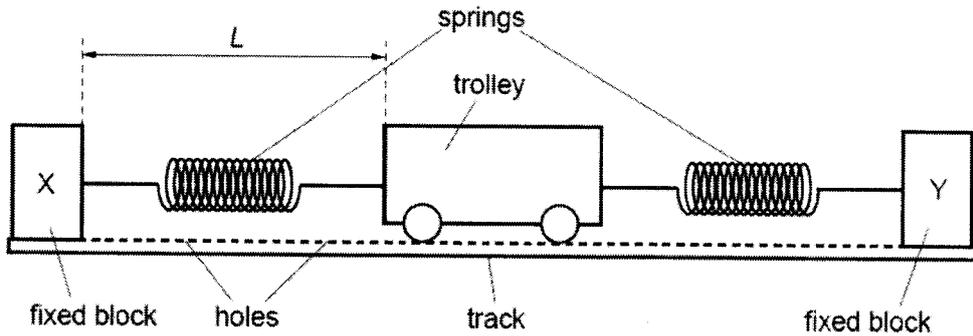


Fig. 1.1

The trolley is pulled to one side of its equilibrium position and then released so that it oscillates initially with simple harmonic motion. After a short time, the air blower is switched off. The variation with time t of the distance L of the trolley from block X is shown in Fig. 1.2.

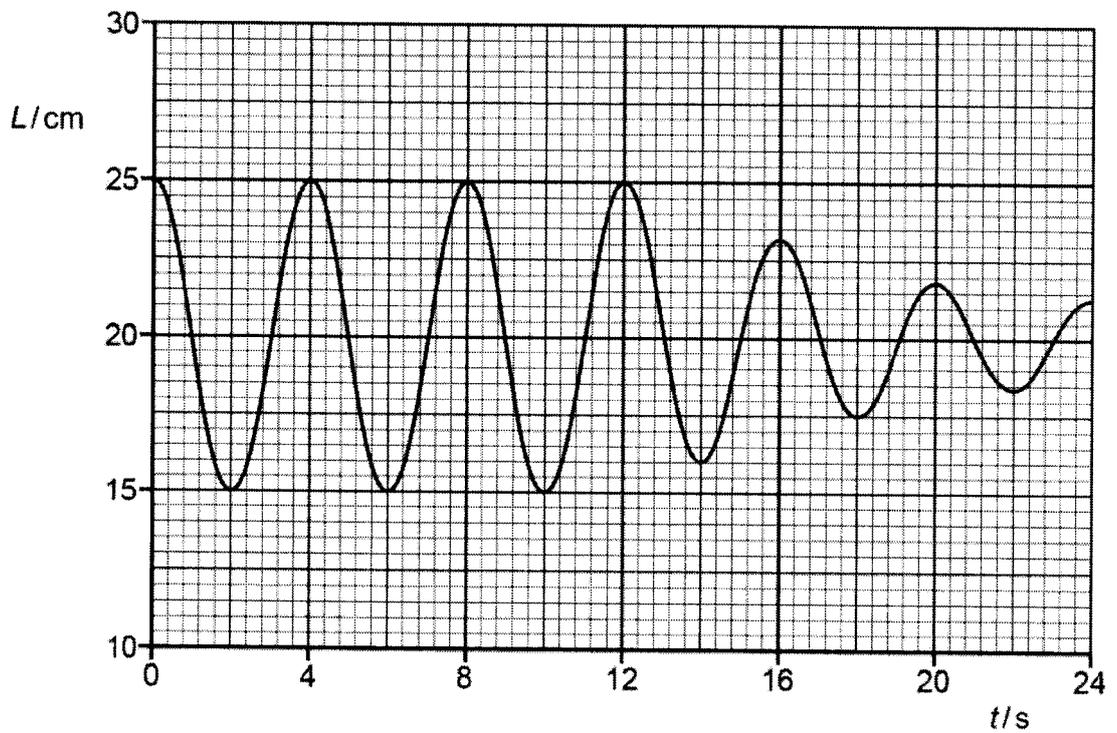


Fig. 1.2

- (i) Use Fig. 1.2 to determine the maximum speed v_0 , of the oscillating trolley. [2]

$v_0 = \dots\dots\dots \text{ cm s}^{-1}$ [2]

- (ii) Apart from the quantities determined in (b)(i), describe what may be deduced from Fig. 1.2 about the motion of the trolley between time $t = 0$ and time $t = 24$ s. No calculations are required.

.....

 [2]

- (iii) On Fig. 1.3, sketch the variation with L of the velocity v of the trolley for its first complete oscillation.

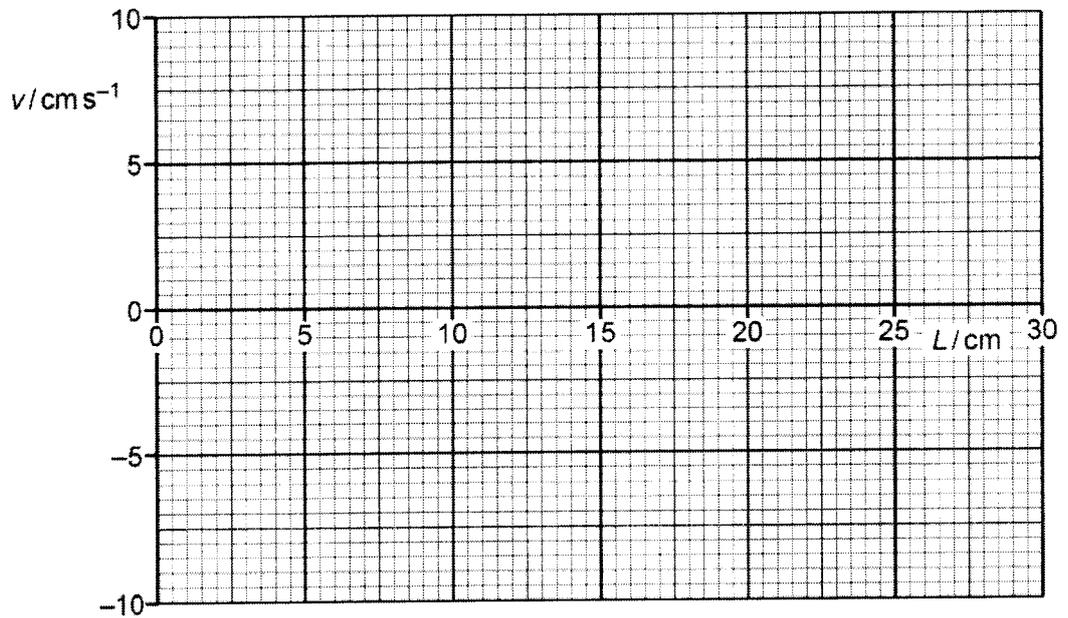


Fig. 1.3

[2]

[Total: 9]

- 2 (a) A block is pulled by a force X along a rough surface inclined at 30° to the horizontal, as shown in Fig. 2.1. The weight of the block is 0.80 N .

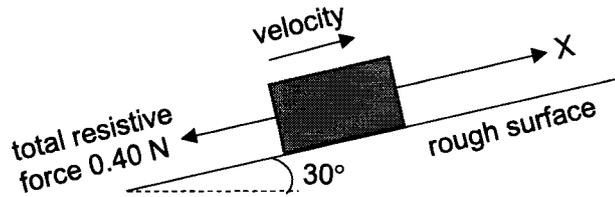


Fig. 2.1 (not to scale)

Assume that the total resistive force opposing the motion of the block is 0.40 N at all speeds of the block.

The variation with time t of the magnitude of the force X is shown in Fig. 2.2.

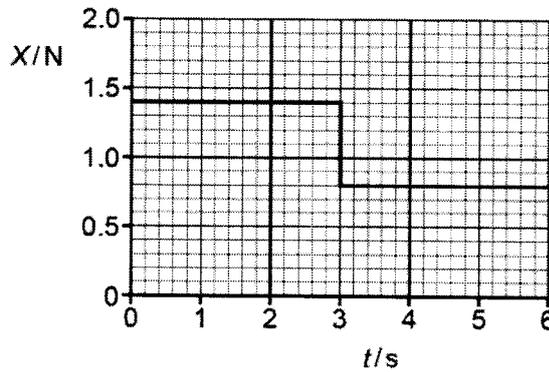


Fig. 2.2

- (i) Show that the change in momentum of the block from time $t = 0$ to time $t = 3.0\text{ s}$ is 1.8 kg m s^{-1} .

[2]

- (ii) Describe and explain the motion of the block between time $t = 3.0\text{ s}$ and time $t = 6.0\text{ s}$.

.....

 [2]

- (iii) The block is at rest at time $t = 0$.

On Fig. 2.3, sketch a graph to show the variation of the momentum of the block with time t from $t = 0$ to $t = 6.0$ s.

Numerical values of momentum are not required.

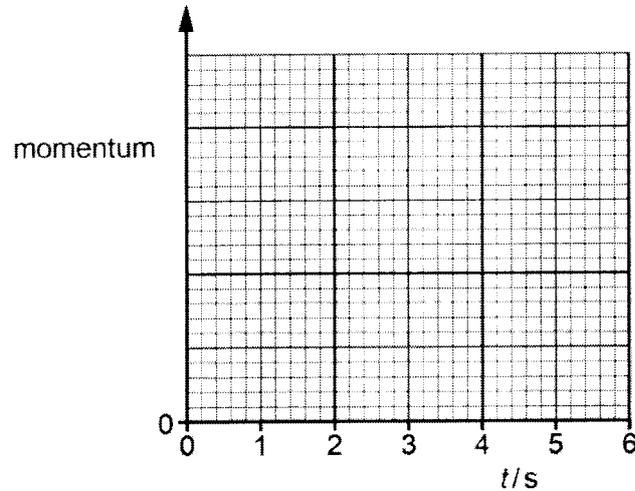


Fig. 2.3

[2]

- (b) A nucleus P and a nucleus Q are moving towards each other at the same speed v as shown in Fig. 2.4. The mass of nucleus Q is smaller than that of nucleus P. The interaction between the nuclei is elastic.



Fig. 2.4

The variation with time t of the velocity of each nucleus is shown in Fig. 2.5.

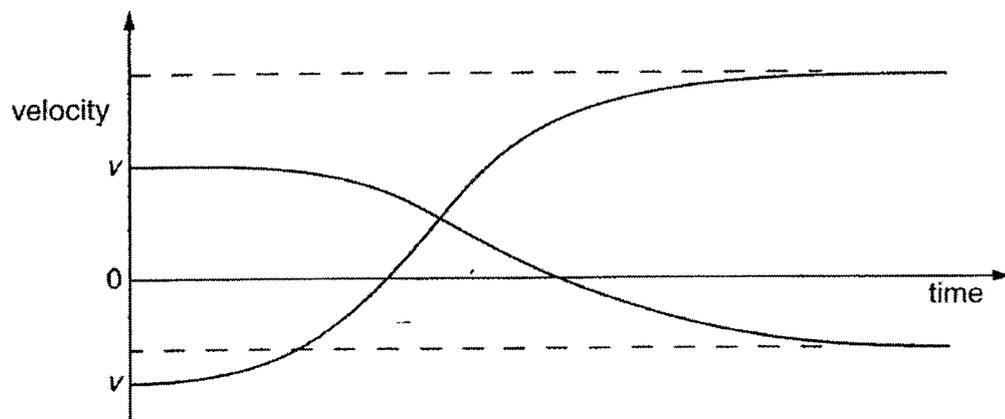


Fig. 2.5 (not to scale)

(i) Explain why it is not possible for the nuclei to stop at the same instant.

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

(ii) On Fig. 2.5, label the curve for nucleus Q.

Explain your reasoning.

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

[Total: 11]

3 (a) State what is meant by a line of force in

(i) a gravitational field,

.....
 [1]

(ii) an electric field.

.....
 [1]

(b) State **one** similarity and **one** difference between the electric field lines and the gravitational field lines around an isolated positively charged metal sphere.

similarity

.....

difference

.....

..... [2]

(c) A positive point charge +Q is positioned at a fixed point X and an identical positive point charge is positioned at a fixed point Y, as shown in Fig. 3.1.

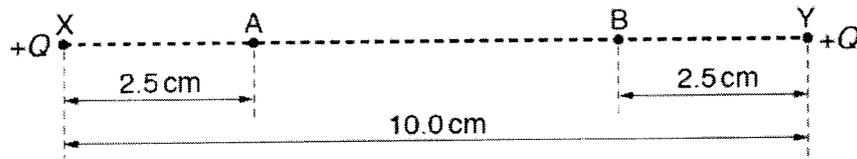


Fig. 3.1

The charges are separated in a vacuum by a distance of 10.0 cm.

Points A and B are on the line XY. Point A is a distance of 2.5 cm from X and point B is a distance of 2.5 cm from Y. The electric field strength at point A is $4.1 \times 10^{-5} \text{ V m}^{-1}$.

(i) Calculate charge +Q.

+Q = C [3]

- (ii) On Fig. 3.2, sketch the variation of the electric field strength E with distance d from A to B, along the line AB.

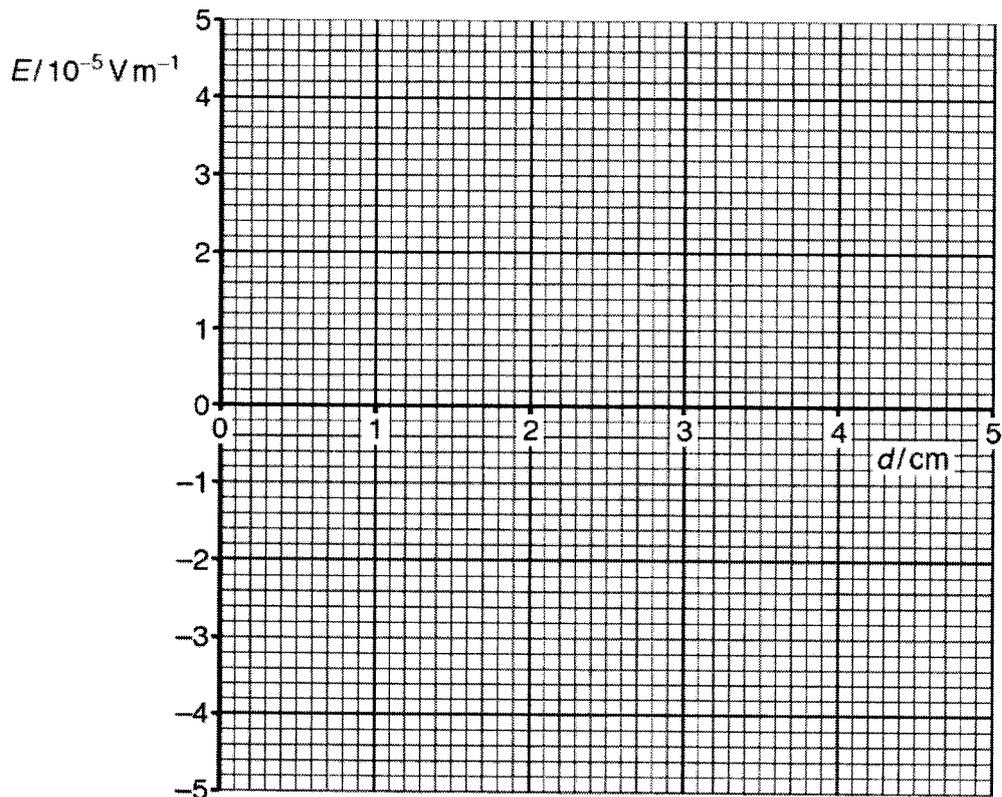


Fig. 3.2

[2]

- (iii) A small positive charge is placed at A. The electric field causes this charge to move from rest along the line AB.

Describe the acceleration of the charge as it moves from A to B.

.....

.....

.....

..... [2]

[Total: 11]

- 4 (a) (i) An ideal gas is said to consist of molecules that are hard elastic identical spheres and there are no intermolecular forces of attraction or repulsion between the molecules.

State two further assumptions of the kinetic theory of gases.

1.
.....

2.
..... [2]

- (ii) Explain why an increase in internal energy of an ideal gas is directly related to a rise in temperature of the gas.

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

- (iii) A fixed mass of oxygen gas at initial pressure P is sealed in a cylindrical container by a movable piston at one end, as shown in Fig. 4.1. Assume that oxygen behaves as an ideal gas.

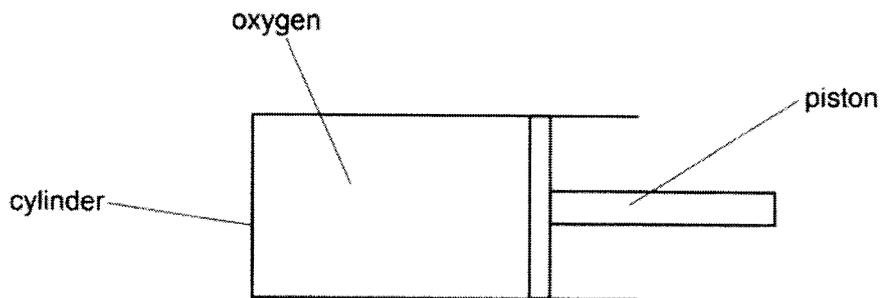


Fig. 4.1

The temperature of gas is T and the root-mean-square (r.m.s.) speed of an oxygen molecule at T is u .

The piston is slowly moved into the cylinder so that the oxygen gas is compressed. At all times, the gas and the container remain in thermal equilibrium with the surroundings.

On Fig. 4.2, sketch the variation with pressure of the root-mean-square (r.m.s.) speed of the oxygen molecules as the pressure increases.

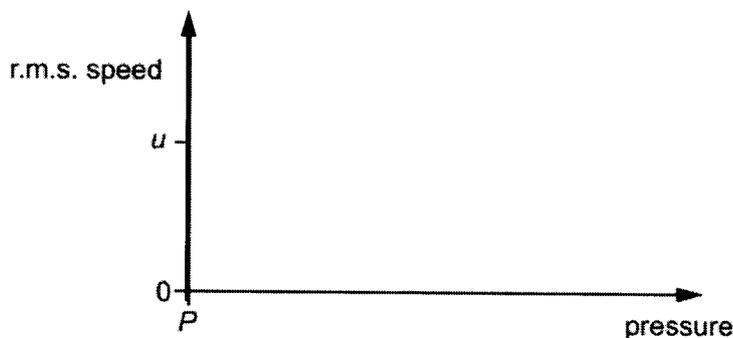


Fig. 4.2

[1]

- (b) State and explain using the first law of thermodynamics the change, if any, in the internal energy of the gas in a tyre when the tyre bursts so that the gas suddenly increases in volume. Assume that the gas is ideal.

.....

.....

.....

.....

.....

.....[3]

[Total: 8]

5 (a) State **two** features of a stationary wave that distinguish it from a progressive wave.

1.
.....
2.
..... [2]

(b) A loudspeaker, microphone A, cathode-ray oscilloscope (CRO) and a metal sheet are arranged as shown in Fig. 5.1.

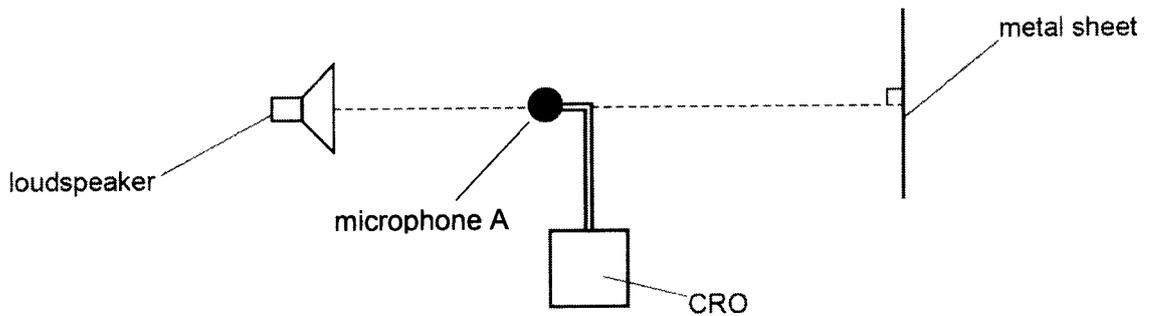


Fig. 5.1

A stationary wave is formed between the loudspeaker and the metal sheet.

(i) Explain how this stationary wave is formed.

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

(ii) The initial position of the microphone is such that the trace on the CRO has an amplitude minimum. It is now moved a distance of 1.05 m away from the loudspeaker along the line joining the loudspeaker and metal sheet.

As the microphone moves, it passes through three positions where the trace has an amplitude maximum before ending at a position where the trace has an amplitude minimum.

Determine the wavelength of the sound wave.

wavelength =m [2]

- (c) The metal sheet is removed and microphone B is added to the setup. Microphones A and B are placed at distances 1.05 m and 1.40 m from the loudspeaker as shown in Fig. 5.2.

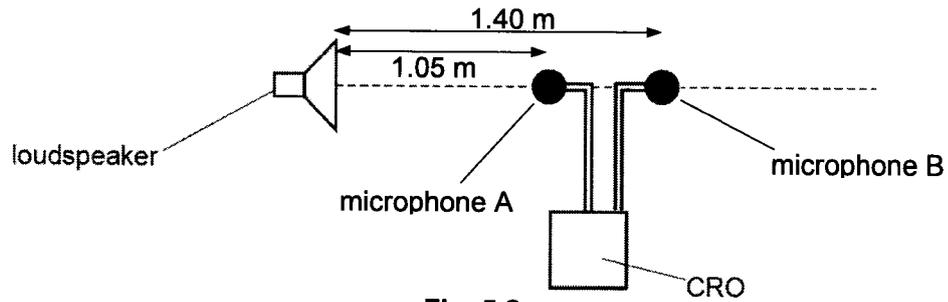


Fig. 5.2

The loudspeaker is assumed to emit sound waves uniformly in all directions. Fig. 5.3 shows the trace on the screen of the CRO due to input from microphone A.

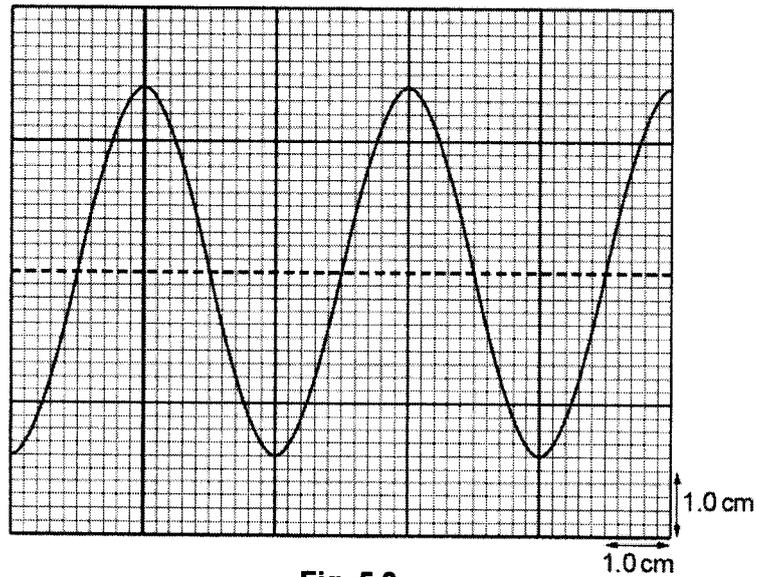


Fig. 5.3

Assume that the amplitude of the signal received by the CRO is proportional to the amplitude of the sound wave.

- (i) Determine the amplitude (in cm) of the trace on the screen of the CRO due to input from microphone B. Show your working.

amplitude = cm [2]

- (ii) On Fig. 5.3, sketch the trace seen on the screen of the CRO due to input from microphone B. [2]

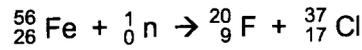
[Total: 10]

6 (a)(i) Define nuclear *binding energy*.

.....

 [1]

(ii) A student suggests that one possible nuclear reaction is



The binding energy per nucleon of a nucleus varies with the nucleon number. Use this variation to explain why the reaction would **not** result in an overall release of energy.

.....

 [3]

(b) One possible nuclear reaction that takes place is



Data for nuclei in this reaction are given in Fig. 6.1.

nucleus	mass / u	total mass of separate nucleons / u	mass defect / u	binding energy per nucleon / MeV
${}_{42}^{95}\text{Mo}$	94.906	95.765	0.859	8.443
${}_{57}^{139}\text{La}$	138.906	140.125	1.219	8.189
${}_{92}^{235}\text{U}$	235.044	236.909

Fig. 6.1

The energy equivalent to a mass of 1.00 u is 934 MeV.

- (i) Use data from Fig. 6.1 to calculate the mass defect and binding energy per nucleon of a nucleus of uranium-235 ($^{235}_{92}\text{U}$). Complete Fig. 6.1.

[3]

- (ii) Calculate the total energy, in MeV, released in this nuclear reaction.

energy = MeV [2]

- (iii) The nuclei in 1.2×10^{-7} mol of uranium-235 all undergo this reaction in a time of 25 ms.

Calculate the average power release during the time of 25 ms.

power = W [3]

[Total: 12]

- 7 The article below is based on articles on the Internet.

Read the article and then answer the questions that follow.

Use of ultrasonic sound waves on biological cells

Ultrasonic sound waves (ultrasound) are produced and detected using an ultrasound transducer. Ultrasound transducers are capable of sending an ultrasound and then the same transducer can detect the sound and convert it to an electrical signal to be diagnosed.

To produce an ultrasound, a piezoelectric crystal has an alternating current running through it. The piezoelectric crystal grows and shrinks depending on the voltage applied across it. Running an alternating current through it causes it to vibrate at a high speed and to produce an ultrasound.

Ultrasound have frequencies outside the audible range of the human ear, that is, greater than about 20 kHz.

When an ultrasound passes through a medium, its wave energy is absorbed. The rate at which energy is absorbed by unit mass of the medium is known as the dose-rate. The dose-rate is measured in W kg^{-1} . The total energy absorbed by unit mass of the medium is known as absorbed dose. This is measured in J kg^{-1} or, as in this question, kJ kg^{-1} .

Under certain circumstances, biological cells may be destroyed by ultrasound. The effect on a group of cells is measured in terms of the survival fraction (SF).

$$SF = \frac{\text{number of cells surviving after exposure}}{\text{number of cells before exposure}}$$

For any particular absorbed dose, it is found that the survival fraction changes as the dose-rate increases. Fig. 7.1 shows the variation with dose-rate of the survival fraction for samples of cells in a liquid. The absorbed dose for each sample of cells was 240 kJ kg^{-1} .

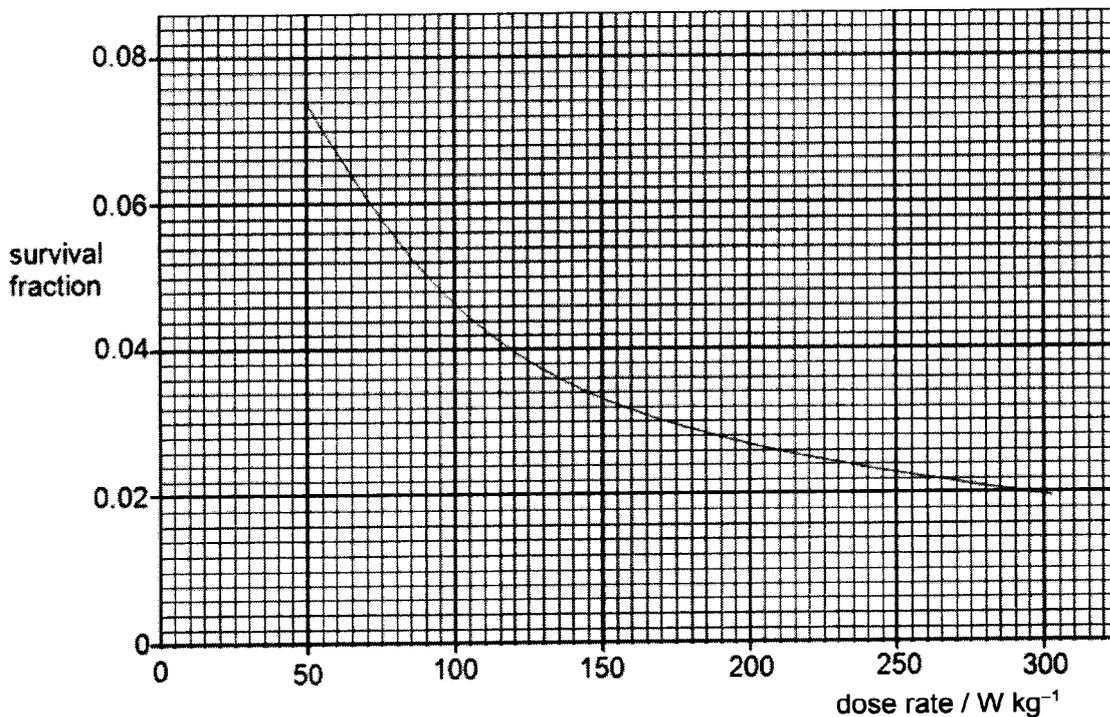


Fig. 7.1

(a) (i) State the transformation of energy that occurs in an ultrasound transducer.

..... [1]

(ii) State two differences between ultrasound and light.

1.

.....

2.

..... [2]

(iii) A medical ultrasound device emits a pulse of frequency 5.0 MHz and wavelength 3.1×10^{-4} m into a patient's body. The pulse travels through soft tissue, reflects off and returns to the transducer as an echo after a total time of 52.0 μ s.

Assuming that the speed of pulse remains constant in the tissue, calculate the one-way distance from the transducer to the reflecting surface inside the body.

distance = m [3]

(b) Calculate the exposure time for an absorbed dose of 240 kJ kg⁻¹ and at a dose-rate of 200 W kg⁻¹.

exposure time = s [2]

- (c) Survival fraction depends not only on dose-rate but also on absorbed dose. Fig. 7.2 shows the variation with dose-rate of $\log_{10}(SF)$ for different values of absorbed dose.

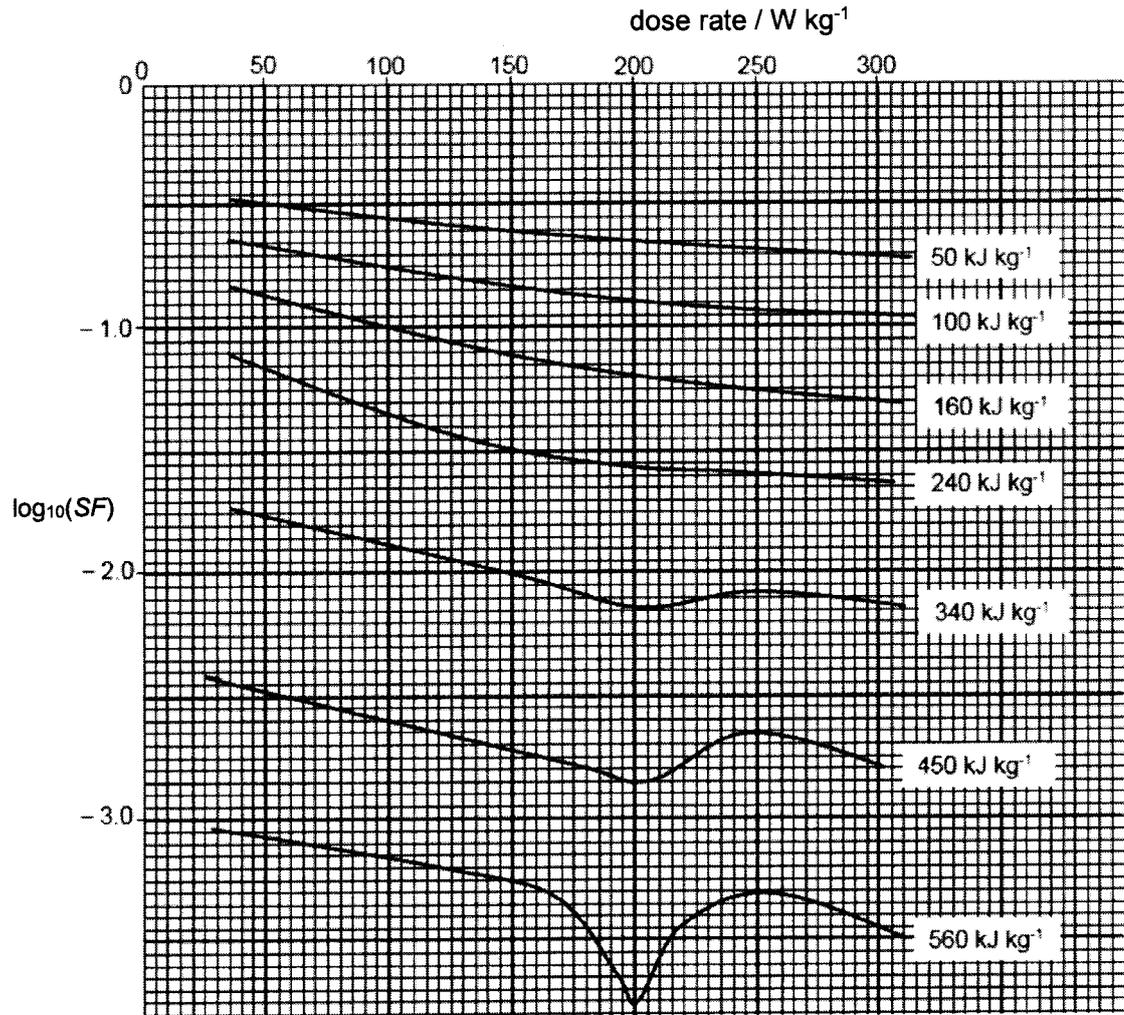


Fig. 7.2

The line with absorbed dose of 240 $kJ\ kg^{-1}$ represents the data given in Fig. 7.1, but with survival fraction plotted on a logarithmic scale.

- (i) Suggest why the survival fraction is plotted on a logarithmic scale.

.....
 [1]

- (ii) Suggest why, for the same absorbed dose, a lower dose rate generally results in higher cell survival fraction.

.....
 [1]

(iii) Use Fig. 7.2 to complete the table of Fig. 7.3 for a dose-rate of 200 W kg^{-1} .

absorbed dose / kJ kg^{-1}	$\log_{10}(SF)$
50	- 0.65
100	-0.90
160	-1.18
240	-1.58
340	-2.15
450	-2.85
560	

Fig. 7.3

[1]

(d) Fig. 7.4 is a graph of some of the data of Fig. 7.3.

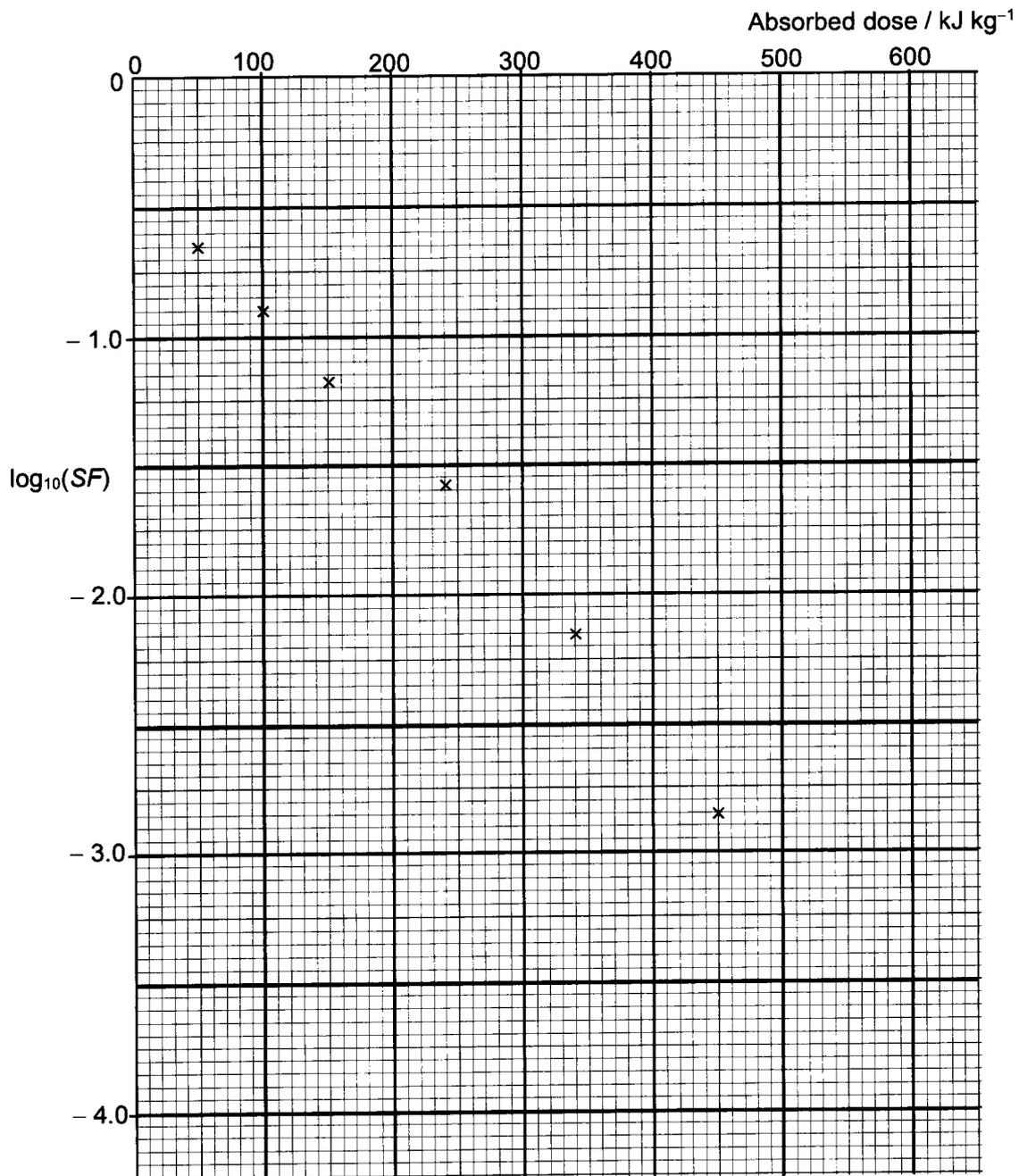


Fig. 7.4

On Fig. 7.4,

- (i) plot the point corresponding to absorbed dose = 560 kJ kg^{-1} ,
- (ii) draw the best-fit line.

[2]

(e) Theory suggests that at a dose-rate of 200 W kg^{-1} , two separate effects may give rise to cell destruction. According to this theory, one of the effects becomes apparent only at higher absorbed doses. State the evidence provided for this theory by

(i) Fig. 7.2,

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

(ii) Fig 7.4.

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

(f) Ultrasound can be employed both for diagnostic imaging, where it's important not to damage tissues, and for therapeutic ablation, where the goal is to destroy unwanted cells.

With reference to Fig. 7.2, suggest and explain an appropriate dose-rate for each for the application of ultrasound.

diagnostic imaging:
.....

therapeutic ablation:
.....[3]

[Total: 19]

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Name: _____ ()

Class: 25 / _____



ANDERSON SERANGOON JUNIOR COLLEGE

2025 JC2 Preliminary Examination

PHYSICS Higher 2

9749/03

Paper 3 Longer Structured Questions

Thursday 28 August 2025

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and class in the spaces provided above.
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 about one and a 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.

For Examiner's Use	
Paper 3 (80 marks)	
1	
2	
3	
4	
5	
6	
7	
8	
9	
Deductions	
Total	

This document consists of **24** printed pages and **0** blank page.

9749/03/ASRJC/2025PRELIM

[Turn Over

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

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

Section A

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

- 1 A ball is kicked from horizontal ground towards the top of a vertical wall, as shown in Fig. 1.1.

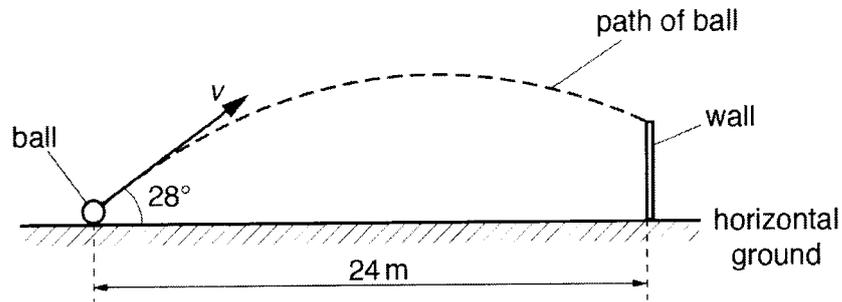


Fig. 1.1

The horizontal distance between the initial position of the ball and the base of the wall is 24 m. The ball is kicked with an initial velocity v at an angle of 28° to the horizontal. The ball hits the top of the wall after a time of 1.5 s. Air resistance may be assumed to be negligible.

- (a) Show that the initial vertical component v_y of the velocity of the ball is 8.5 m s^{-1} .

[2]

- (b) Calculate the time taken for the ball to reach its maximum height above the ground.

time =s [2]

- (c) The ball is kicked at time $t = 0$. On Fig. 1.2, sketch the variation with time t of the vertical component v_y of the velocity of the ball until it hits the wall. It may be assumed that velocity is positive when in the upwards direction.

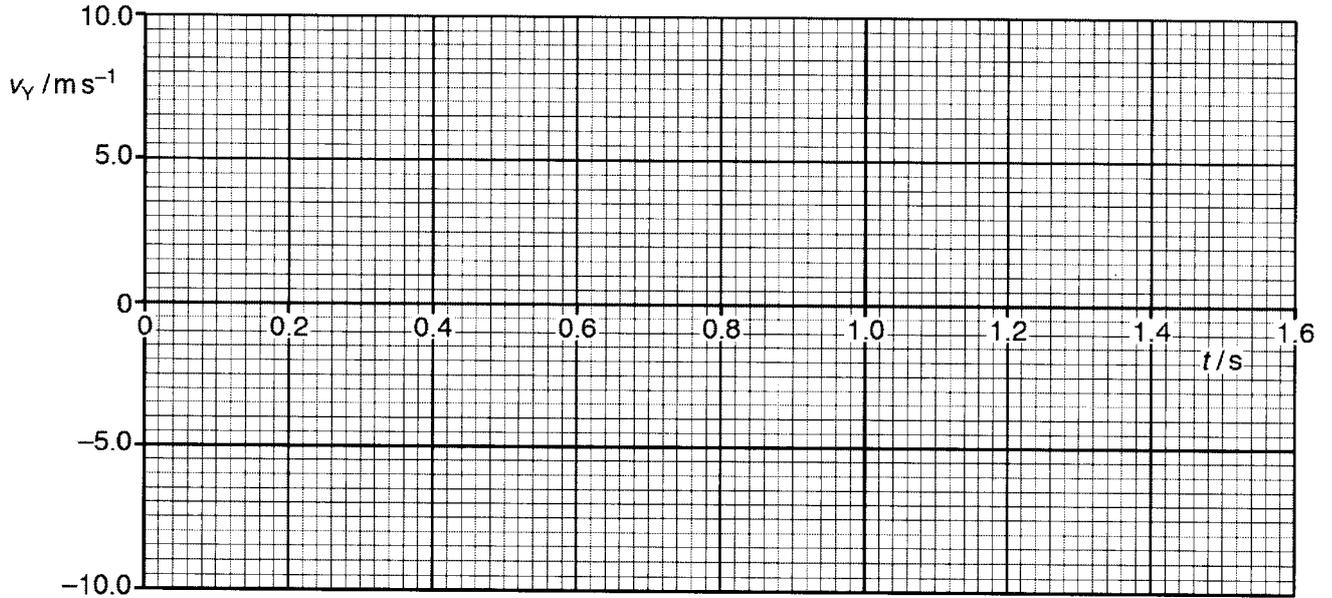


Fig. 1.2

[2]

- (d) A ball of greater mass is kicked with the same velocity v and at an angle of 28° to the horizontal.

State and explain the effect, if any, of the increased mass on (b). Air resistance is still assumed to be negligible.

.....

 [1]

- (e) State and explain the effect of air resistance on the answer in (b).

.....

 [2]

[Total: 9]

2 (a) A copper wire of diameter 1.4 mm connects to the tungsten filament wire of a light bulb of diameter 0.020 mm. A current of 0.42 A flows through both of the wires. Copper has 8.0×10^{28} electrons per cubic metre and tungsten can be assumed to have 3.4×10^{28} electrons per cubic metre.

(i) The filament is 2.0 m long when uncoiled and has a resistivity of $5.5 \times 10^{-8} \Omega \text{ m}$.

Calculate the power dissipated in the filament bulb.

power dissipated =W [2]

(ii) The drift speed of electrons in the copper wire is $0.021 \times 10^{-3} \text{ m s}^{-1}$.

1. Determine the drift speed of electrons in the tungsten filament.

drift speed =m s⁻¹ [2]

2. Explain, in microscopic terms, why the copper wire stays cool although the tungsten filament reaches a high temperature.

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

- (b) A thermistor has resistance $3900\ \Omega$ at $0\ ^\circ\text{C}$ and resistance $1250\ \Omega$ at $30\ ^\circ\text{C}$. The thermistor is connected into the circuit of Fig. 2.1 in order to monitor temperature changes.

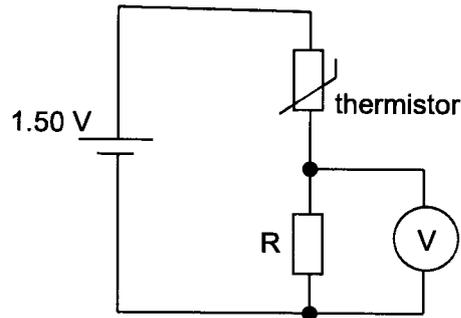


Fig. 2.1

The battery of e.m.f. $1.50\ \text{V}$ has negligible resistance and the voltmeter has infinite resistance.

The reading on the voltmeter is $1.00\ \text{V}$ at $0\ ^\circ\text{C}$.

- (i) The temperature of the thermistor is increased to $30\ ^\circ\text{C}$. Determine the reading on the voltmeter.

reading =V [2]

- (ii) The voltmeter in Fig. 2.1 is replaced with one having a resistance of $7800\ \Omega$. Calculate the reading on this voltmeter for the thermistor at a temperature of $0\ ^\circ\text{C}$.

reading =V [2]

[Total: 10]

- 3 The Earth may be assumed to be an isolated uniform sphere with its mass M concentrated at its centre. A satellite of mass m orbits the Earth in a circular path of radius R .

For the satellite in its orbit, show that

- (a) (i) its kinetic energy E_K is given by

$$E_K = \frac{GMm}{2R}$$

where G is the gravitational constant.

[3]

- (ii) its total energy E_T is given by

$$E_T = -\frac{GMm}{2R}$$

[2]

- (b) The satellite in (a) gradually loses energy due to small resistive forces. Suggest why many such satellites eventually “burn up” in the Earth’s atmosphere.

.....

.....

.....

.....

.....

..... [3]

(c) Polar orbiting satellites have orbits over the poles of the Earth. Geostationary satellites are in equatorial orbits.

State one advantage and one disadvantage of the use of a geostationary satellite as compared with a polar orbiting satellite.

(i) advantage:

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

(ii) disadvantage:

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

[Total: 10]

- 4 A sphere floats in equilibrium on the surface of sea water of density 1050 kg m^{-3} , as shown in Fig. 4.1.

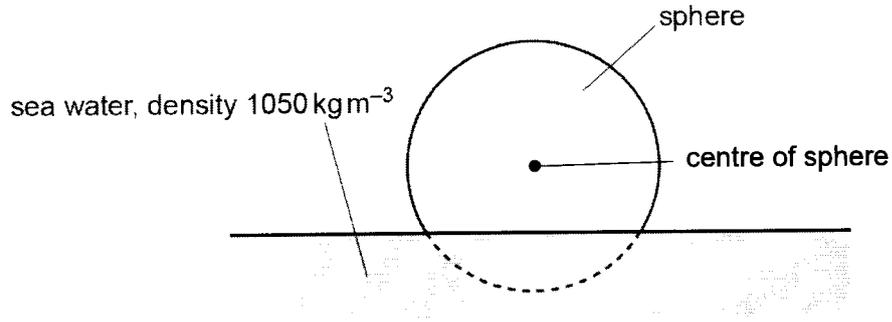


Fig. 4.1

- (a) On Fig 4.1, draw an arrow to represent the force exerted on the sphere due to the seawater. [2]

- (b) Explain the origin of the force in (a).

.....
 [1]

- (c) Explain how the force in (a) helps the sphere to stay in equilibrium.

.....

 [2]

- (d) 21% of the volume of the sphere is below the surface of the water. Calculate the density of the sphere.

density = kg m^{-3} [2]

- (e) The sphere is now held stationary by a force of 2000 N so that its entire volume is below the surface of the water.

Calculate the diameter of the sphere.

diameter = m [2]
 [Total: 9]

- 5 A pinball machine uses a spring to launch a small metal ball of mass 4.5×10^{-2} kg up a ramp. The spring is compressed by 8.0×10^{-2} m and held in equilibrium, as shown in Fig. 5.1.

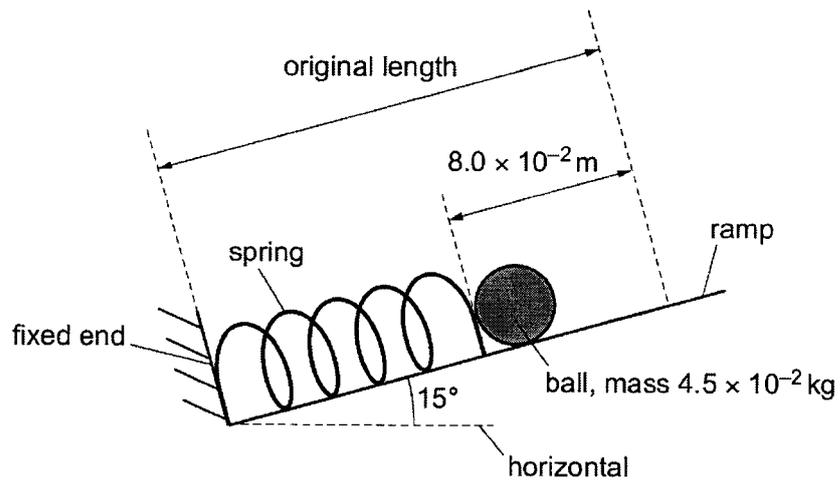


Fig. 5.1 (not to scale)

The ramp is at an angle of 15° to the horizontal.

- (a) The spring obeys Hooke's law and has a spring constant of 29 N m^{-1} .

Calculate the elastic potential energy in the compressed spring.

elastic potential energy =J [2]

- (b) The spring is released and expands quickly back to its original length.

The ball leaves the spring when the spring reaches its original length. Assume that all the elastic potential energy of the spring is transferred to the ball.

Calculate the speed of the ball as it leaves the spring.

speed =m s⁻¹ [3]

(c) State and explain the effect on the speed in (b) when the mass of the spring cannot be neglected.

.....

.....[1]

[Total: 6]

- 6 A transformer has a turns ratio of $N_p/N_s = 1/20$ and the sinusoidal input signal voltage has a value of 9.0 V r.m.s. The mean power input to the transformer is 30 W. A graph of the power input is shown in Fig. 6.1.

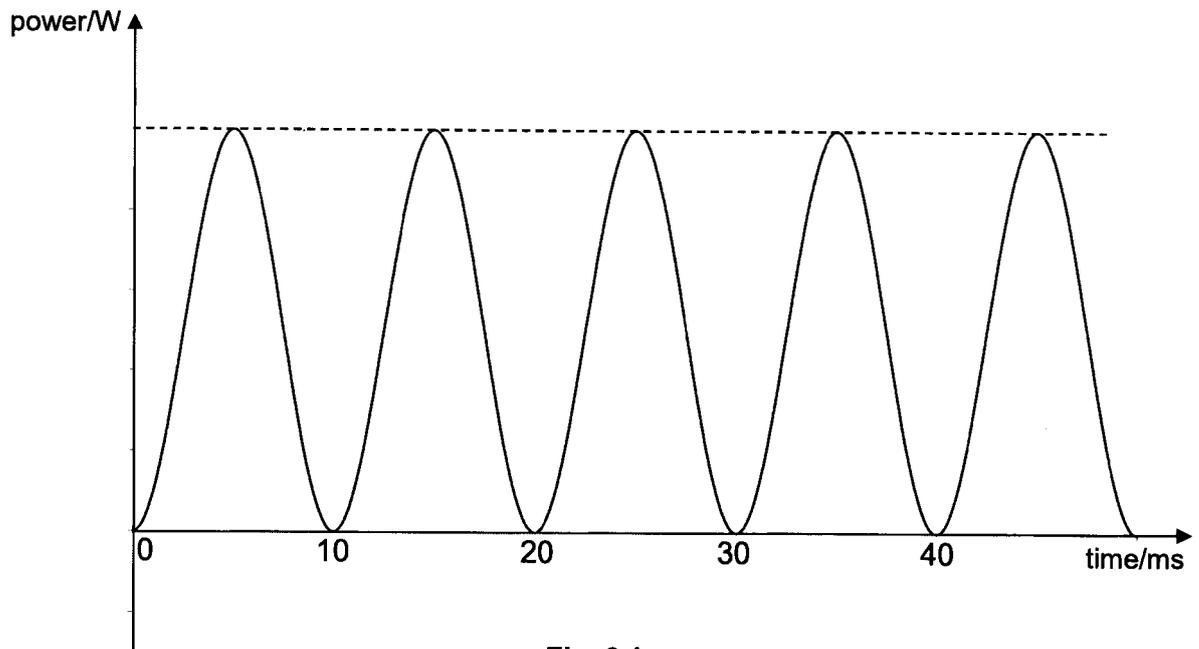


Fig. 6.1

The output of the transformer is connected across a resistor R.

(a) For the transformer, assumed to be ideal, calculate

- (i) the r.m.s. value of the output voltage,

r.m.s. output voltage =V [1]

- (ii) the r.m.s. value of the input current,

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

(iii) State the equation of the variation with time t of the output voltage V .

[2]

(b) A diode is inserted in series with the resistor R .

State

(i) the peak power dissipated in R ,

peak power =W [1]

(ii) the mean power dissipated in R .

mean power =W [1]

(c) (i) Explain why thermal energy is generated in the core when the transformer is in use.

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

(ii) State a typical feature in the design of the iron core to reduce power loss.

..... [1]

[Total: 9]

7 (a) State what is meant by the *diffraction* of a wave.

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

(b) A pair of distant stars is being observed through a telescope with an aperture of 12.0 cm. The stars emit light with a wavelength of 550 nm.

(i) Explain what is meant by the *Rayleigh criterion* for the resolution of the two stars as observed through the telescope.

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

(ii) State and explain the effect of having a smaller aperture on the resolving power of the telescope.

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

(iii) Calculate the minimum angular separation θ , between the stars that allows them to be just resolved by the telescope.

$\theta = \dots\dots\dots$ rad [2]

[Total: 7]

Section B

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

- 8 (a) A long straight vertical wire A carries a current in an upward direction. The wire passes through the centre of a horizontal card, as illustrated in Fig. 8.1.

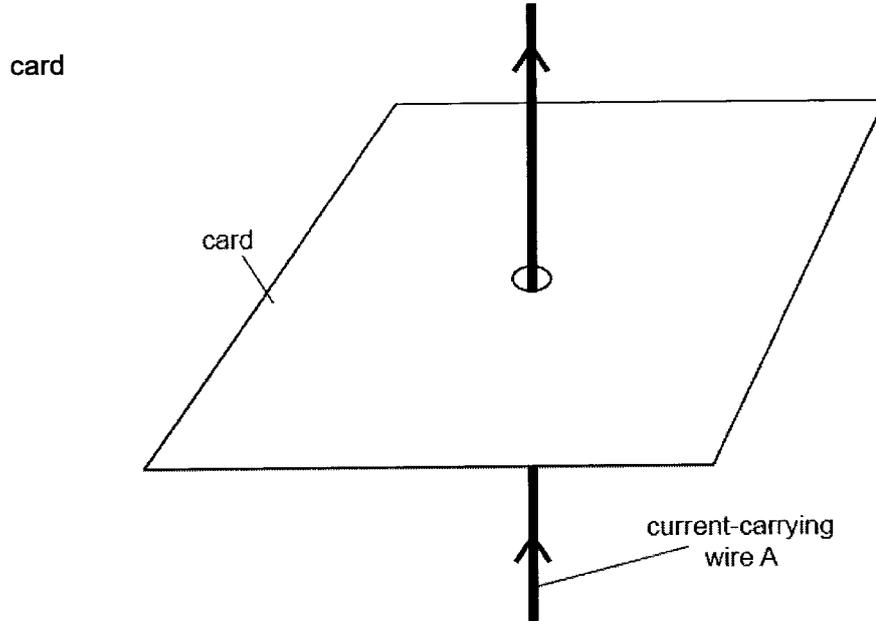


Fig. 8.1

The card is viewed from above. The card is shown from above in Fig. 8.2.

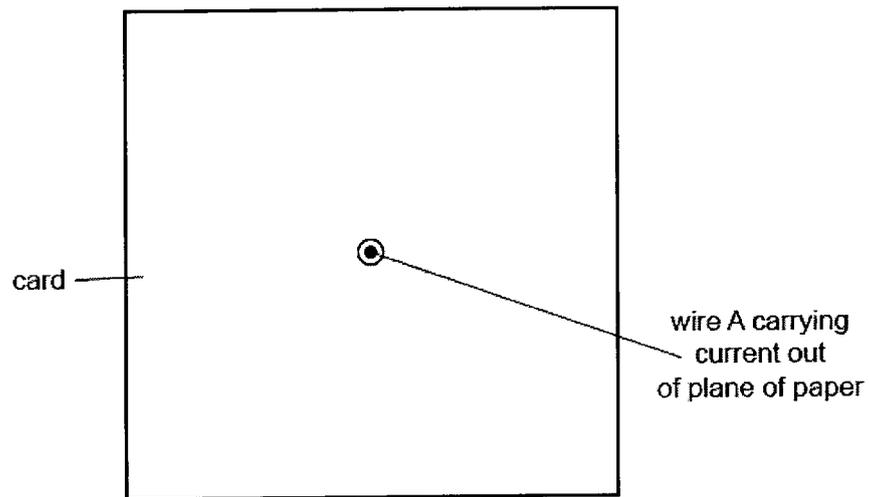


Fig. 8.2

- (i) On Fig. 8.2, draw lines to represent the magnetic field produced by the current-carrying wire.

[2]

- (ii) Two wires A and B are now placed through a card. The two wires are parallel and carrying currents in the same direction, as illustrated in Fig. 8.3.

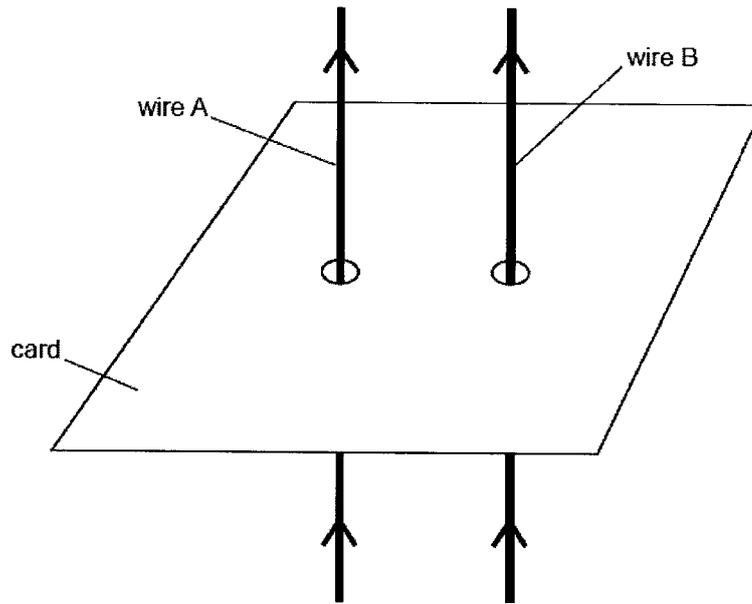


Fig. 8.3

1. Explain why a magnetic force is exerted on each wire.

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

2. The currents in the two wires are not equal.
Explain whether the magnetic forces on the two wires are equal in magnitude.

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

- (b) Electrons are moving in a vacuum with speed $1.70 \times 10^7 \text{ m s}^{-1}$. The electrons enter a uniform magnetic field of flux density 4.80 mT . Fig. 8.4 shows the path of the electrons.

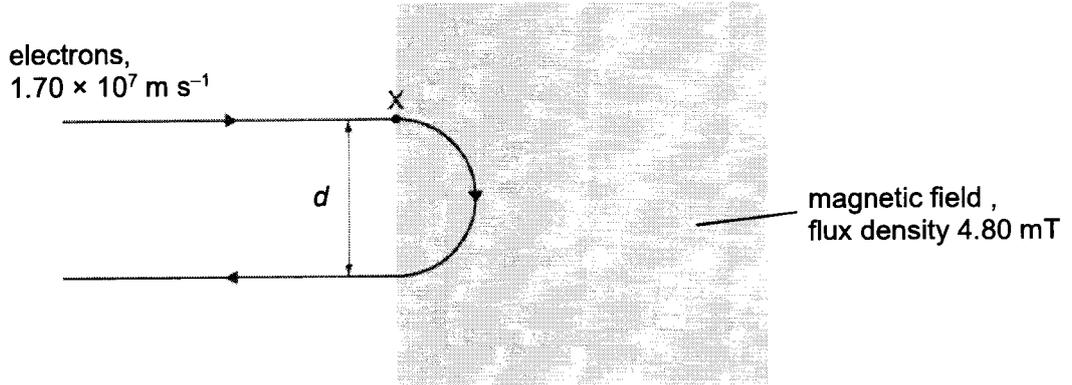


Fig 8.4

The path of the electrons remains in the plane of the page.

- (i) Define magnetic flux density.

.....

 [2]

- (ii) State the direction of the magnetic field.

.....
 [1]

- (iii) Explain why the path of the electron in the magnetic field is the arc of a circle.

.....

 [2]

- (iv) Calculate the distance d between the path of the electrons entering the magnetic field and the path of the electrons leaving it.

$$d = \dots\dots\dots\text{cm} [3]$$

- (v) Show that the duration which the electron is inside the magnetic field is approximately 3.7×10^{-9} s.

[1]

- (vi) A uniform electric field of magnitude 18.0 kV m^{-1} is directed into the page in the same region as the magnetic field.

Use your answer in (b)(v) to determine the final speed of the electron as it leaves the fields.

$$\text{final speed} = \dots\dots\dots \text{m s}^{-1} [4]$$

- (c) The magnitude and direction of the uniform electric field in part (b)(vi) is adjusted so that electrons with speed $1.7 \times 10^7 \text{ m s}^{-1}$ now travel in a straight path in the region of uniform fields, as shown in Fig. 8.5.

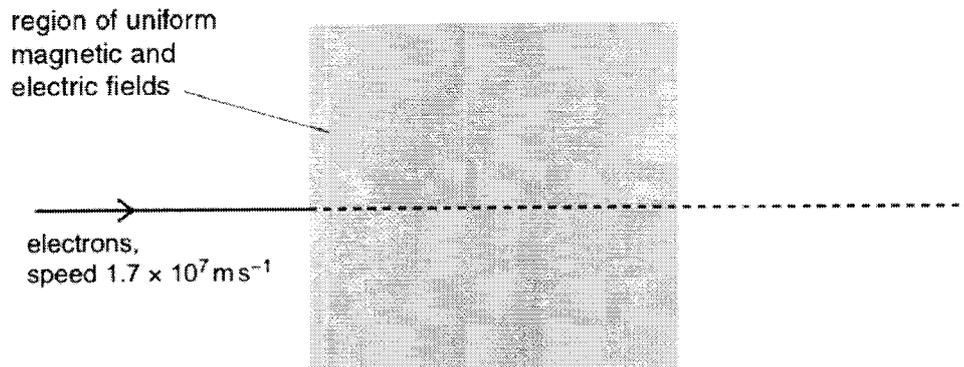


Fig 8.5

If the electrons are replaced with protons moving with speed $2.0 \times 10^7 \text{ m s}^{-1}$, sketch the path of the protons on Fig. 8.5.

[2]

[Total: 20]

9 (a) For a particular metal surface, it is observed that there is a minimum frequency of light below which photoelectric emission does not occur. This observation provides evidence for a particulate nature of electromagnetic radiation.

(i) State two further observations from photoelectric emission that provide evidence for a particulate nature of electromagnetic radiation.

1.
.....
2.
..... [2]

(ii) When electromagnetic radiation of wavelength λ is incident on a metal surface, electrons of maximum kinetic energy E_{MAX} are emitted.

1. On Fig. 9.1, sketch the variation with $1/\lambda$ of E_{MAX} .

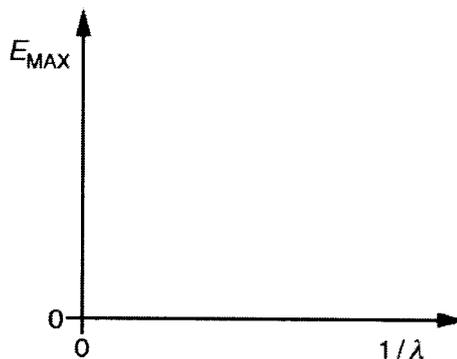


Fig. 9.1

[2]

2. State an equation relating the gradient of the graph drawn on Fig. 9.1 to the Planck constant h .
Explain any symbols you use.

-
..... [1]

3. Light of a particular wavelength is incident on a metal surface and gives rise to a photoelectric current.

The wavelength is reduced. The intensity of the light is kept constant.

State and explain the effect, if any, on the photoelectric current.

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

- (b) Fig. 9.2 shows the visible part of the emission spectrum from hydrogen gas in a laboratory on the Earth. The numbers indicate the wavelength, in nm, represented by each line.

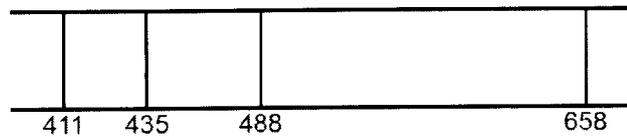


Fig. 9.2

- (i) Explain how the emission spectrum provides evidence for the existence of discrete energy levels for the electron in a hydrogen atom.

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

- (ii) Fig. 9.3 shows five of the energy levels in the hydrogen atom. The wavelengths of radiation shown in Fig. 9.2 relate to transitions to the -3.400 eV level in Fig. 9.3.

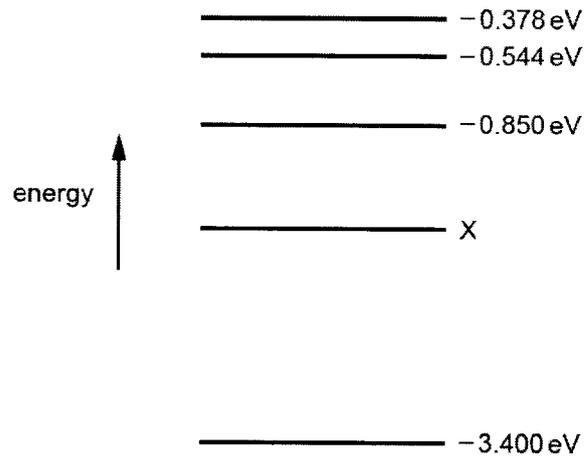


Fig. 9.3 (not to scale)

Show that the energy level X is -1.51 eV .

[3]

- (c) Electrons are accelerated through a potential difference of 15 kV . The electrons collide with a metal target and a spectrum of X-rays is produced.

- (i) Calculate the wavelength of the highest energy X-ray photon produced.

wavelength =m [2]

(ii) Describe and explain the changes, if any, in the x-ray spectrum if the accelerating potential is increased.

.....
.....
.....
.....
..... [4]

[Total: 20]