SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME ______________________

CG __________ **INDEX NO.** __________

PHYSICS 9749/01

Preliminary Examination **21st Sep 2017**
Paper 1 Multiple Choice **1 hour**

Additional Materials: OMS.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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 record your choice in soft pencil on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiners' Use	
MCQ	/ 30

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /ºC + 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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Answer all questions.

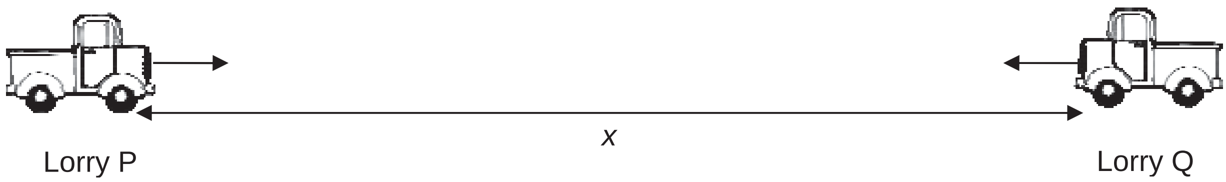
1 Four students conducted an experiment to determine the value of g, acceleration of free fall. The values obtained by the students are as shown in the table.

Student	g_1 / m s^{-2}	g_2 / m s^{-2}	g_3 / m s^{-2}	g_4 / m s^{-2}
P	9.40	9.80	9.55	9.65
Q	9.80	9.60	9.90	10.06
R	10.10	9.90	10.15	9.85
S	9.45	9.48	9.52	9.55

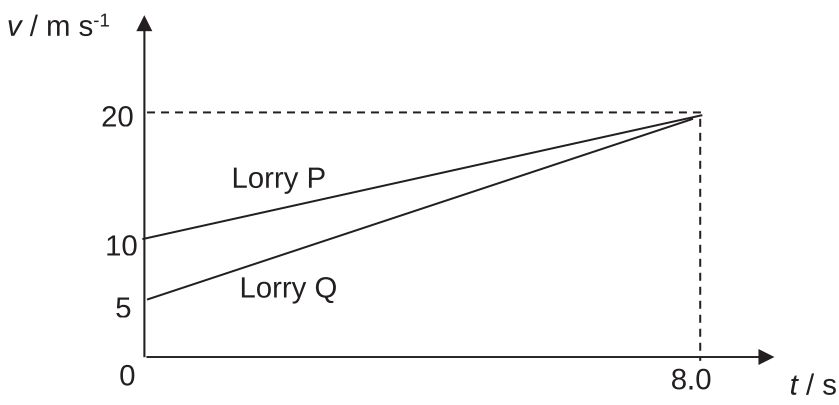
If the correct value of g is 9.82 m s^{-2}, which of the students has/have the largest systematic and random errors in their experiments ?

	Largest systematic error	Largest random error
A	Q	P
B	P	Q
C	Q	S
D	S	Q

2 Lorry P and Lorry Q are initially at a distance x metres apart and are travelling in the opposite directions as shown below.



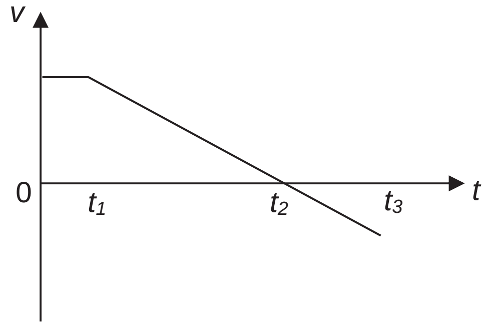
The graph shows the variation with time t of the speeds v of Lorry P and Lorry Q respectively.



At t = 8.0 s, the two lorries are 40 m apart. What is x?

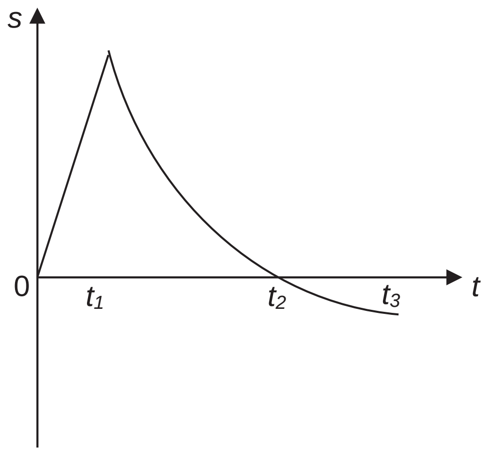
A 60 m **B** 120 m **C** 220 m **D** 260 m

3 The graph shows how the speed v of an object varies with time t.

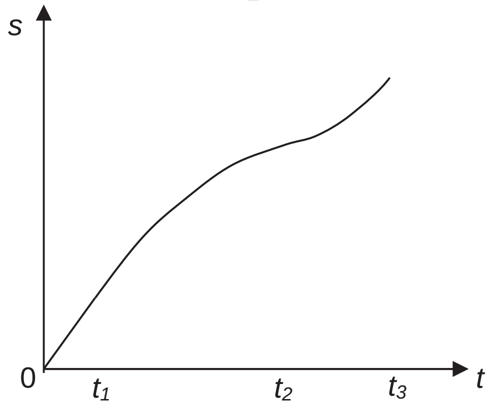


Which graph represents the variation the displacement s travelled by the object with time t?

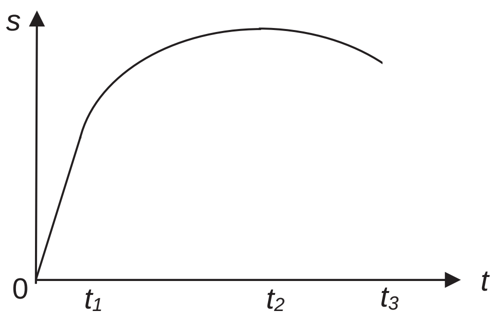
A



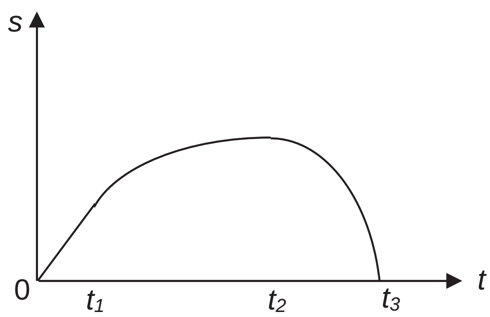
B



C



D



4 A jet of water of density 1000 kg m^{-3} leaves the nozzle of a hose of radius 2.0×10^{-2} m. The water is directed perpendicularly to the wall at a speed of 0.50 m s^{-1}. Assume that the water does not rebound.

What is the force exerted on the wall by the water?

A 0.314 N **B** 0.628 N **C** 1.27 N **D** 15.7 N

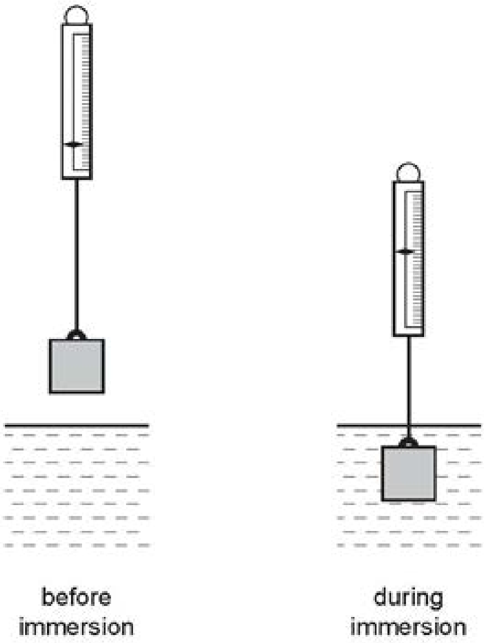
5 An astronaut falls vertically from a space vehicle and hops on the moon. The following statements are about the forces acting while the astronaut is in contact with the surface of the moon.

Which statement is correct?

A The force that the astronaut exerts on the moon is always equal to the weight of the astronaut.
B The force that the astronaut exerts on the moon is always less than the weight of the astronaut.
C The weight of the astronaut is always equal in magnitude and opposite in direction to the force that the moon exerts on the astronaut.
D The force that the astronaut exerts on the moon is always equal in magnitude and opposite in direction to the force the moon exerts on the astronaut.

6 The diagram shows a metal cube suspended from a spring balance before and during immersion in water.

A reduction in the balance reading occurs as a consequence of the immersion.



Which statement is correct?

A The balance reading will be further reduced if the cube is lowered further into the water.

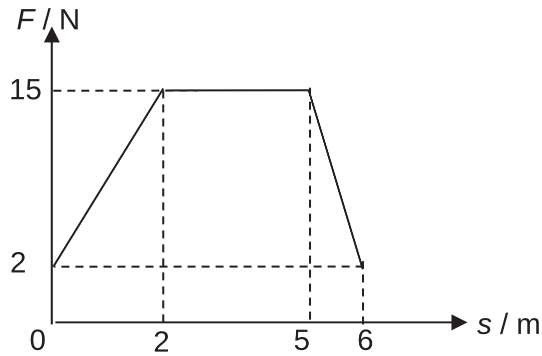
B The balance reading during immersion corresponds to the upthrust of the water on the cube.

C The forces acting on the vertical sides of the cube contribute to the change in the balance reading.

D The balance reading during immersion will be increased if the water is replaced by oil.

7 A student pushes a box from rest along a rough floor with constant friction of 2.0 N.

The graph shows the variation of the force exerted by the student on the box with displacement.

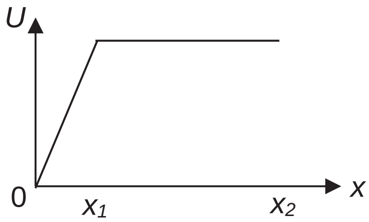


The final speed of the box after travelling 6 m is 5.0 m s^{-1}.

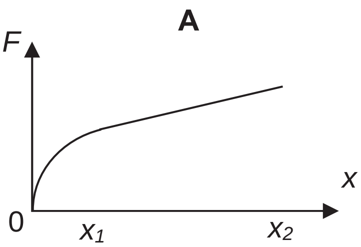
What is the mass of the box?

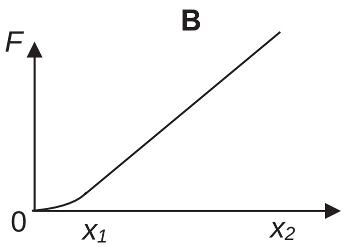
A 4.68 kg **B** 5.64 kg **C** 23.4 kg **D** 28.2 kg

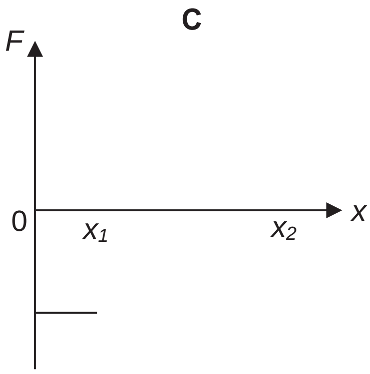
8 The graph how the potential energy *U* of an object varies with displacement x.

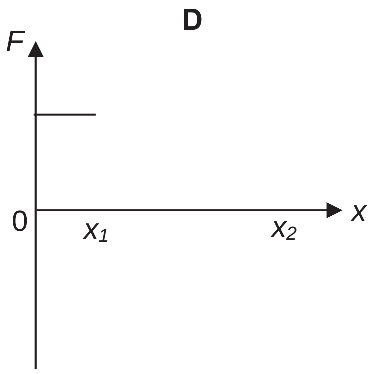


Which of the following graphs represents the variation of force acting on the object with displacement *x*?

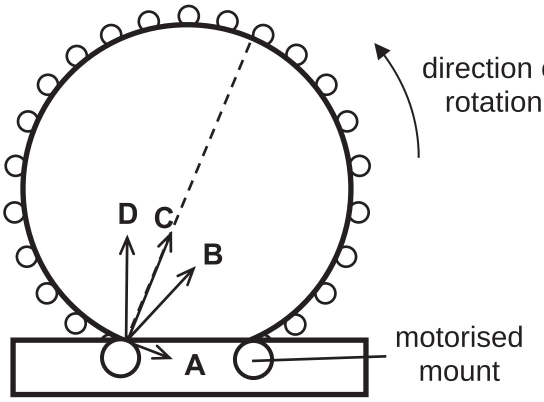






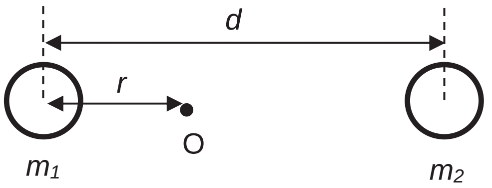


9 The Singapore Flyer wheel is supported at two points on the bottom by motorised mounts which cause it to rotate anticlockwise with constant angular velocity.



Which of the labelled arrows shows the direction of the force exerted by the motorised mount on the wheel just as it starts to turn?

10 Two planets of mass m_1 and m_2 perform circular motion about their common centre of mass O with the same angular velocity. If the mean separation between the centres of the masses is d, what is the distance from the centre of mass m_1 to the centre of mass of the system, r?



A $\frac{m_1}{m_2}d$

B $\frac{m_2}{m_1}d$

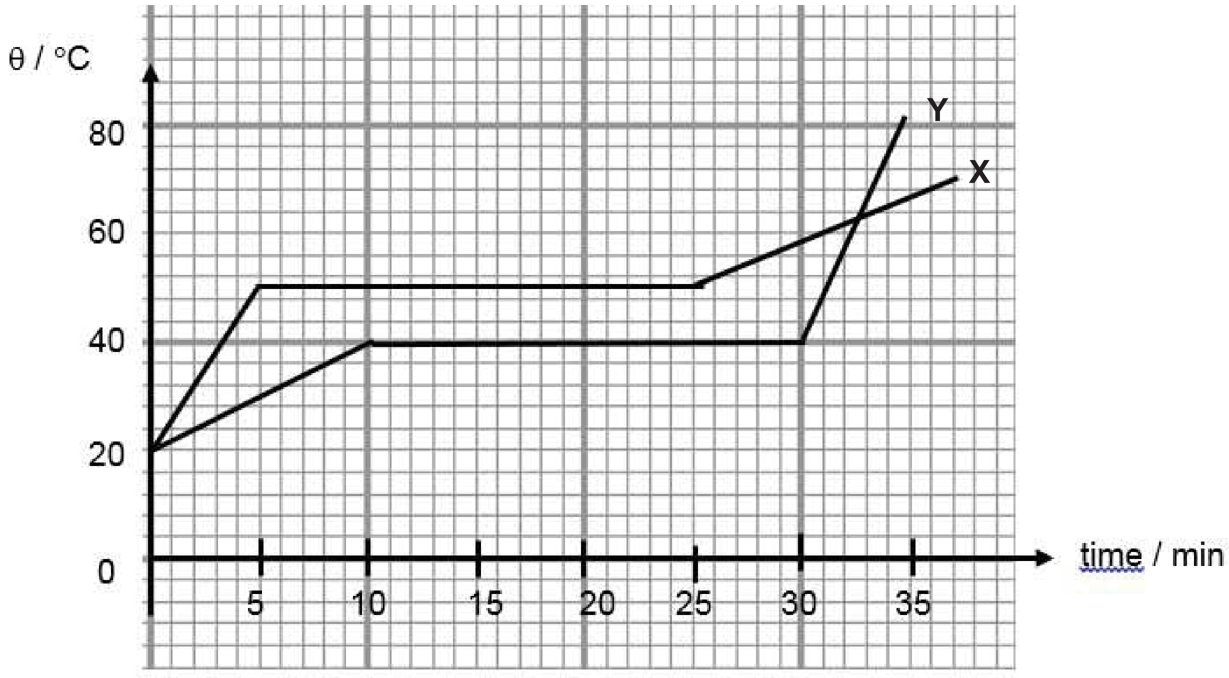
C $\frac{m_1}{m_1+m_2}d$

D $\frac{m_2}{m_1+m_2}d$

11 The escape speed of an oxygen molecule at the Earth's surface is 1.1×10^4 m s^{-1}.
What is the escape speed at a height of $0.2R$ above the Earth's surface, where R is the radius of the Earth?

A 0.5×10^4 m s^{-1}
B 1.0×10^4 m s^{-1}
C 1.1×10^4 m s^{-1}
D 1.2×10^4 m s^{-1}

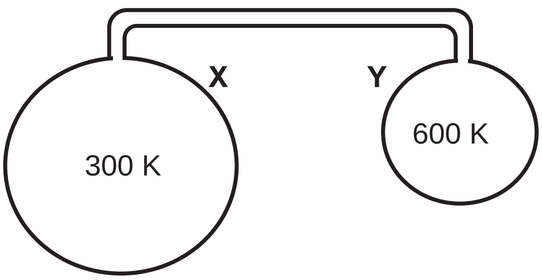
12 2.0 kg of solid X and 1.0 kg of solid Y are separately heated by two heaters of the same power. The power output of the heaters is the same throughout the whole experiment. The following graphs show the variation of the temperatures of X and Y with time.



What is the ratio of the specific heat capacity of solid X to solid Y?

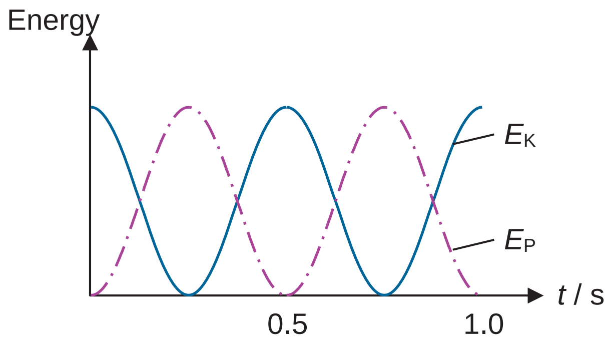
A 1:3 **B** 1:6 **C** 2:3 **D** 3:2

13 The volume of Bulb X is twice that of Bulb Y. They are filled with the same ideal gas and are connected by a narrow tube, as shown. A steady state is established with Bulb X held at 300 K and Bulb Y at 600 K. If there are *n* moles of gas in Bulb X, how many moles of gas are there in Bulb Y?

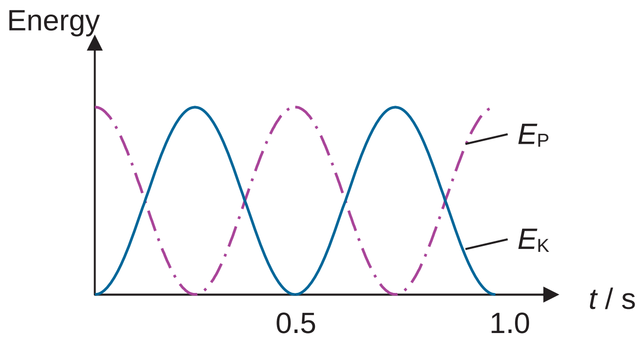


A ¼ *n* **B** ½ *n* **C** *n* **D** 2*n*

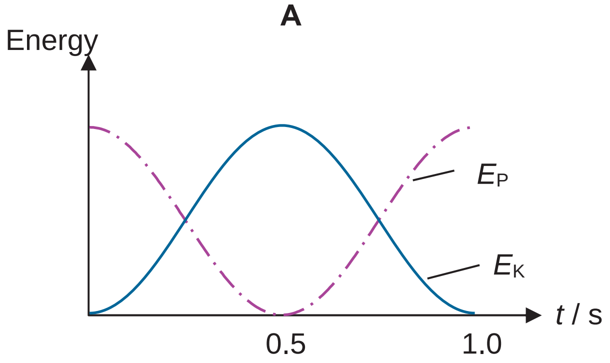
14 A certain simple pendulum swings with a period of 1.0 s. The bob of such a pendulum is given a small displacement and released at t = 0. Which diagram correctly shows the bob's kinetic energy E_K and its potential energy E_P varies with time?



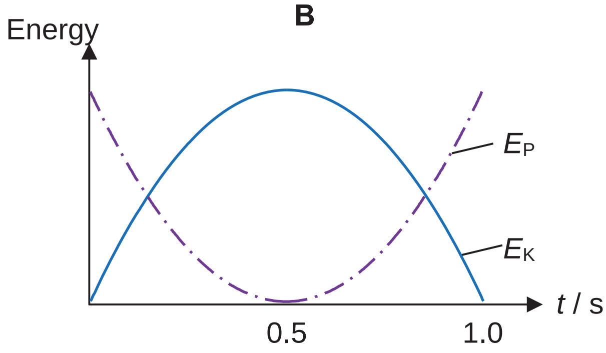
A



B

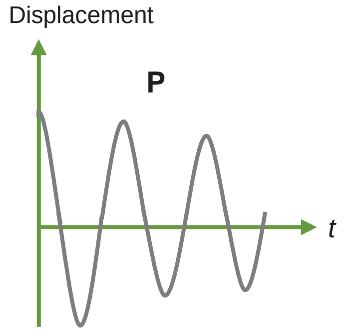


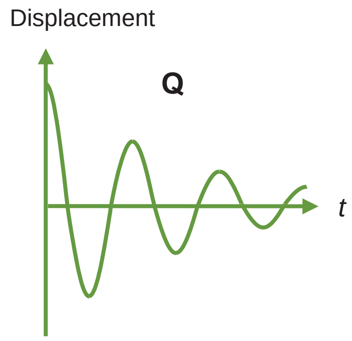
C

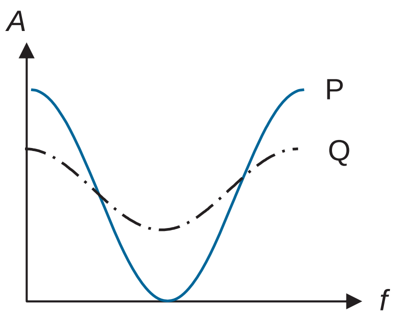


D

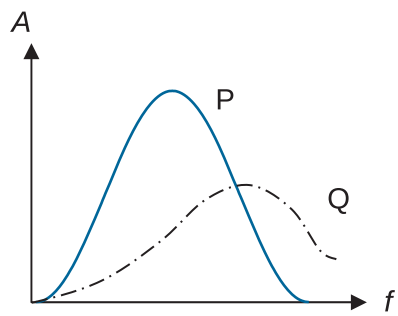
15 Two objects P and Q are given the same initial displacement and then released. The variation of their displacements with time *t* are as shown in the given graphs. The two objects are then driven by sinusoidal driving forces of the same constant amplitude and of variable frequency *f*. Which of the following graphs correctly shows how the amplitudes *A* of P and Q varies with *f* ?



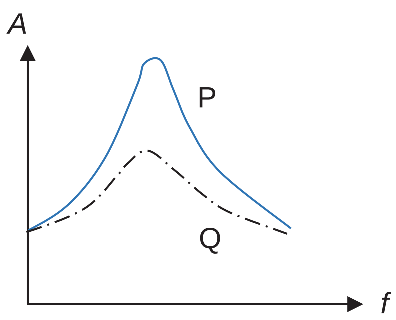




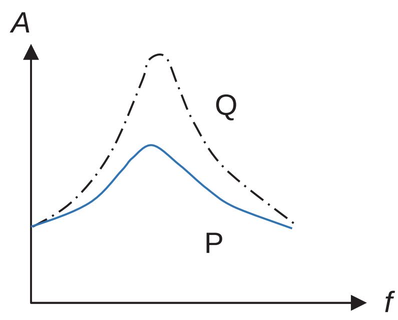
A



B

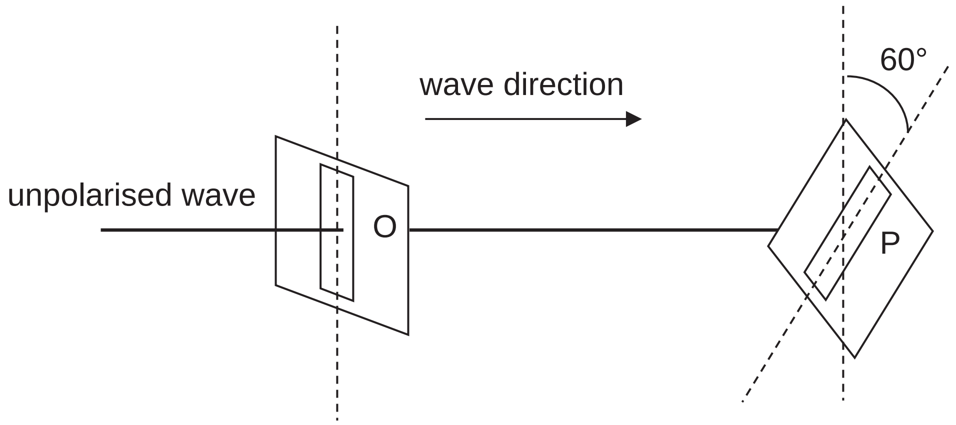


C



D

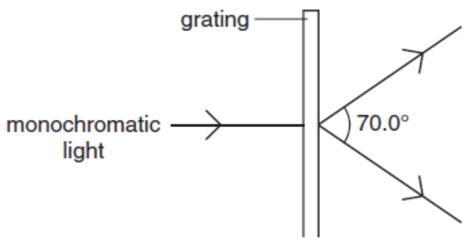
16 An unpolarised wave passes through polariser O such that the emerging wave is plane-polarized with an intensity of 2.0 W m^{-2}. A second polariser P is placed further such that the plane-polarised wave is incident normally on it. Polariser P is rotated clockwise by an angle of 60°.



What is the intensity of the wave after passing through polariser P ?

A 0.25 W m^{-2} **B** 0.5 W m^{-2} **C** 1.0 W m^{-2} **D** 2.0 W m^{-2}

17 A diffraction grating is used to measure the wavelength of monochromatic light as shown below.

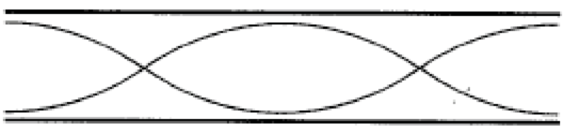


The spacing of the slits in the grating is 1.00 x 10^{-6} m. The angle between the first order diffraction maximas is 70.0°.

What is the wavelength of the light?

A 287 nm **B** 470 nm **C** 574 nm **D** 940 nm

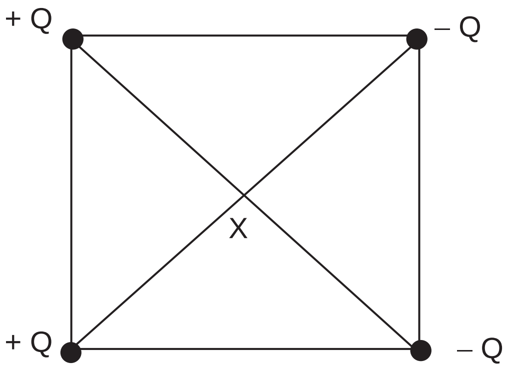
18 A stationary wave is formed in an open tube as represented in the diagram.



How many antinodes are formed by a stationary wave of twice the frequency?

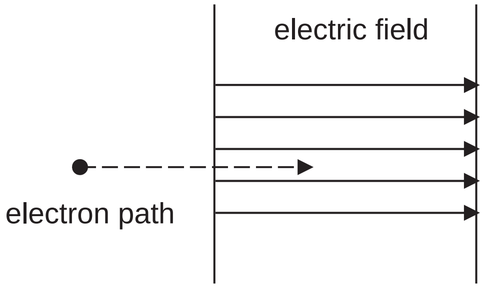
A 2 **B** 4 **C** 5 **D** 6

19 The diagram shows four point charges arranged in the corners of a square. What are the values of the electric field strength E and the electric potential V at a point X in the middle of the square?



	E	V
A	not zero	zero
B	not zero	not zero
C	zero	not zero
D	zero	zero

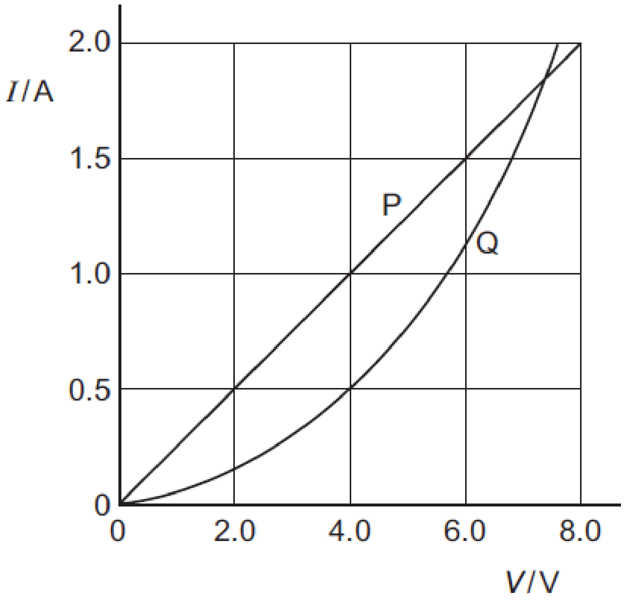
20 An electron has a de Broglie wavelength of 5.6×10^{-11} m. It enters an electric field with strength of 2.3×10^{4} V m^{-1} as shown.



How long will it take for the electron to stop after it enters the electric field?

A 5.0×10^{-28} s **B** 2.0×10^{-15} s **C** 3.2×10^{-9} s **D** 4.2×10^{-2} s

21 The I-V characteristics of two electrical components P and Q are shown below.



Which statement is correct?

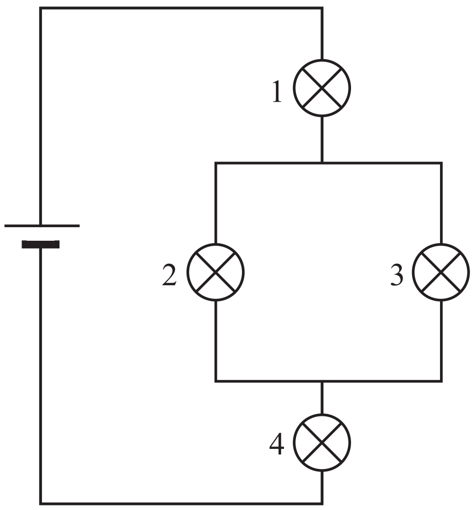
A P is a resistor and Q is a filament lamp.

B The resistance of Q increases as the current in it increases.

C At 1.9 A the resistance of Q is approximately half that of P.

D At 0.5 A the power dissipated in Q is double that in P.

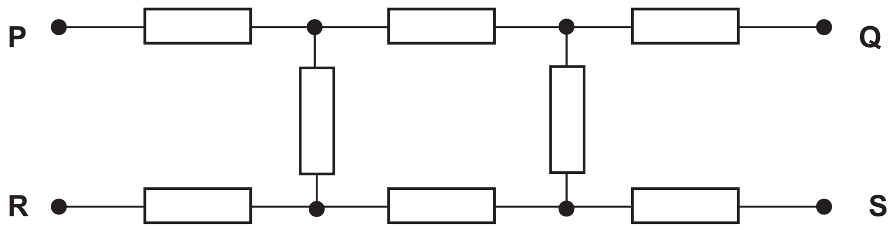
22 An ideal cell and four identical bulbs are connected as shown.



Bulb 3 is removed. Which of the following describes the changes in the brightness of bulbs 1, 2 and 4?

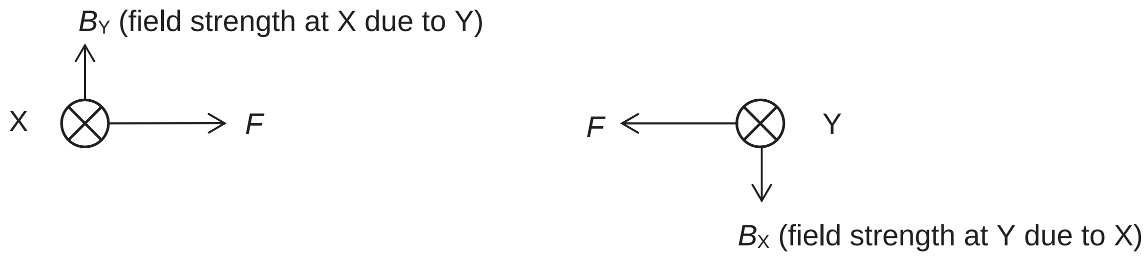
	Bulb 1	**Bulb 2**	**Bulb 4**
A	dimmer	brighter	brighter
B	dimmer	brighter	dimmer
C	brighter	dimmer	brighter
D	dimmer	dimmer	dimmer

23 Each resistor has a similar resistance of 10 Ω. What is the equivalent resistance of the circuit shown in the figure below between points **P** and **S**?



A 10 Ω **B** 20 Ω **C** 30 Ω **D** 40 Ω

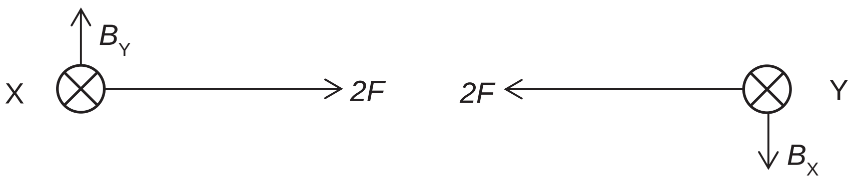
24 Two long, parallel, straight wires X and Y carry equal currents into the plane of the page as shown. The diagram shows arrows representing the magnetic field strength B at the position of each wire and the magnetic force F on each wire.



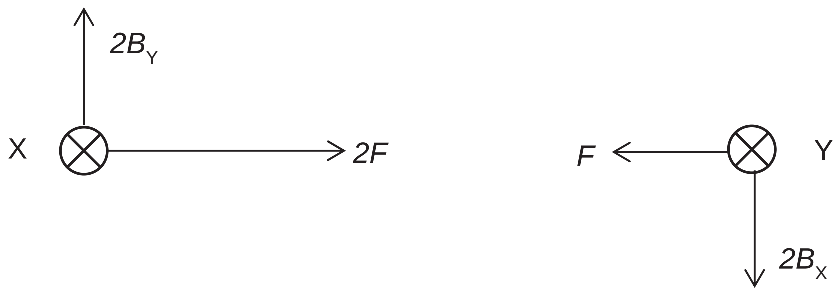
The current in wire Y is doubled. Which diagram best represents the magnetic field strengths and forces?

A

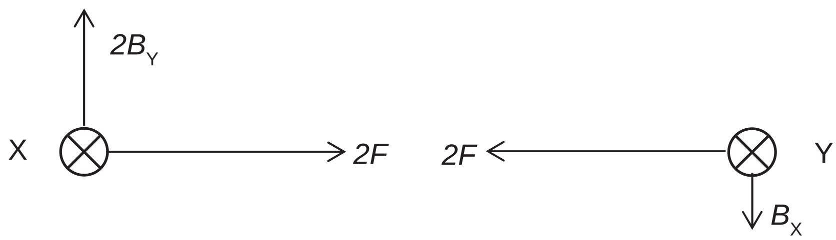
B



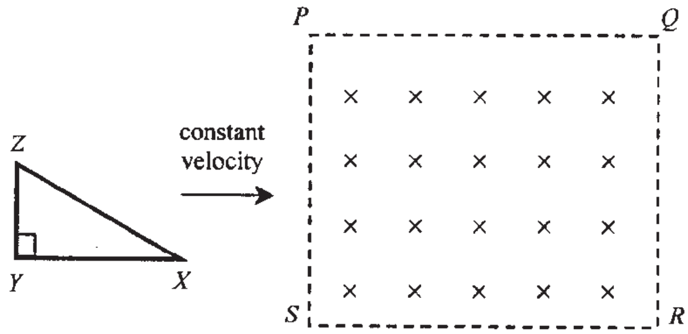
C



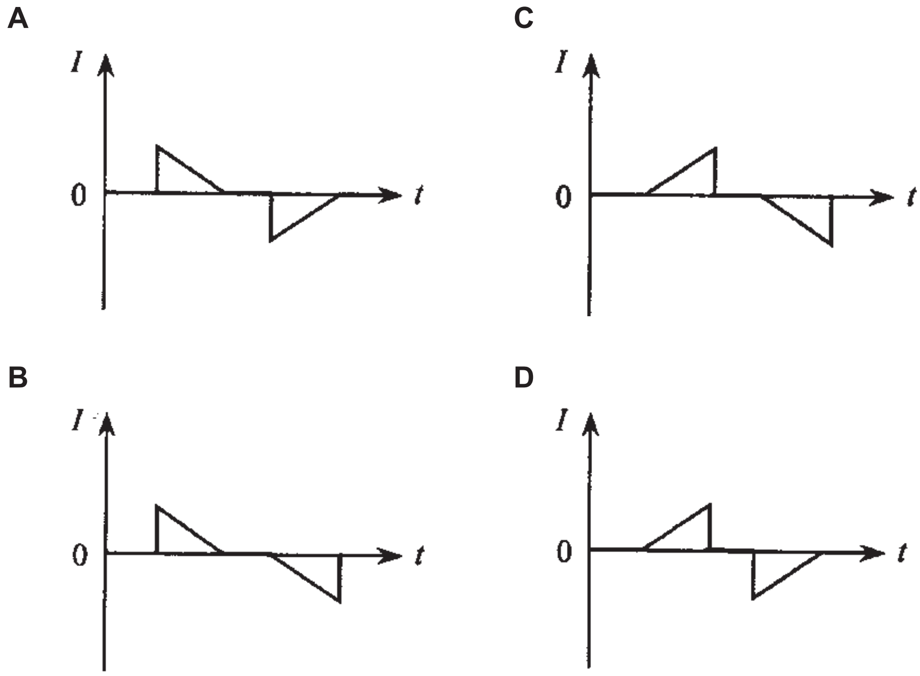
D



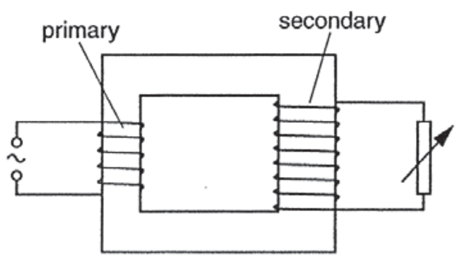
25



In the diagram above, *XYZ* is a small right-angled triangular metal frame moving with a constant velocity across a rectangular region *PQRS* with a uniform magnetic field pointing into the paper. Which of the following graphs best shows the variation of the current *I* induced in the frame with time *t*?



26 The primary coil of a transformer is connected to an alternating voltage supply. The secondary coil is connected across a variable resistor.



Which change will cause a decrease in the p.d. across the secondary coil?

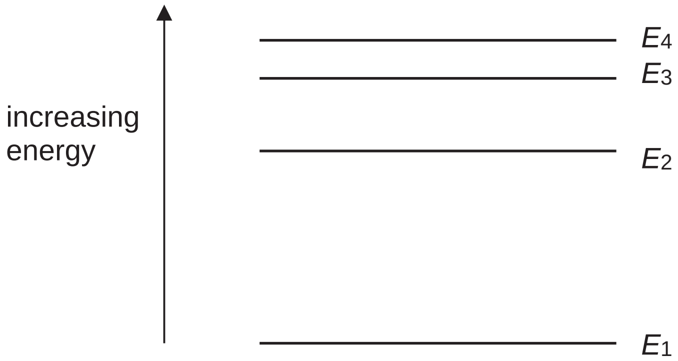
A Increasing the number of turns of the primary coil

B Increasing the current in the primary coil

C Increasing the cross-sectional area of the secondary coil

D Increasing the resistance of the variable resistor

27 Some of the energy levels of the hydrogen atom are represented in simplified form by the given diagram which has a linear scale. The emission of blue light is associated with the transition of an electron from E_4 to E_2. Which of the following transitions could be associated with the absorption of the red light ?



A E_2 to E_3

B E_1 to E_4

C E_3 to E_2

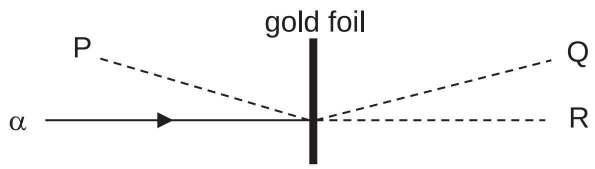
D E_4 to E_1

28 The momentum of a proton is measured with an uncertainty of 1.0%. Given that it has kinetic energy of 1.00 MeV, which of the following is the minimum uncertainty in its position?

A 1.1×10^{-11} m **B** 2.9×10^{-12} m **C** 1.1×10^{-12} m **D** 7.0×10^{-13} m

29 In an experiment on α-particle scattering, α-particles are directed onto a gold foil, and detectors are placed at positions P, Q and R as shown in the diagram below.

What is the distribution of α-particles as recorded at P, Q and R respectively?



	Position P	**Position Q**	**Position R**
A	none	none	all
B	none	some	most
C	most	some	fewer than at position Q
D	fewer than at position Q	some	most

30 Which statement about alpha, beta and gamma radiation is correct?

A Alpha radiation has the greatest ionising power.
B Beta radiation has the greatest ionising power.
C Gamma radiation has the greatest ionising power.
D Alpha, beta and gamma radiation have nearly equal ionising powers.

END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME	
CG	
INDEX NO.	

PHYSICS 9749/02

Preliminary Examination **11th September 2017**
Paper 2 Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 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.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 9
Q3	/ 15
Q4	/ 9
Q5	/ 20
Q6	/ 19
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /ºC + 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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 In order to determine the value of the gravitational acceleration *g*, a student throws a ball at a speed of 15 m s^{-1} horizontally from a building.

(a) The student collects the following data for the ball when it reaches the ground.

Quantity	Value	Absolute Uncertainty
Vertical displacement	122.500 m	0.002 m
Horizontal displacement	75.000 m	0.002 m

(i) Show that the time taken to reach the ground is 5.0 s. [1]

(ii) The uncertainty of the time taken is 0.4 s.

Determine the value of *g*, with its associated uncertainty.

g = ………………….. ± ……………….. m s^{-2} [3]

(b) In the absence of air resistance, the variation of the vertical speed *v* of the ball with time *t* is shown in Fig. 1.1.

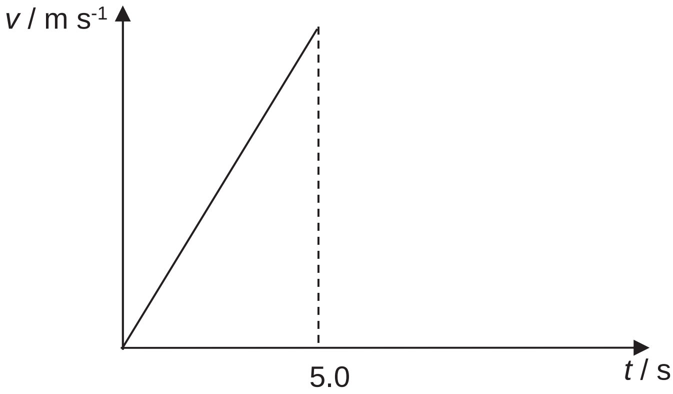


Fig. 1.1

(i) In reality, there is air resistance. Sketch the graph of variation of vertical speed with time on Fig. 1.1, and label this graph Z. [2]

(ii) Explain the shape of the graph Z.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

2 Truck X of mass 22 000 kg and moving at a speed of 3.0 m s^{-1}, catches up and collides with Truck Y moving at 1.0 m s^{-1} moving in the same direction as shown in Fig. 2.1.

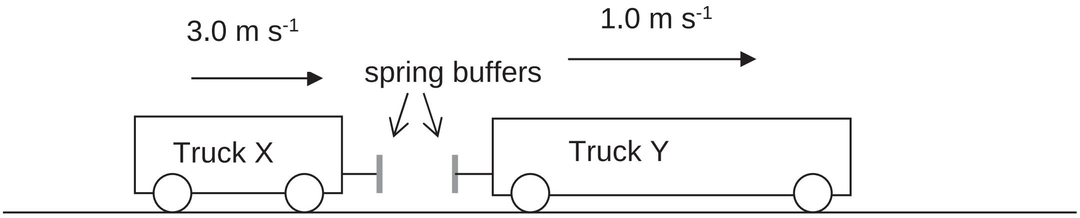


Fig. 2.1

Fig. 2.2 shows how the speeds of the trucks vary with time *t* before, during and after the collision.

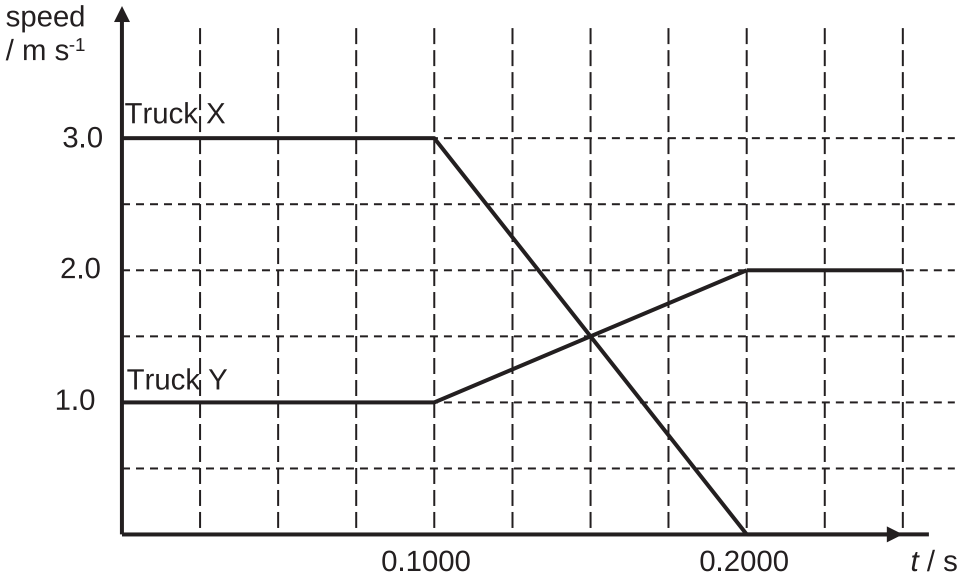


Fig. 2.2

(a) Using Fig. 2.2, show that the mass of Truck Y is 66000 kg. [1]

(b) Showing your working clearly, explain whether this collision is elastic. [2]

For Examiner's Use

(c) **(i)** State the time at which the trucks are closest to each other.

t = …………………… s [1]

(ii) **1.** Calculate the total kinetic energy of the two trucks at the time stated in **(i).**

total kinetic energy = ………………… J [1]

2. Hence, calculate the maximum elastic potential energy stored in the spring buffer during the collision.

maximum elastic potential energy stored = ………………… J [1]

(d) **(i)** Calculate the magnitude of the impulse exerted by Truck X on Truck Y.

magnitude of impulse = ………………… N s [2]

(ii) If the duration of the collision is reduced, with the initial and final speeds of both trucks unchanged, state and explain how this affects your answer in **(i)**.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

3 **(a)** State what is meant by *coherent sources*.

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

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

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

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

(b) A stereo system in a large hall has two identical speakers, S_1 and S_2, placed 1.2 m apart as shown in Fig. 3.1. The amplitude of the output of each speaker is proportional to the potential difference across its terminals, which is adjusted by means of a balance control.

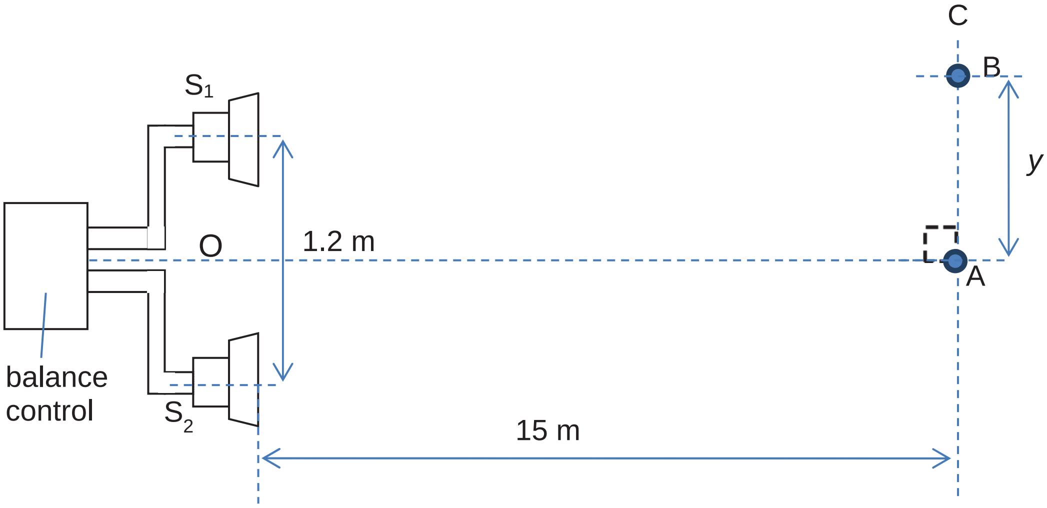


Fig. 3.1 (not to scale)

Initially, the speakers are emitting signals of frequency 1000 Hz which are in phase. The balance control is set such that the potential difference across the terminals of both speakers are the same.

Line AC is 15 m away from the speakers. An observer hears a loud sound of intensity I_{max} at A. As he moves along the line AC, 15 m away from the speakers, he observes that the intensity of the sound first falls to zero at point B, a distance *y* from A. The speed of sound in air is 330 m s^{-1}.

(i) Determine the distance *y*.

y = ……………. m [2]

For Examiner's Use

(ii) By calculating the path difference of the two sound waves arriving at B, determine the next higher frequency of the speaker such that point B would also be a point of zero intensity.

frequency = …………………. Hz [3]

(iii) With the speakers emitting the original signal frequency of 1000 Hz, the balance control is now adjusted such that the potential difference across the terminals of S_1 is reduced while the potential difference across the terminals of S_2 is unchanged.

Suggest and explain any changes to the sound heard at B.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(c) Monochromatic light is passed through a rectangular slit of width *b* of 0.20 mm. The light is observed on a screen placed 0.75 m from the slit, as shown in Fig. 3.2.

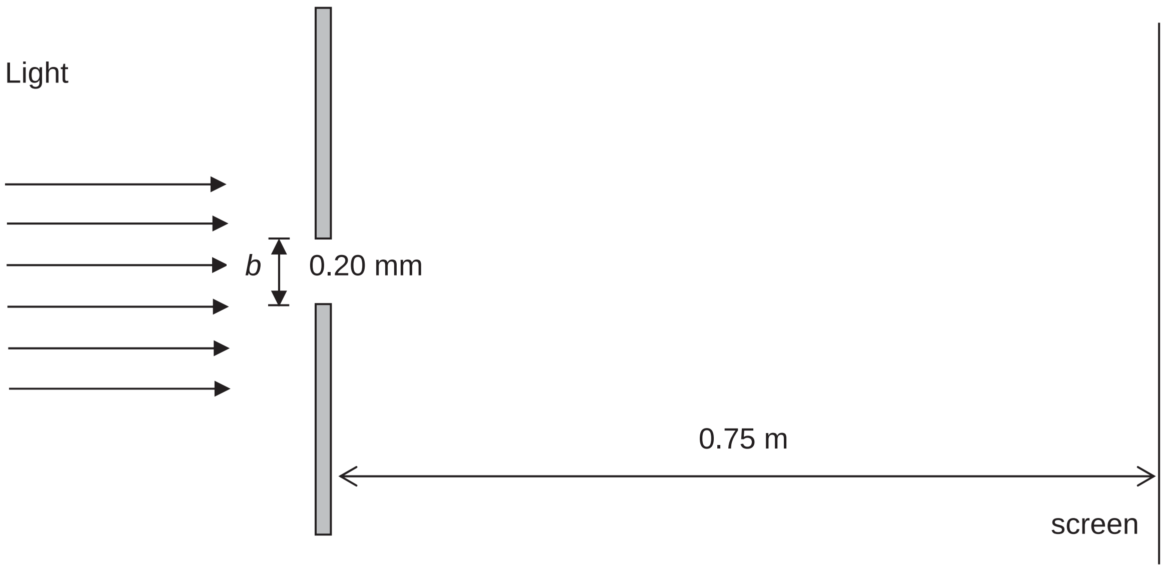


Fig. 3.2

Light passing through the slit is diffracted through an angle θ.

The variation of the intensity I of the light with the angle θ of diffraction is shown in Fig. 3.3. The maximum value of intensity is I_0.

The angular separations between successive minima are the same.

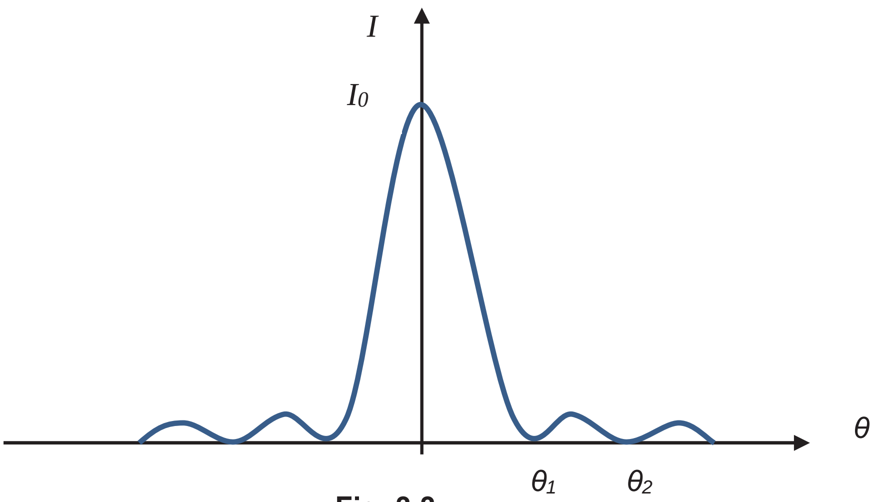


Fig. 3.3

(i) The value of θ_2, the location of the second order minima, is 0.338°. Determine the wavelength of the monochromatic light.

wavelength = ……………. nm [2]

(ii) Determine the angle between two beams of light incident on the slit, each of the same wavelength as in **(i)**, such that their diffraction patterns are just resolved. Explain your working.

angle = ……………° [2]

(iii) Sketch, on the axes of Fig. 3.3, how the intensity of the light varies with θ if the slit width is halved. Label any relevant intercepts on your sketch. [2]

For Examiner's Use

4 **(a)** Define the *tesla*.

……

……

……

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

(b) Ions, all of the same element, are travelling in a vacuum with a speed of 9.6×10^4 m s^{-1}. The ions are incident normally on a uniform magnetic field B of flux density 320 mT. The ions follow semicircular paths A and B before reaching a sensor, as shown in Fig. 4.1.

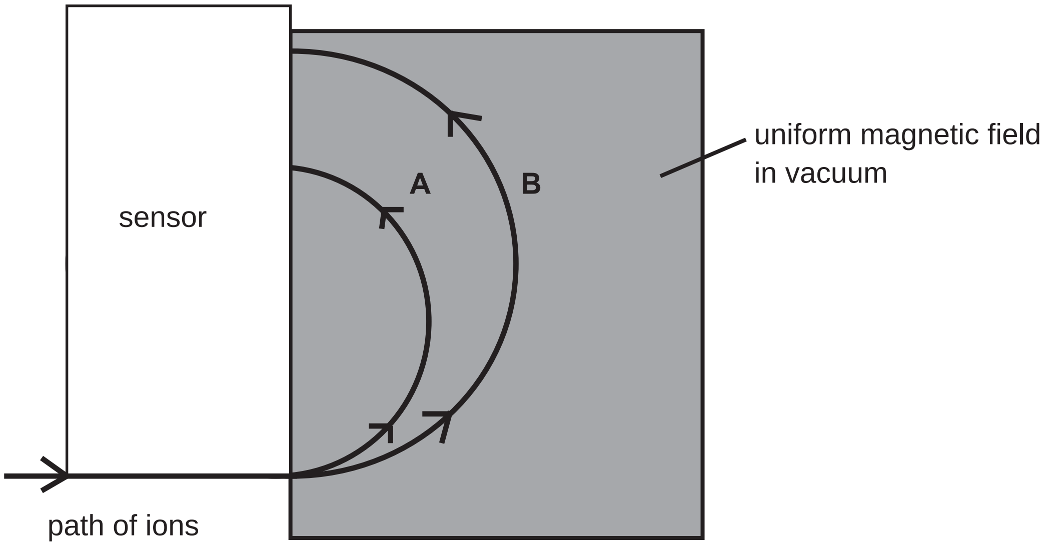


Fig. 4.1

The diameters of paths A and B are 6.2 cm and 12.4 cm respectively. The ions in path B each have charge $+1.6 \times 10^{-19}$ C.

(i) Explain why the path of the ions in the magnetic field is an arc of a circle.

…………………………………………………………………………………………………

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…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

For Examiner's Use

(ii) Calculate the mass of the ions in path B.

mass = …………….kg [2]

(iii) Explain the reason for the difference in radii of the paths A and B of the ions.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

5 **(a)** **(i)** Define *binding energy*.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Sketch a graph in Fig. 5.1 to show the variation of the binding energy per nucleon with nucleon number. Label the value of nucleon number and binding energy per nucleon for the isotope that has the highest binding energy per nucleon. [2]

Fig. 5.1

(iii) With reference to your graph drawn in Fig. 5.1, explain how fission can be a potential source of energy.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

(iv) A typical nuclear fission reaction that involves uranium-235 is represented by the equation

$$^{235}_{92}U + n \rightarrow Kr + \, ^{141}_{56}Ba + 3n$$

Data for the binding energy per nucleon for the different nuclei are given in the table below:

Nuclei	**Binding energy per nucleon / MeV**
$^{235}_{92}U$	7.59
Kr	8.51
$^{141}_{56}Ba$	8.33

1. Deduce the number of protons and neutrons in the Kr nucleus.

number of protons = ………………….

number of neutrons = ………………….[2]

2. Calculate the energy released in the above reaction.

energy released = …………………. J [2]

For Examiner's Use

(b) A stationary $^{228}_{88}\mathrm{Ra}$ nucleus undergoes beta minus decay to form an actinium isotope. The actinium isotope and beta particle move as shown in Fig. 5.2.

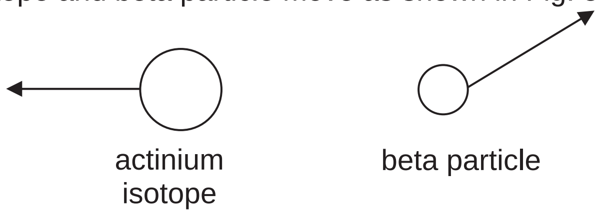

Fig. 5.2

Explain why a neutrino must also be released in this process.

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

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

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

(c) Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium $^{40}_{19}\mathrm{K}$ to argon $^{40}_{18}\mathrm{Ar}$, which is stable. The decay constant of potassium-40 is 5.3 × 10^{-10} per year.

(i) Explain what is meant by the decay constant of potassium-40 being 5.3 × 10^{-10} per year.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………[1]

(ii) Sketch a labelled graph on Fig. 5.3 to show how the activity of $^{40}_{19}\mathrm{K}$ changes with time if the initial activity is A_o. Mark on your graph the value of the half-life of $^{40}_{19}\mathrm{K}$. [2]

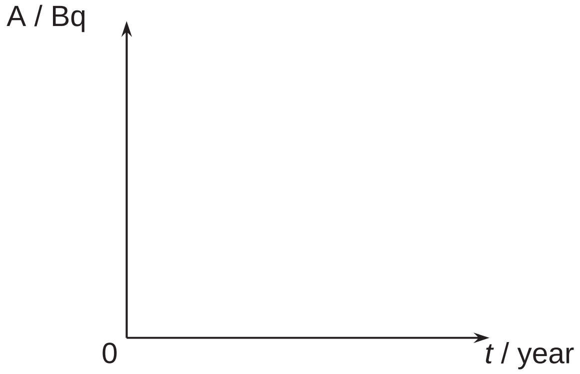

Fig. 5.3

For Examiner's Use

(iii) In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40.

1. Calculate the activity of the potassium-40 in the rock sample.

activity = ………………… Bq [2]

2. Calculate the age of the rock sample in years.

age of rock sample = ………………… years [2]

3. State any assumption that you have made for the calculation in **2**.

………………………………………………………………………………………

………………………………………………………………………………………[1]

(iv) Explain why the determination of the decay constant by measuring the mass and activity of a sample is not suitable for nuclides that have relatively large decay constants.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

6 A capacitor is an electrical device which can store charges and energy. A simple parallel plate capacitor consists of two parallel conducting plates separated by an insulator, as shown in Fig. 6.1.

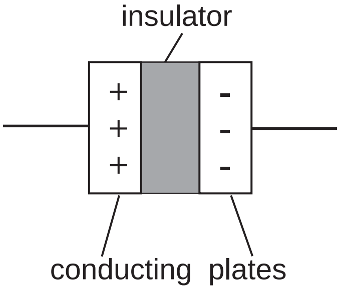

Fig. 6.1

When charged, the two plates carry opposite charges of the same magnitude. The relationship between the amount of charge stored Q, the potential difference V between the plates and the capacitance C is given by the equation

$$Q = CV$$

(a) Deduce the base units of C.

base units = ... [3]

(b) The capacitor is now charged. Fig. 6.2 shows the values of potential difference *V* and the corresponding amount of charge *Q*.

***V*/ V**	***Q*/ μC**
0.0	0.0
0.4	1.9
1.3	6.1
3.0	14.3
3.3	15.5
4.2	19.7
5.1	23.5

Fig. 6.2

On Fig. 6.3,

(i) plot the missing data points from Fig. 6.2. [2]

(ii) sketch the best fit line to show the variation of the amount of charge *Q* with the potential difference *V* between the plates. [1]

For Examiner's Use

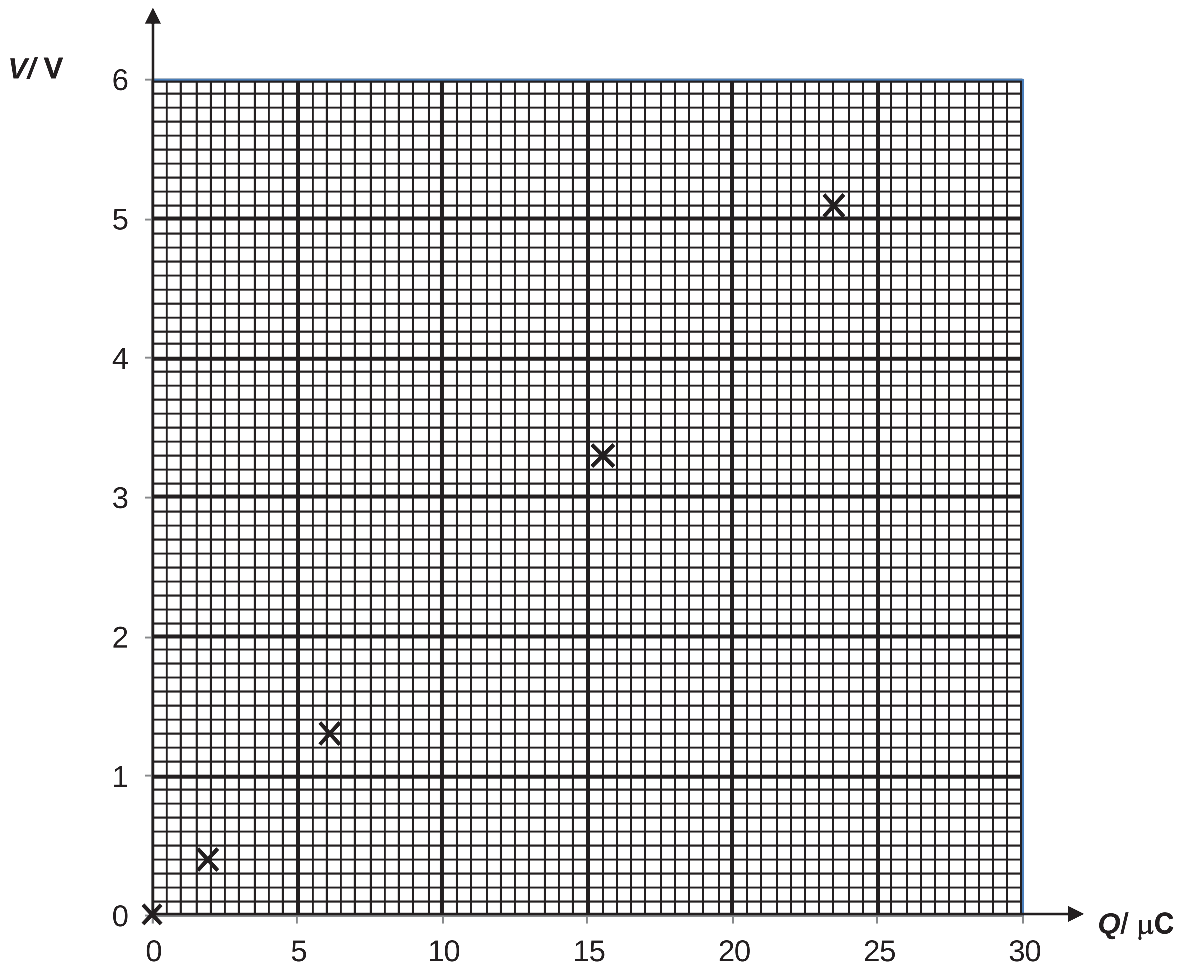

Fig. 6.3

(iii) State the quantity represented by the:

1. gradient of the graph,

.... [1]

2. area under the graph.

.... [1]

(iv) Hence, show that the energy E stored in a capacitor is ½ CV^2.

[1]

(c) The capacitor is now discharged by connecting it across a resistor of resistance *R* as shown in Fig. 6.4.

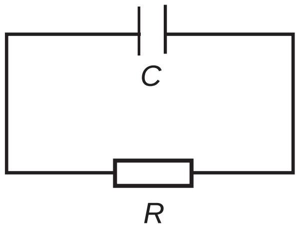

Fig. 6.4

Fig. 6.5 shows the variation with time *t* of the potential difference *V* across the resistor.

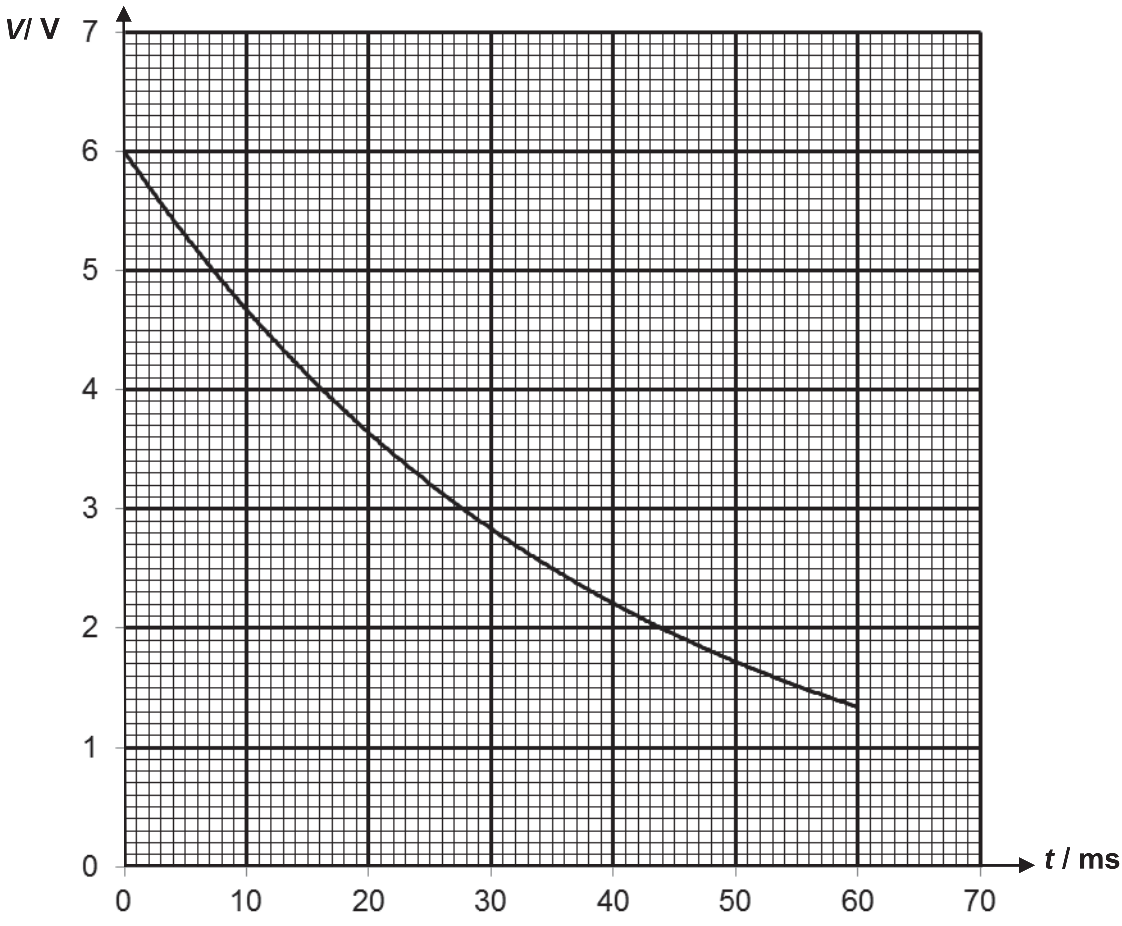

Fig. 6.5

(i) Using Fig. 6.3 and Fig. 6.5, determine the initial amount of charge stored.

charge = ... μC [2]

For Examiner's Use

(ii) Hence, calculate the capacitance *C*.

capacitance = ... C V^{-1} [2]

(iii) Calculate the energy lost when the capacitor has been discharged for 45 ms.

energy lost = ... J [3]

(d) The graph in Fig. 6.5 can be represented by the following equation, where V_o is the initial potential across the resistor *R*.

$$V = V_o e^{-t/RC}$$

State how the value of *RC* affects the rate of discharge of the capacitor.

.... [1]

For Examiner's Use

(e) Fig 6.6 shows an A.C. supply connected to resistor-capacitor (RC) circuit containing an ideal diode. Fig 6.7 shows the potential difference measured by the CRO.

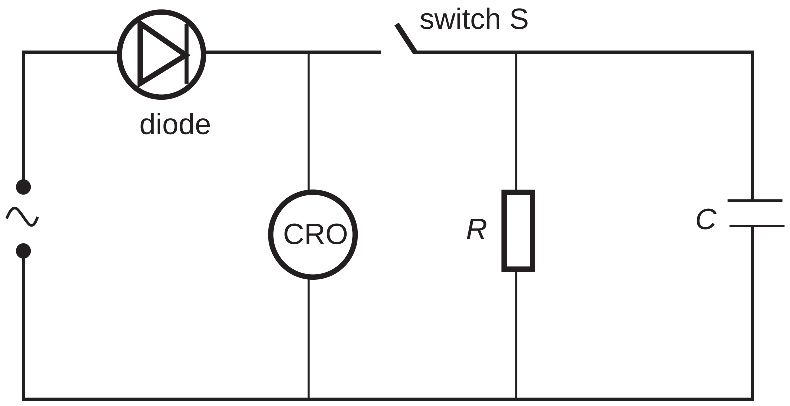

Fig. 6.6

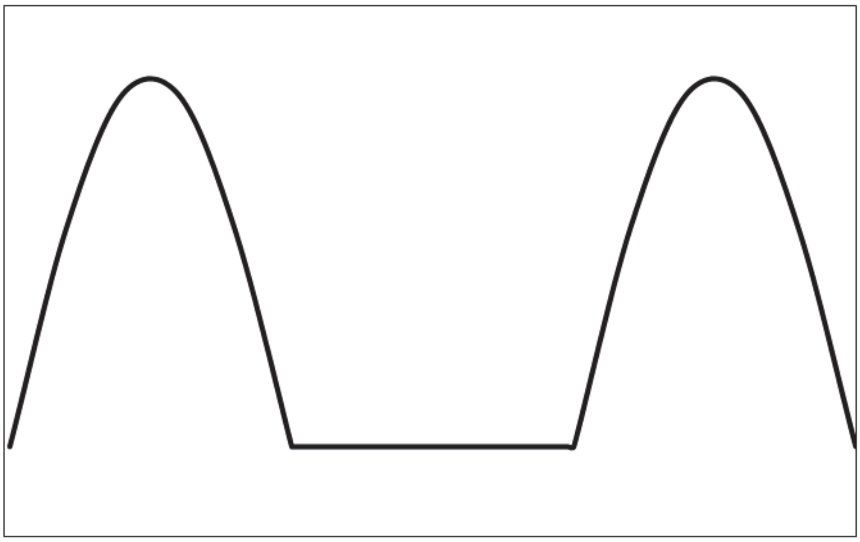

Fig. 6.7

Switch S is now closed. When the diode is in forward bias, current flows through both the resistor and the capacitor. When the diode is in reverse bias, the capacitor discharges through the resistor.

(i) Sketch on Fig. 6.7, the expected display on the CRO. [1]

(ii) State what the RC circuit does to the wave on the CRO.

.... [1]

END OF PAPER

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SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME ____________________

CG __________ **INDEX NO.** __________

PHYSICS 9749/03

Preliminary Examination **15th September 2017**
Paper 3 Longer Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 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 in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 7
Q2	/ 13
Q3	/ 20
Q4	/ 20
Q5	/ 20
Q6	/ 20
Total marks	/ 80

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /ºC + 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	=	$Anqv$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{ln2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A: Answer all questions.

1 A uniform rod of weight 20 N is freely hinged to a wall at P as shown in Fig. 1.1. It is held horizontal by an elastic cord made of material X of force constant 10 N cm^{-1}, attached at Q at an angle of 15˚ to the rod.

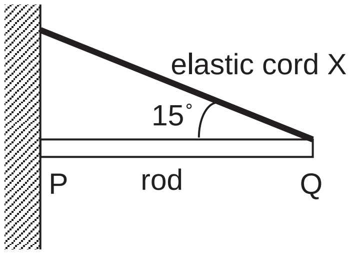

Fig. 1.1

(a) Show that the extension of the elastic cord X is 3.86 cm. [2]

(b) Determine the magnitude of the resultant force acting at P.

magnitude of resultant force at P = …………………. N [3]

(c) The elastic cord X is now replaced by two other identical elastic cords of the same unstretched length as elastic cord X. These two elastic cords are connected in parallel. The rod PQ remains horizontal.
State and explain the value of the force constant of each of the new elastic cords.

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

For Examiner's Use

2 (a) State the *first law of thermodynamics*, indicating the directions of all energy changes.

....

....

.... [2]

(b) A heat pump contains a fixed mass of ideal gas undergoing a cycle of changes of pressure, volume and temperature as illustrated in Fig. 2.1.

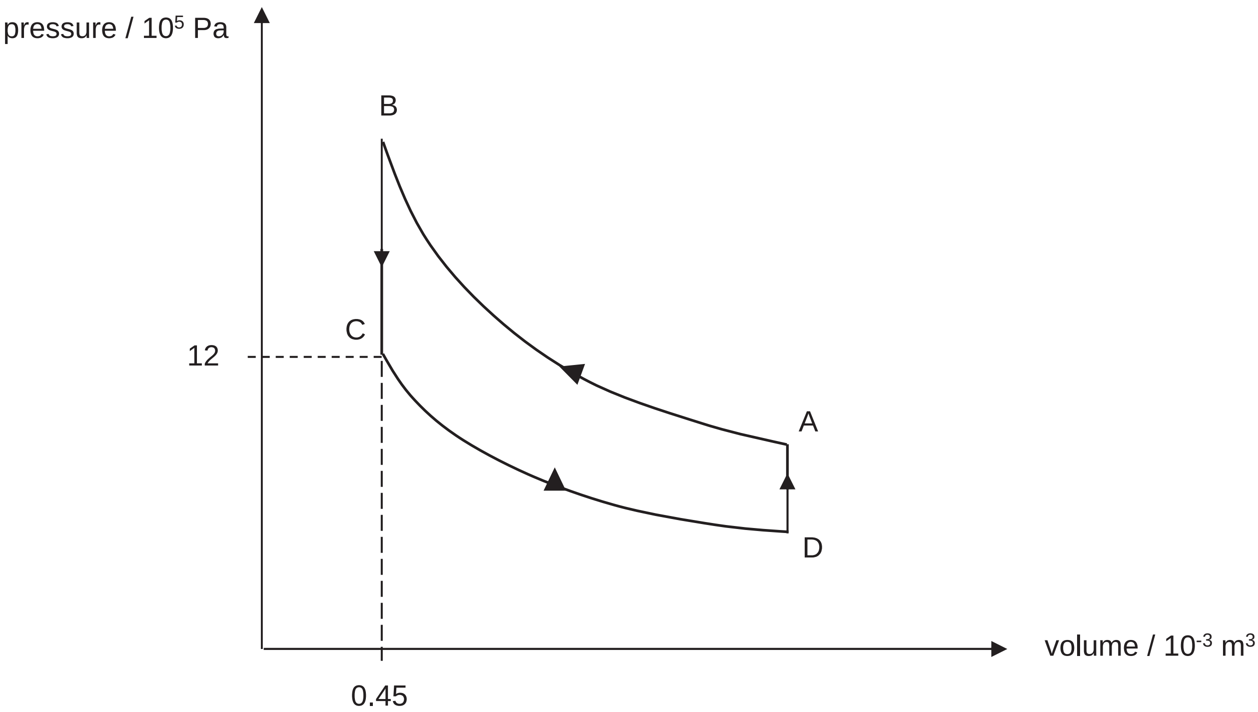

Fig. 2.1

The increase in internal energy which takes place during three of the changes are as shown in Fig. 2.2. It is also known that no heat is supplied in the changes A → B and C → D.

(i) Complete Fig. 2.2.

Change	**Increase in internal energy / J**	**Heat supplied to gas / J**	**Work done on gas / J**
A → B	720		
B → C	-810		
C → D	- 360		
D → A			

Fig 2.2 [4]

For Examiner's Use

(ii) Given that the temperature at C is 360 K, calculate the number of molecules, N, in the heat pump.

number of molecules = ………………………………..[2]

(iii) Given that the total kinetic energy of the gas molecules, E_K is given as E_K = 3/2 NkT, using your answers in **(i)** and **(ii)**, determine the temperature at D.

temperature = …………………….. K [3]

(iv) Given that the gas is Helium-4, calculate the root-mean-square speed of the Helium molecules at C.

r.m.s speed = ……………… m s^{-1} [2]

For Examiner's Use

3 (a) A satellite is in a geostationary circular orbit of radius *r* about the Earth of mass *M*, and appears to remain above the same point on the Earth. The mass of the Earth may be assumed to be concentrated at its centre.

(i) State two features of a geostationary satellite of the Earth.

1. ……………………………………………………………………………………………

……………………………………………………………………………………………

2. ……………………………………………………………………………………………

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

(ii) Show that the period *T* of the orbit of the satellite is given by the expression

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where G is the gravitational constant. Explain your working.

[3]

(iii) The mass *M* of the Earth is 6.0×10^{24} kg.

Determine the radius of the geostationary orbit.

radius = …………………………………….. m [2]

For Examiner's Use

(b) The variation of the resultant gravitational potential due to the Earth and the Moon along a line XY joining the centres of the Earth and Moon is as shown in Fig. 3.1.

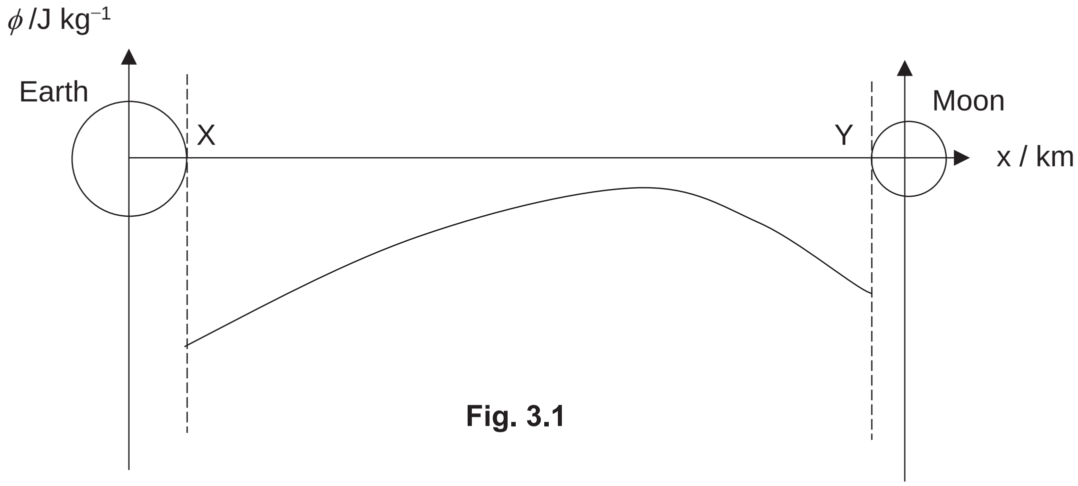

Fig. 3.1

(i) Given that the mass of the Moon is 7.3×10^{22} kg and the distance between the centres of the Earth and Moon is 380 000 km, show that the distance from the centre of the Earth along XY, where the net gravitational field strength is zero, is 342 000 km.

[1]

(ii) Hence, sketch the corresponding net gravitational field strength due to the Earth and the Moon in Fig. 3.2. [2]

Fig. 3.2

For Examiner's Use

(c) Two point charges A and B are separated by a distance of 8.0 cm in a vacuum, as illustrated in Fig. 3.3.

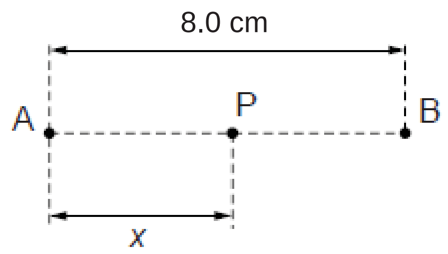

Fig. 3.3

Point P is at a distance *x* from A along AB. The variation of the resultant potential due to charges A and B is as shown in Fig. 3.4.

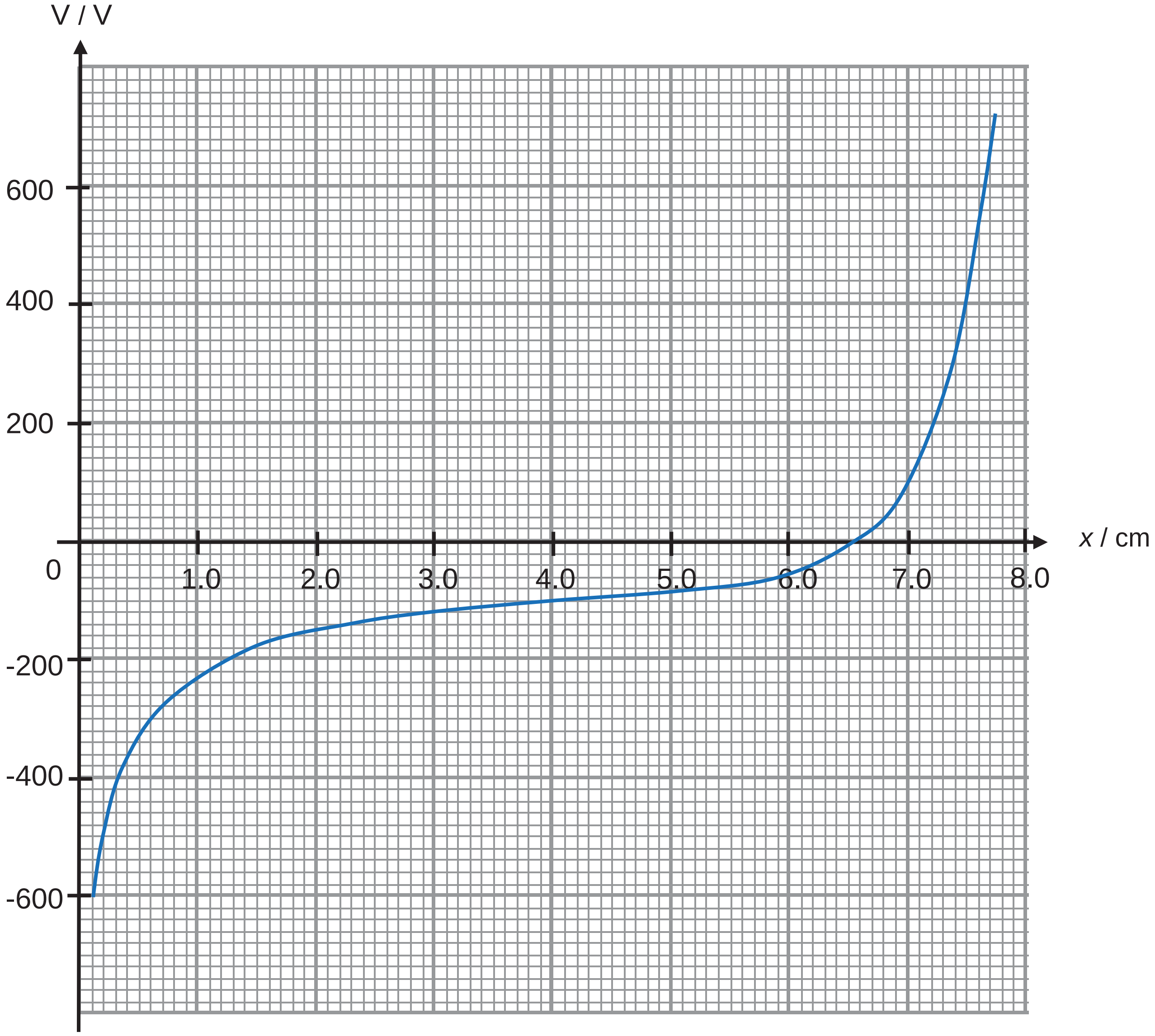

Fig. 3.4

(i) State and explain whether the two charges are of the same sign.

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

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

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

(ii) Calculate the ratio of the numerical value of $\dfrac{\textit{Charge of A}}{\textit{Charge of B}}$.

ratio = ………..[2]

(iii) State and explain the direction of the electric field at the point P, where x = 2.0 cm.

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

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

(iv) Sketch the variation of the electric field strength with x in Fig. 3.5. Label where appropriate.

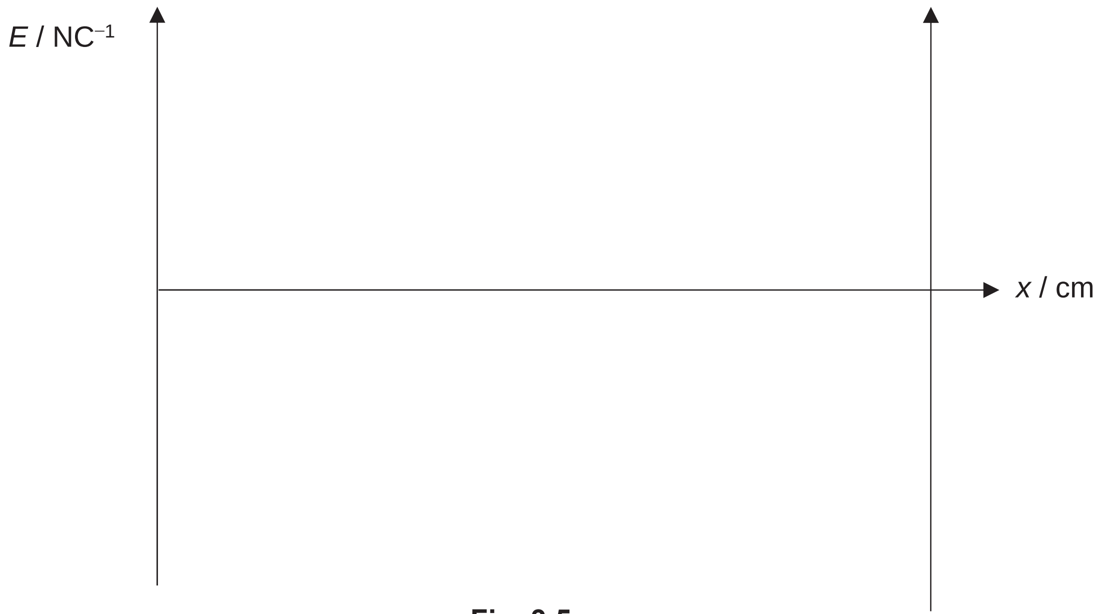

Fig. 3.5

[1]

(v) When a -2.0 nC charge is moved from x = 3.0 cm to 6.0 cm, calculate the change in kinetic energy of the -2.0 nC charge.

change in kinetic energy = ………………………… J [2]

For Examiner's Use

4 **(a)** By reference to the photoelectric effect, explain

(i) what is meant by *work function*,

....

....[1]

(ii) why, even when the incident light is monochromatic, the emitted electrons have a range of kinetic energies up to a maximum value.

....

....

....

....

....

....[2]

(iii) In an experiment to investigate the photoelectric effect, a student measures the wavelength λ of the light incident on a metal surface, and the maximum kinetic energy E_{max} of 1/λ as shown in Fig. 4.1.

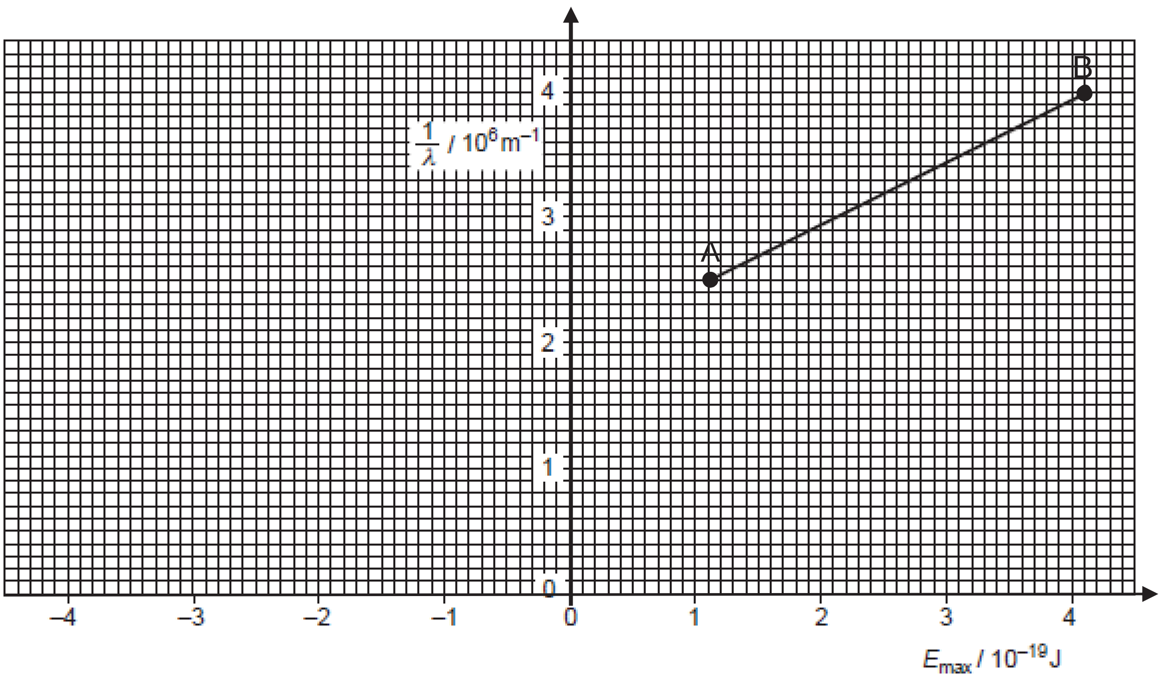

Fig. 4.1

For Examiner's Use

1. Without using the value of the Planck constant, determine the work function of the metal surface.

work function = ……………… J [2]

2. Using points A and B, determine the Planck constant.

Planck constant = …………………….. J s [3]

(b) Fig. 4.2 shows how x-rays are produced inside an x-ray tube. The electrons emitted at the filament are accelerated from rest using an accelerating voltage to hit a target of heavy metal at the anode and produce x-rays as a result.

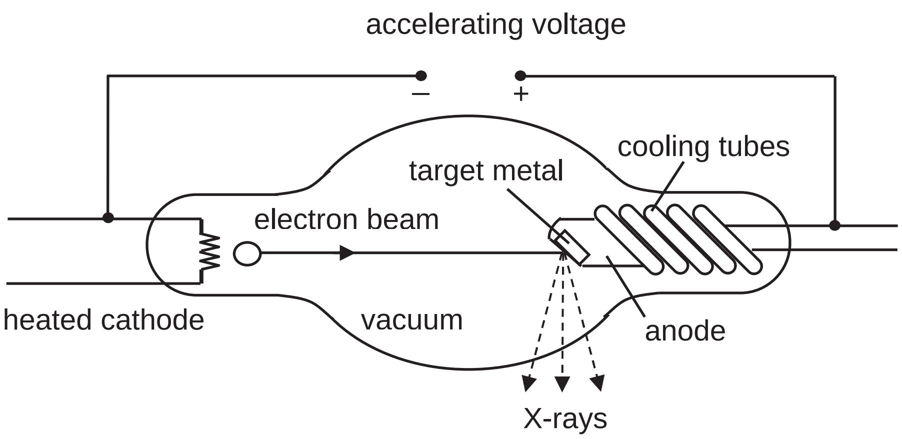

Fig 4.2

A graph of relative intensity against wavelength of the emitted radiation is as shown in Fig. 4.3.

For Examiner's Use

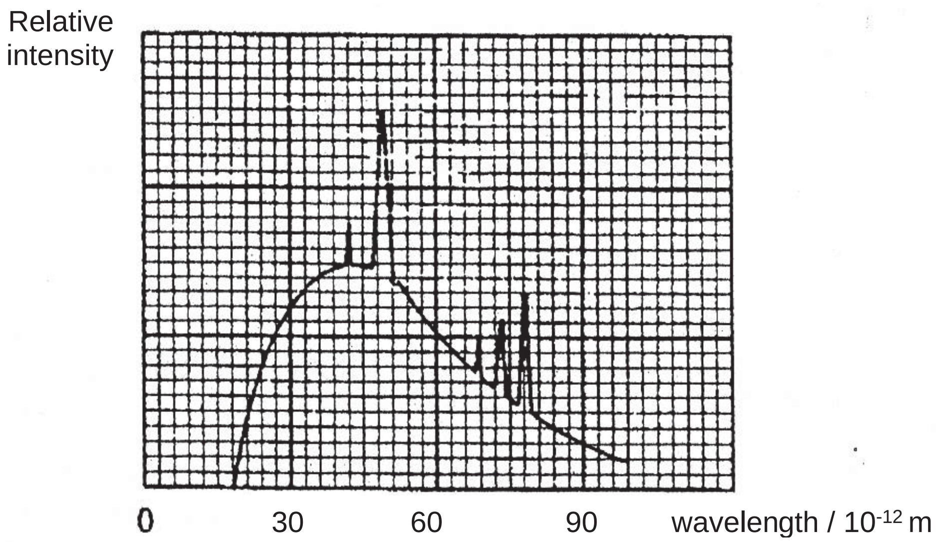

Fig. 4.3

(i) State and explain what must be done to the accelerating voltage if the minimum wavelength of the x-rays emitted is to be doubled.

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…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) Determine the accelerating voltage used to produce the minimum wavelength as shown in Fig. 4.3.

accelerating voltage = …………………….. kV [2]

For Examiner's Use

(c) Electrons, accelerated through a potential difference, are incident on a very thin carbon film, with speed v as shown in Fig. 4.4.

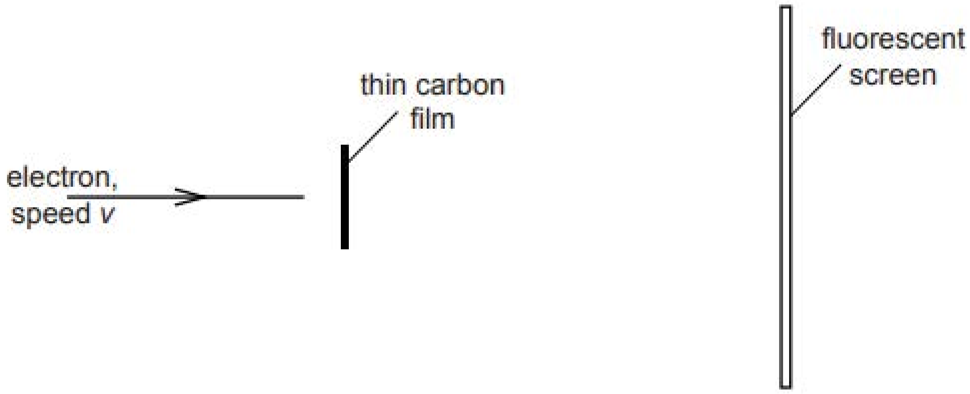

Fig. 4.4

The emergent electrons are incident on a fluorescent screen. A series of concentric rings is observed on the screen.

(i) State and explain what the observed rings suggest about the nature of the electrons.

…………………………………………………………………………………………

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…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) The stream of electrons is now replaced by a stream of alpha particles arriving at the thin film with the same speed v. State and explain the effect, if any, on the rings observed on the screen.

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…………………………………………………………………………………………

…………………………………………………………………………………………[3]

For Examiner's Use

(iii) A proton and an alpha particle are each accelerated from rest through the same potential difference. Determine the ratio

$$\frac{\text{de Broglie wavelength of the proton}}{\text{de Broglie wavelength of alpha particle}}$$

ratio = …………………………. [3]

For Examiner's Use

Section B: Answer ONE out of TWO questions.

5 (a) The headlights of a car are switched on. The distance along the copper connecting wires between the car battery and one of the headlights is 1.5 m.

(i) The current in the wire is 3.0 A, the cross-sectional area of the wire is 3.0×10^{-7} m^2, and the number density of electrons in copper is 8.5×10^{28} m^{-3}.
Determine the average time that an individual electron will take to drift from the battery to the headlight.

time taken = ……………………… s [2]

(ii) Using your answer in **(i)**, comment on how the light of the headlamp comes on almost immediately when switched on.

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

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

(b) An electric heater consists of three similar heating elements A, B, C, connected as shown in Fig. 5.1.

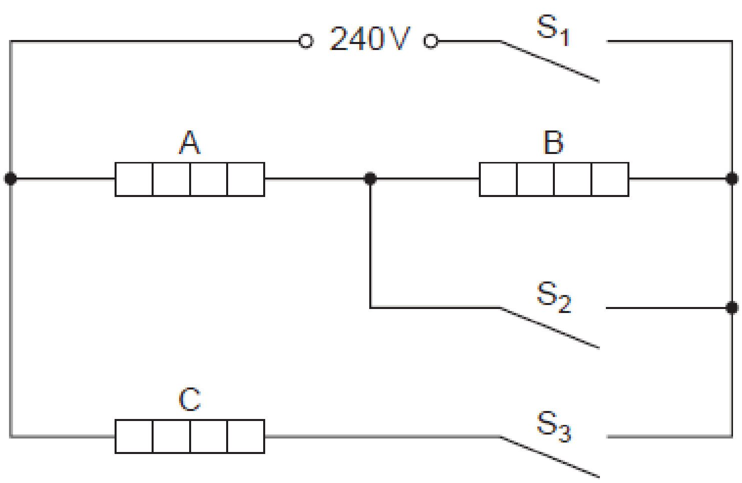

Fig. 5.1

Each heating element is rated as 1.5kW, 240V and may be assumed to have constant resistance.
The circuit is connected to a 240 V supply.

(i) Calculate the resistance of one heating element.

resistance = …………………………..Ω [2]

(ii) The switches S_1, S_2 and S_3 may be either open or closed.

1. When S1, S2 and S3 are all closed, state the total power dissipation of the heater.

total power dissipation = ……………………….. kW [1]

2. When S1 is closed, S2 is open, and S3 is open, determine the total power dissipation of the heater.

total power dissipation = ……………………….. kW [2]

3. Hence, determine the total power dissipation of the heater when S1 is closed, S2 is open, and S3 is closed.

total power dissipation = ……………………….. kW [2]

(c) A circuit used to measure the power transfer from a battery is shown in Fig. 5.2. The battery has an electromotive force (e.m.f.) *E* and an internal resistance *r*. The power is transferred to a variable resistor of resistance *R*, when the potential difference (p.d.) across it is *V*, and the current through it is *I*.

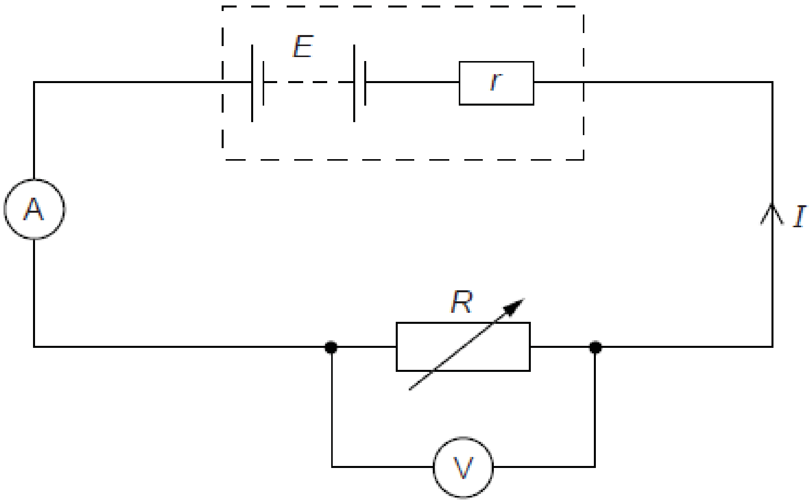

Fig. 5.2

(i) By reference to the circuit shown in Fig. 5.2, distinguish between the definitions of e.m.f. and p.d.

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

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

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

For Examiner's Use

(ii) The variation with current *I* of the p.d. *V* across *R* is shown in Fig. 5.3.

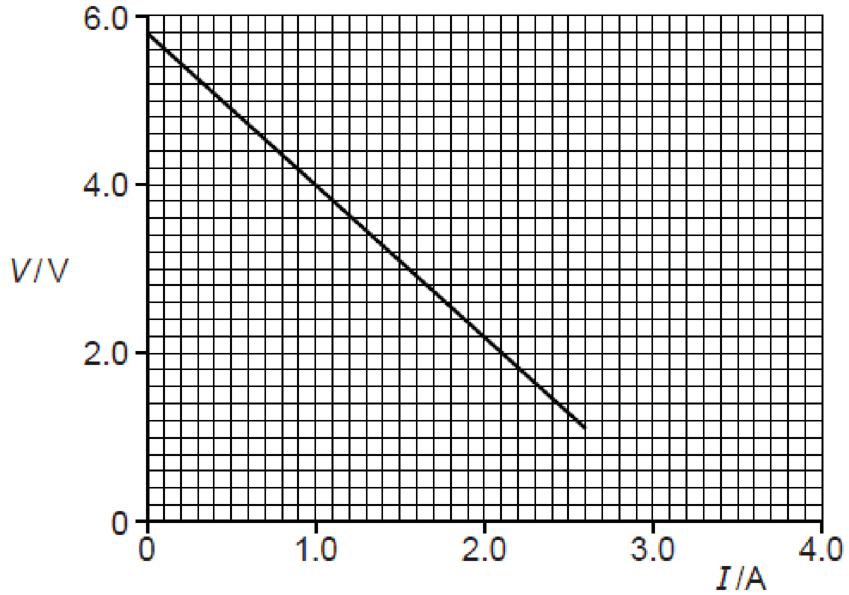

Fig. 5.3

Use Fig. 5.3 to determine

1. the e.m.f. *E*,

E = …………………………..V [1]

2. the internal resistance *r*.

r = …………………………..Ω [2]

For Examiner's Use

(iii) **1.** Using data from Fig. 5.3, show that the power transferred to *R* for a current of 1.6 A is 4.64 W. [1]

2. Use your answers from **(ii)1** and **(iii)1** to calculate the efficiency of the battery for a current of 1.6 A.

efficiency = …………………………..% [2]

(iv) The variable resistor *R* in Fig. 5.2 is replaced by a few identical lamps connected in parallel. A student claims that as the number of lamps connected in parallel is increased, the lamps become dimmer.
Comment on the student's claim.

……………………………………………………………………………………………….

……………………………………………………………………………………………….

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

For Examiner's Use

6 **(a)** A composite block of mass 10 kg, made of woods of different densities ρ_1 and ρ_2, floats in still water of density ρ_w, as shown in Fig. 6.1. Each portion of wood is of height x and of a base with cross-sectional area A.

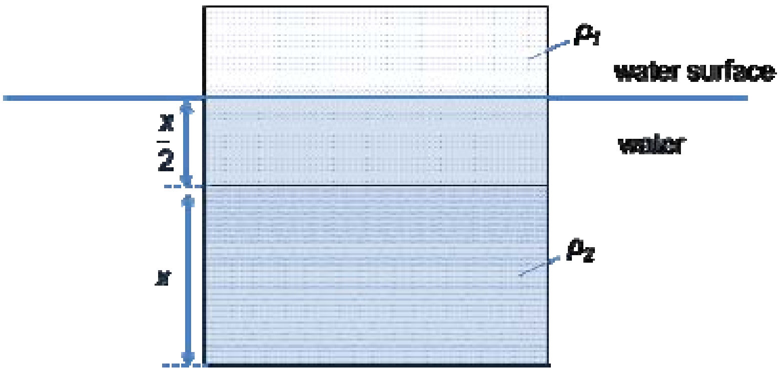

Fig. 6.1

(i) The block is pushed down by a distance l into the water without totally submerging it, and is then released.
It can be shown that the acceleration a of the block is given by

$$a = -\frac{\rho_w g}{(\rho_1 + \rho_2)x} l$$

Explain why the expression leads to the conclusion that the block bobs up and down in simple harmonic motion.

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

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(ii) The depth h of the block is measured from below the water surface to the base of the block as shown in Fig. 6.2.

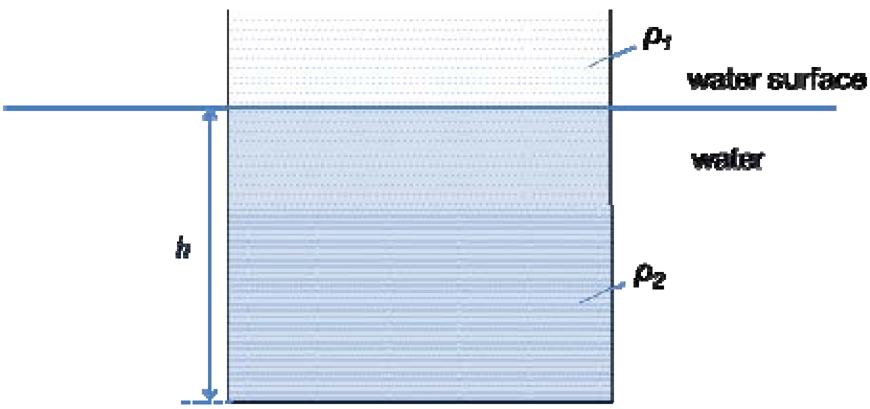

Fig. 6.2

Fig. 6.3 shows the variation with time t of the depth h of the base of the block below the surface.

For Examiner's Use

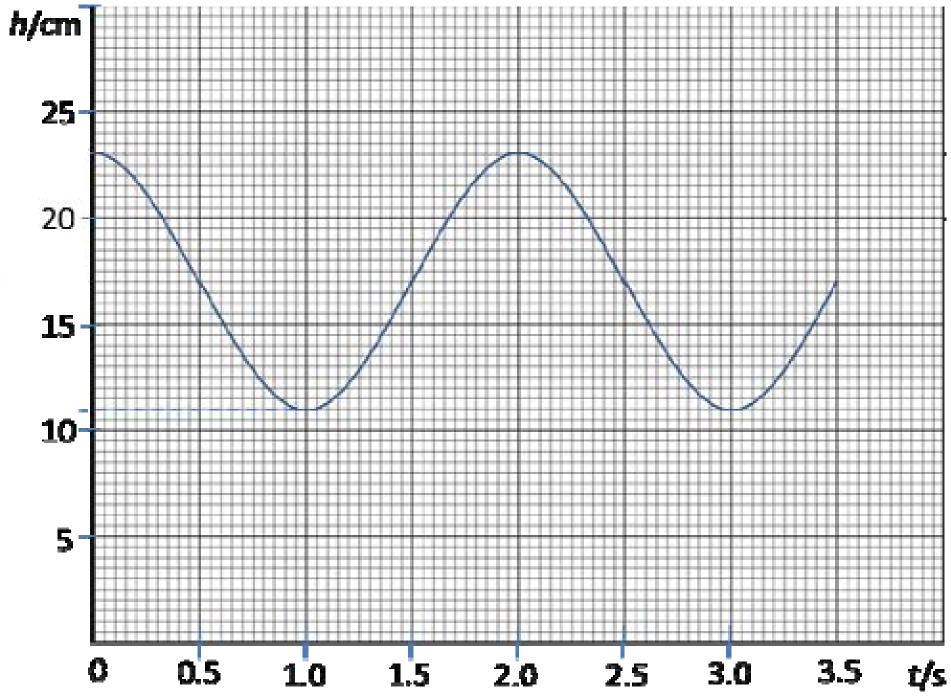

Fig. 6.3

1. Determine the amplitude of the oscillation of the block.

amplitude = …………… m [1]

2. Determine the angular frequency of the oscillation.

angular frequency = …………… rad s^{-1} [2]

3. Hence, show that the energy of the oscillation is 0.177J. [1]

For Examiner's Use

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

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

(ii) A coil with 800 turns is placed in a uniform horizontal magnetic field of flux density 5.0 x 10^{-2} T. The area of the coil perpendicular to the field is 2.5 x 10^{-2} m^2, as shown in Fig. 6.4.

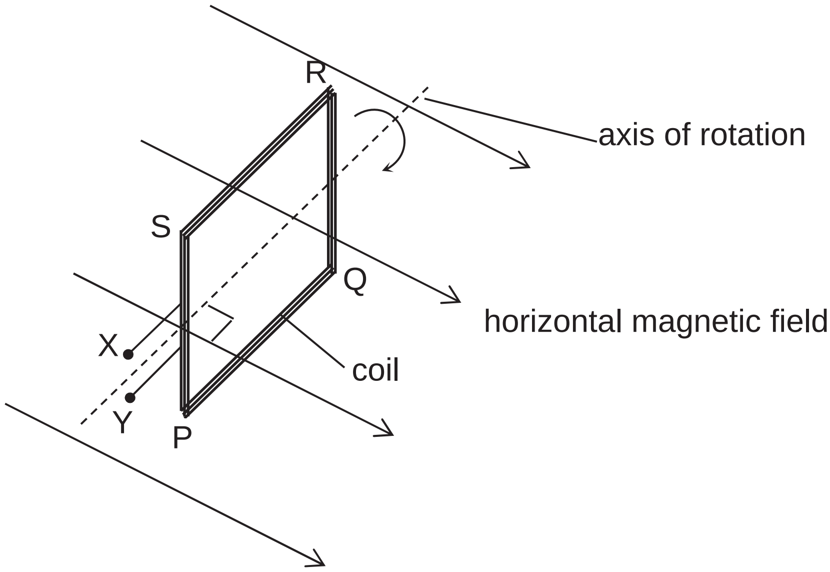

Fig. 6.4

1. Explain why an e.m.f. is induced in the coil.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

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

2. Determine the magnetic flux linkage of the coil.

magnetic flux linkage = ……………..……… Wb-turns [2]

For Examiner's Use

(c) The coil in **(b)** is rotated around the axis shown in Fig. 6.4. The flux linkage Φ of the coil varies with time t as shown in Fig. 6.5.

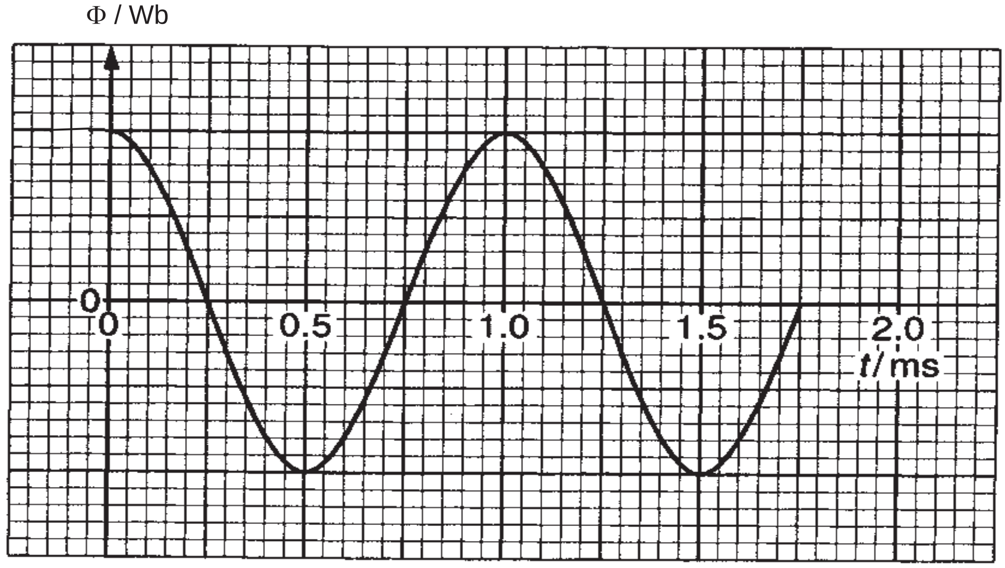

Fig. 6.5

(i) Derive the equation for the induced e.m.f. E of the coil, where N is the number of turns in the coil, B is the magnetic flux density, A is the area of coil, and ω is the angular frequency of the change in magnetic flux linkage. [2]

For Examiner's Use

(ii) Sketch on Fig. 6.6 the variation with time of the e.m.f. across XY. Label the maximum value of the e.m.f. [2]

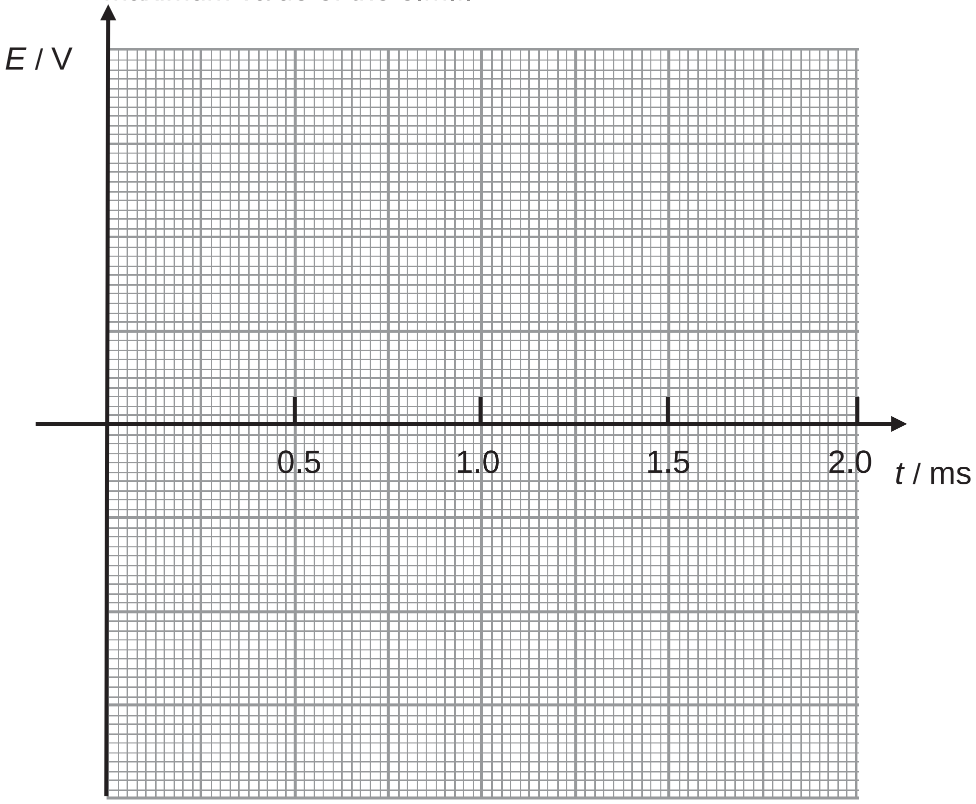

Fig. 6.6

(d) A resistor of resistance 5000 Ω is now connected across XY.

(i) Determine the mean power dissipated in the resistor.

mean power = ……………..……… kW [2]

(ii) Use energy conservation to explain why the oscillations of the coil are damped.

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………………………………………………………………………………………[2]

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General Certificate of Education Advanced Level
Higher 2

NAME	

CG		**INDEX NO.**	

PHYSICS 9749 / 04

Preliminary Examination **29 August 2017**
Paper 4 Practical **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

Additional Material: Question Booklet for Question 4

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 14
2	/ 9
3	/ 20
4	/ 12
Total	/ 55

For Examiner's Use

1 This investigation considers the angles formed by the threads in a pulley system when it is in equilibrium.

(a) In this set-up, there are two threads – a long thread AB and a short thread CD, as shown in Fig.1.1. Two pulleys P and Q are identical.

Tie end A to the 100 g mass.

Pass the thread AB through pulleys P and Q.

Tie end B to the 50 g mass.

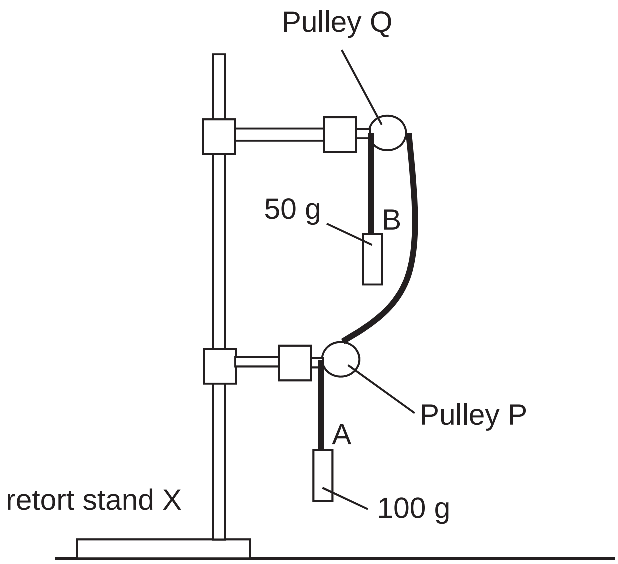

Fig.1.1

(b) Tie thread CD as shown in Fig.1.2. **Thread CD must be kept horizontal** throughout the whole experiment.

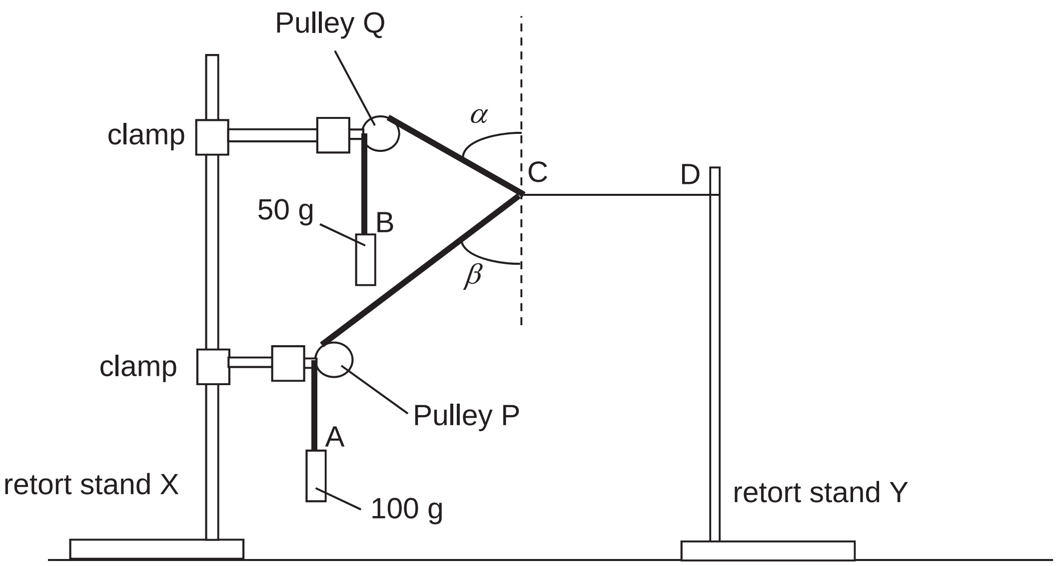

Fig.1.2

(c) Measure the angles α and β.

α = ………………..

β = ……………….. [1]

(d) Estimate the percentage uncertainty in α.

percentage uncertainty in α = ……………….. [1]

(e) State one significant source of error that may have affected the accuracy of the readings of angles α and β.

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(f) Suggest one improvement that could be made to the experiment to address the error identified in **(e).** You may suggest the use of other apparatus or a different procedure.

………………………………………………………………………………………………

………………………………………………………………………………………………

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

For Examiner's Use

(g) It is suggested that cos α is directly proportional to cos β. Move the retort stand Y to the right and adjust thread CD so that it is horizontal. Obtain one more set of values of α and β to investigate this suggestion. State and explain whether you agree with this suggestion.

Present your measurements and calculated results clearly. Plotting of graph is not required.

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……………………………………………………………………………………………………[6]

(h) Let the tensions in CA, CB and CD be T_1, T_2, and T_3 respectively.

By considering the equilibrium of forces acting at point C, write two equations relating T_1, T_2, T_3, α and β. [2]

(i) A student suggests that when there is an increase in the ratio of the mass hung at end A to the mass hung at end B of thread AB, the ratio of cos α to cos β would increase. Suggest how you would verify this.

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

[Total: 14 marks]

For Examiner's Use

2 In this experiment, you will measure the potential difference across resistor R_2 as the resistance of the circuit is varied.

(a) The Digital Multimeter (DMM) is used as a voltmeter.

Ensure that the black lead of the Digital Multimeter (DMM) is connected to the "COM" jack input, while the red lead is connected to the "V / Ω / mA" jack input.

Set the dial on the DMM to "**20 V**" mark in the "V" range.

(b) Set up the circuit as shown in Fig. 2.1. Connect one R_1 to the circuit and close the switch.

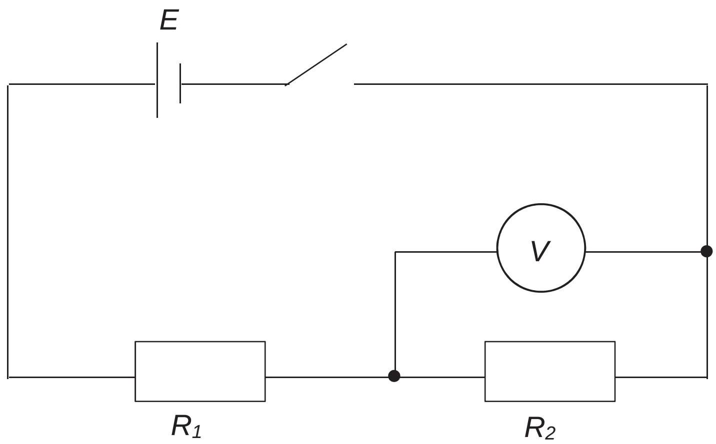

Fig. 2.1

(c) Record the potential difference across R_2, V using the voltmeter.

V = ……………….. [1]

(d) Change n, the number of resistor R_1 connected **<u>in parallel</u>**. Obtain three further sets of values for n and the corresponding values of V. [3]

For Examiner's Use

(e) Theory suggests that V and n are related by the equation

$$\frac{1}{V} = \frac{R_1}{nER_2} + \frac{1}{E}$$

where E is the e.m.f. of the power supply.

Suggest how you would determine the ratio of $\frac{R_1}{R_2}$ without measuring the resistance of the resistors directly.

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

(f) In the specification of a resistor, "tolerance" refers to the percentage error in the resistance of the resistor. The tolerance of each resistor that you use in this experiment is $\pm$ 5%, resulting in an absolute error of ΔR_1 for the resistance R_1, and ΔR_2 for the resistance of R_2.

Explain how the absolute error in the effective resistance of the circuit would change when a few R_1 are connected in series instead of being connected in parallel.

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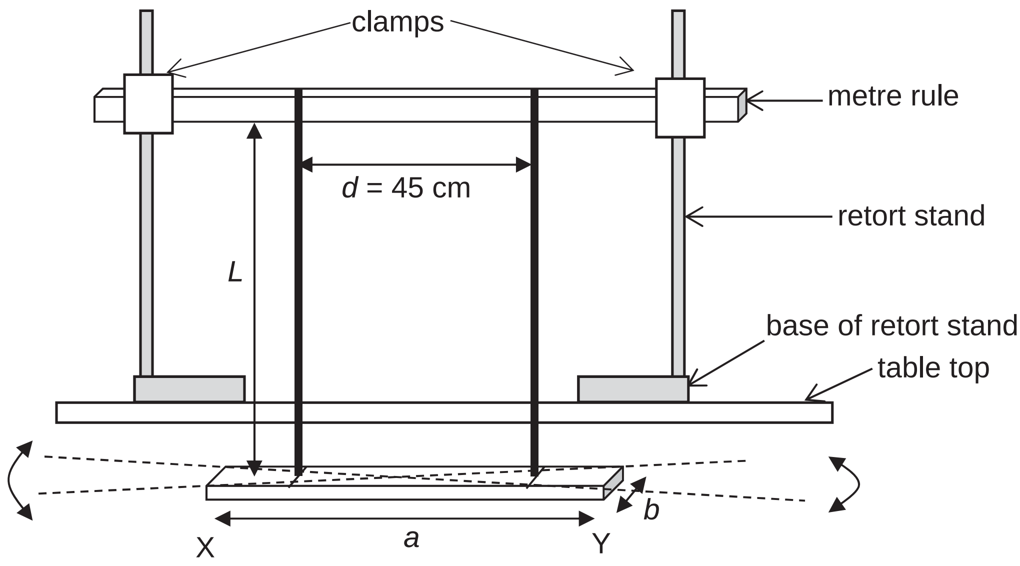
……………………………………………………………………………………………………[2]

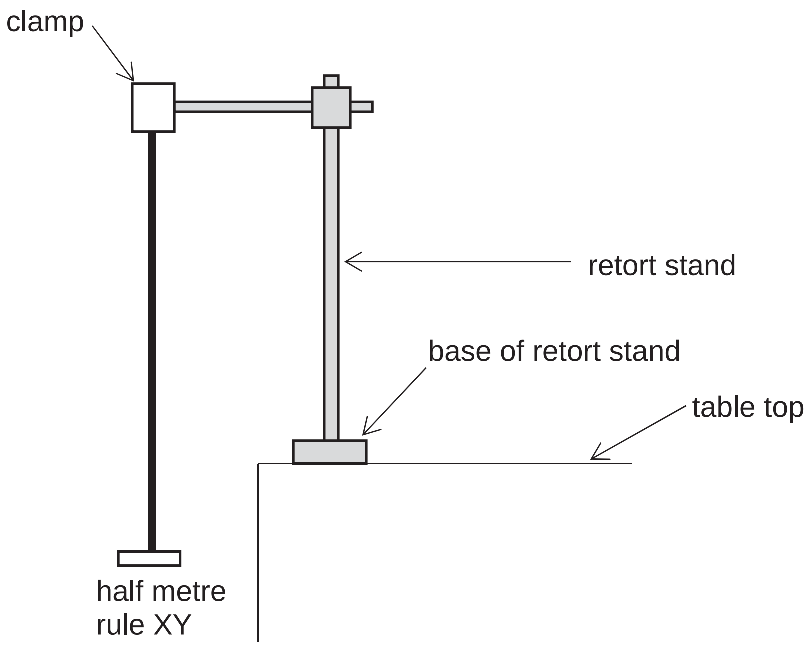
[Total: 9 marks]

3 In this experiment, you will investigate how the period of oscillation T of a suspended half-metre rule about a vertical axis through its centre, is related to its separation L from a horizontal metre rule.

(a) Suspend a half-metre rule XY symmetrically by two exactly equal lengths of threads. XY has a length of a, and a width of b. Fig.3.1 shows the front view and Fig.3.2 shows the side view of the set up.



Front view
Fig.3.1



Side view
Fig.3.2

(b) Arrange the threads at a distance d of 45 cm apart.

(c) Ensure that the threads are vertical. Adjust L to about 100 cm.

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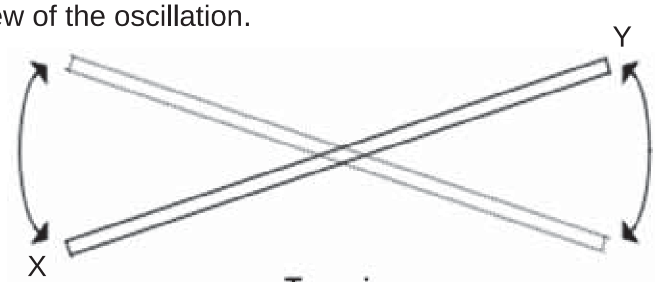
(d) Measure and record *L*.

L = ……………….. [1]

(e) Estimate the absolute uncertainty in this value of *L*.

absolute uncertainty = ……………….. [1]

(f) Give the suspended half-metre rule XY an angular displacement about a vertical axis through its centre, and set it into small angular oscillation as shown in Fig.3.1. Fig.3.3 shows the top view of the oscillation.



Top view
Fig. 3.3

(g) Determine the period *T* of the oscillations.

T = ……………….. [1]

(h) Vary L and repeat **(f)** and **(g)** to obtain further sets of values for L ranging from 20.0 cm to 100.0 cm, and the corresponding values of T. [7]

(i) It is suggested that T *and* L are related by the equation

$$g = \frac{16\pi^2(a^2+b^2)}{12d^2}\frac{L}{T^2}$$

Plot a suitable graph and hence determine the acceleration due to gravity, g. [6]

For Examiner's Use

(j) Comment on any anomalous data or results you may have obtained. Explain your answer.

…………………………………………………………………………………………………

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

(k) State one significant source of error in this experiment.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(l) Suggest one improvement that could be made to the experiment to address the error identified in **(k)**. You may suggest the use of other apparatus or different procedures.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(m) On the graph grid on page 10, sketch a second graph to represent the results if the distance between two threads *d* is increased. Label this graph Z. [1]

[Total: 20 marks]

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SERANGOON JUNIOR COLLEGE
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Higher 2

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PHYSICS 9749 / 04

Preliminary Examination **29 August 2017**
Paper 4 Practical **2 hour 30 minutes**

Question Booklet for Question 4

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

Shift
Laboratory

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
4	/ 12
Total	/ 12

For Examiner's Use

4 The history of solar energy is as old as humankind. In 1954, some scientists in the United States produced electricity from the sun. They invented photovoltaic cells, which capture the sun's energy and convert it into electricity. A photovoltaic cell is an electric cell made from two layers of different materials that can produce an electric current when light of certain frequencies shines on the cell. A solar panel is a collection of photovoltaic cells.

The frequency of the light falling on the solar panel can be varied by placing different colour filters in front of the light source as shown in Fig.4.1.

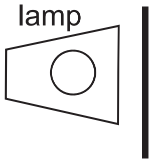

Fig.4.1

Design an experiment to investigate how the power generated by a solar panel depends on the frequency of the light falling on it.

The equipment available includes the following:

- Solar panel
- Colour filters
- Lamp
- Spectrometer with diffraction grating
- Ammeter
- Voltmeter
- Resistors
- Switch
- Stopwatch
- Rule
- Micrometer screw gauge

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) how the frequency of the light used is to be measured,
(d) how the power generated by the solar panel is to be measured,
(e) the control of variables,
(f) any precautions that would be taken to improve the accuracy, precision and safety of the experiment.

Diagram

[Total: 12 marks]

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END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

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PHYSICS 9749/01

Preliminary Examination **21st Sep 2017**
Paper 1 Multiple Choice **1 hour**

Additional Materials: OMS.

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.

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 record your choice in soft pencil on the OMS.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

For Examiners' Use	
MCQ	/ 30

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	ϕ	$= -\frac{GM}{r}$
temperature	T /K	$= T$ /ºC + 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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \frac{ln2}{t_{\frac{1}{2}}}$

Answer all questions.

1 Four students conducted an experiment to determine the value of g, acceleration of free fall. The values obtained by the students are as shown in the table.

Student	g_1 / m s^{-2}	g_2 / m s^{-2}	g_3 / m s^{-2}	g_4 / m s^{-2}
P	9.40	9.80	9.55	9.65
Q	9.80	9.60	9.90	10.06
R	10.10	9.90	10.15	9.85
S	9.45	9.48	9.52	9.55

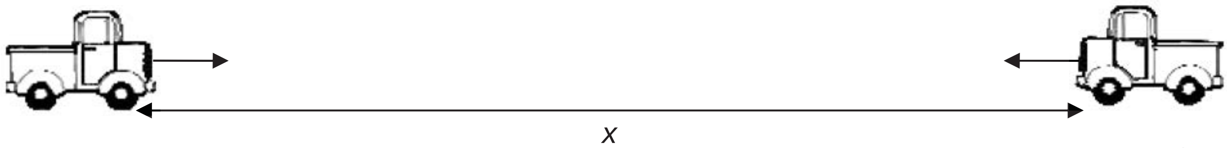
If the correct value of g is 9.82 m s^{-2}, which of the students has/have the largest systematic and random errors in their experiments ?

	Largest systematic error	Largest random error
A	Q	P
B	P	Q
C	Q	S
D	S	Q

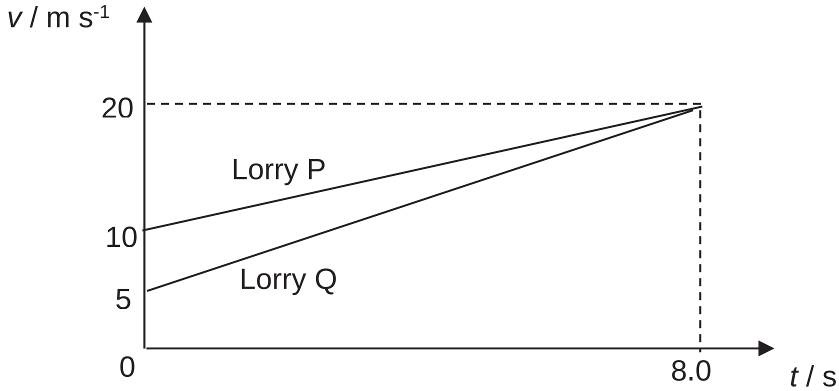
Ans : D

Student	Mean	Range
P	9.60	0.4
Q	9.84	0.46 (biggest range)
R	10.0	0.3
S	9.50 (biggest diff to correct value of 9.82 m s $^{-2}$)	0.1

2 Lorry P and Lorry Q are initially at a distance *x* metres apart and are travelling in the opposite directions as shown below.



The graph shows the variation with time *t* of the speeds *v* of Lorry P and Lorry Q respectively.



At t = 8.0 s, the two lorries are 40 m apart. What is x?

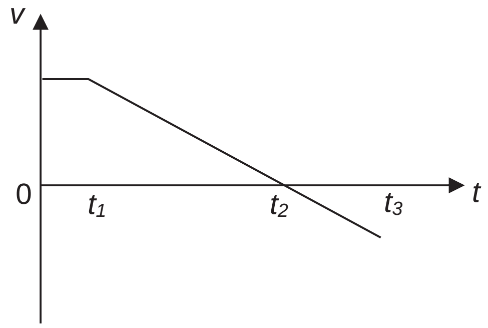
A 60 m **B** 120 m **C** 220 m **D** 260 m

Answer: D
Distance travelled by Lorry P + Distance travelled by Lorry Q + 40 = x

$$\frac{1}{2}(10+20)(8.0)+\frac{1}{2}(5+20)(8.0)+40=x$$

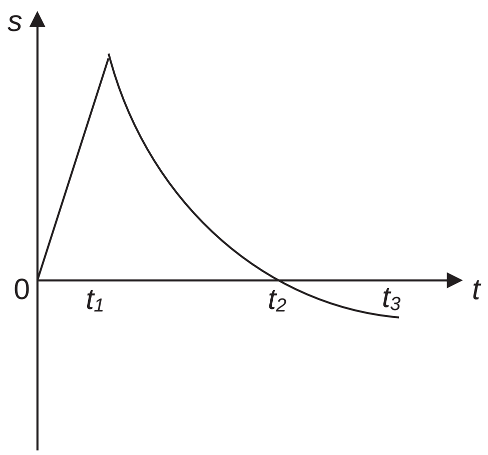
$$x=260\text{ m}$$

3 The graph shows how the speed v of an object varies with time t.

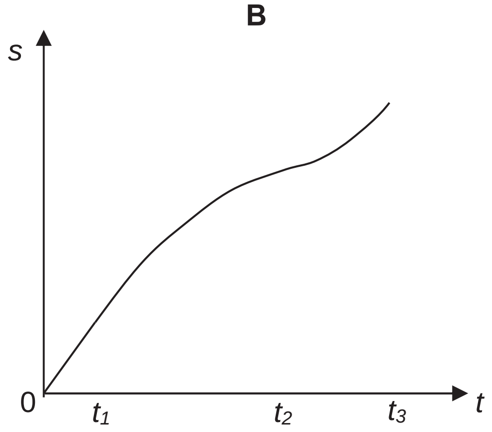


Which graph represents the variation the displacement s travelled by the object with time t?

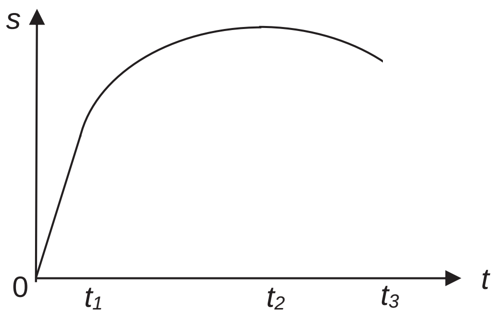
A



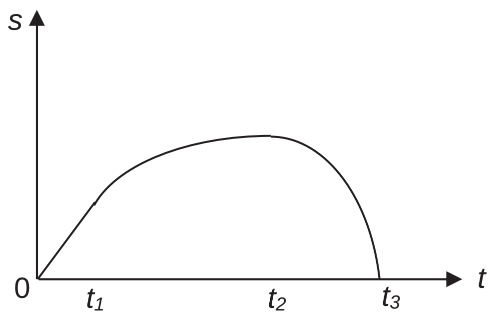
B



C



D



Answer: C
The area under v-t graph represents the change in displacement.

4 A jet of water of density 1000 kg m^{-3} leaves the nozzle of a hose of radius 2.0×10^{-2} m. The water is directed perpendicularly to the wall at a speed of 0.50 m s^{-1}. Assume that the water does not rebound.

What is the force exerted on the wall by the water?

A 0.314 N **B** 0.628 N **C** 1.27 N **D** 15.7 N

Answer: A

Force by wall on water $= \langle F_{net} \rangle = \text{mass per unit time} \times \Delta v$

$$= \frac{m}{\Delta t}\Delta v = \frac{\rho(Vol)}{\Delta t}\Delta v \qquad \text{since } m = \rho(Vol)$$

$$= \frac{\rho \times \pi r^2 L}{t}\Delta v$$

$$= \rho \times \pi r^2 v \Delta v$$

$$= \rho \pi r^2 v(0 - v)$$

$$= -\rho \pi r^2 v^2$$

$$= -1000\pi(2.0 \times 10^{-2})^2(0.50)^2$$

$$= -0.314 \text{ N}$$

By Newton's 3rd Law, Force by water on wall = Force by wall on water = 0.314 N

5 An astronaut falls vertically from a space vehicle and hops on the moon. The following statements are about the forces acting while the astronaut is in contact with the surface of the moon.

Which statement is correct?

A The force that the astronaut exerts on the moon is always equal to the weight of the astronaut.

B The force that the astronaut exerts on the moon is always less than the weight of the astronaut.

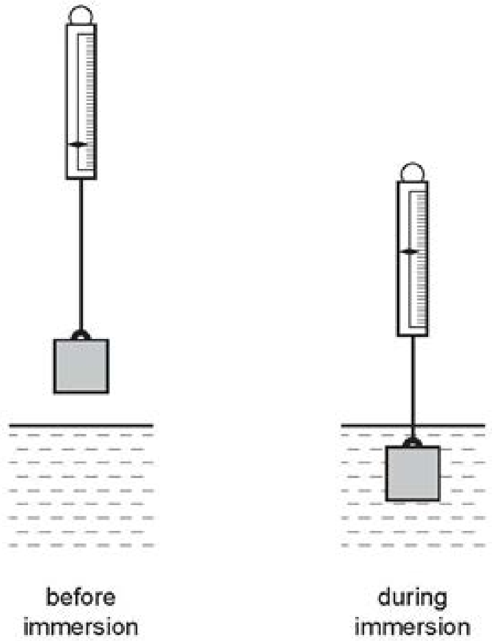
C The weight of the astronaut is always equal in magnitude and opposite in direction to the force that the moon exerts on the astronaut.

D The force that the astronaut exerts on the moon is always equal in magnitude and opposite in direction to the force the moon exerts on the astronaut.

Answer: D
Newton's third law

6 The diagram shows a metal cube suspended from a spring balance before and during immersion in water.

A reduction in the balance reading occurs as a consequence of the immersion.



Which statement is correct?

A The balance reading will be further reduced if the cube is lowered further into the water.

B The balance reading during immersion corresponds to the upthrust of the water on the cube.

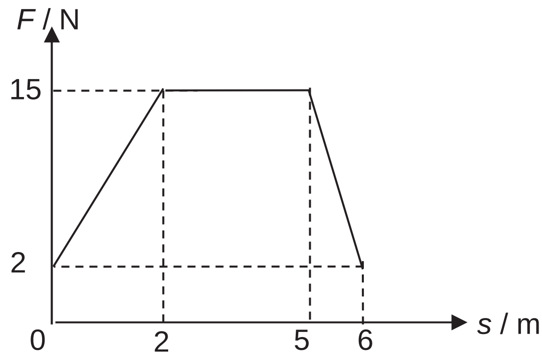
C The forces acting on the vertical sides of the cube contribute to the change in the balance reading.

D The balance reading during immersion will be increased if the water is replaced by oil.

Answer: D
Balance reading = W – U
Density of oil is less than the density of water, therefore the upthrust experienced by the cube when it is immersed in oil is less than when it is immersed in water. Therefore the balance reading increases when water is replaced by oil.

7 A student pushes a box from rest along a rough floor with constant friction of 2.0 N.

The graph shows the variation of the force exerted by the student on the box with displacement.



The final speed of the box after travelling 6 m is 5.0 m s^{-1}.

What is the mass of the box?

A 4.68 kg **B** 5.64 kg **C** 23.4 kg **D** 28.2 kg

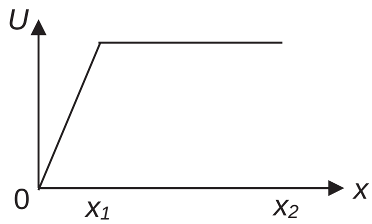
Answer: A
Using Work-energy theorem,
Net work done = Gain in KE

Work done by $F_{net} = KE_f - 0$

$$\frac{1}{2}(3+6)(13) - 2.0(6) = \frac{1}{2}m(5.0)^2 - 0$$

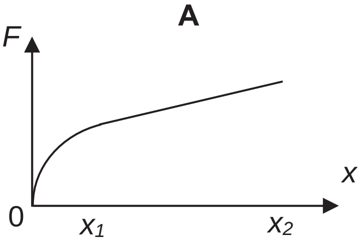
$m = 4.68$ kg

8 The graph how the potential energy U of an object varies with displacement x.

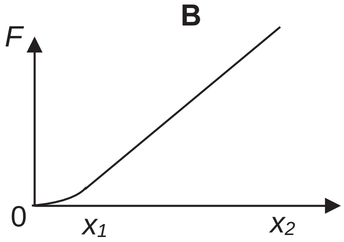


Which of the following graphs represents the variation of force acting on the object with displacement x?

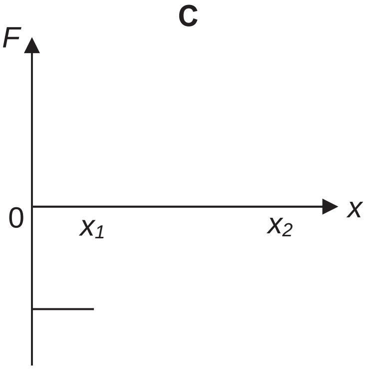
A



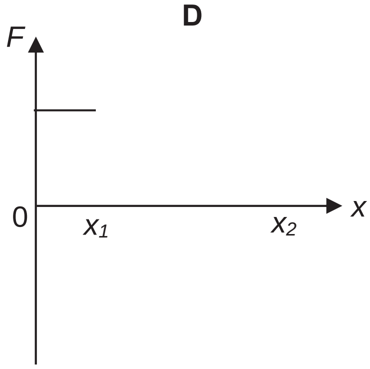
B



C

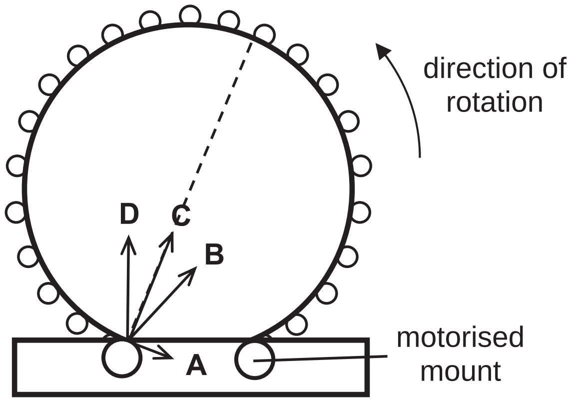


D



Answer: C
Using $F = -dU/dx$, the graph of F - x will be the negative of potential gradient.

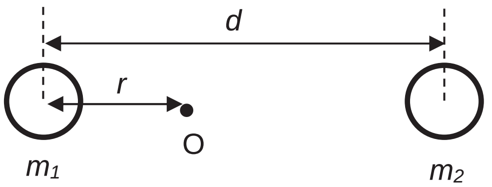
9 The Singapore Flyer wheel is supported at two points on the bottom by motorised mounts which cause it to rotate anticlockwise with constant angular velocity.



Which of the labelled arrows shows the direction of the force exerted by the motorised mount on the wheel just as it starts to turn?

Ans: **B**
There is normal contact force providing centripetal force for circular motion (indicated by C), plus tangential force (for wheel to start to move from rest) in anticlockwise direction (indicated by A). Thus, resultant force is indicated by B.

10 Two planets of mass m_1 and m_2 perform circular motion about their common centre of mass O with the same angular velocity. If the mean separation between the centres of the masses is d, what is the distance from the centre of mass m_1 to the centre of mass of the system, r?



A $\frac{m_1}{m_2}d$

B $\frac{m_2}{m_1}d$

C $\frac{m_1}{m_1+m_2}d$

D $\frac{m_2}{m_1+m_2}d$

	Ans: D Both masses should move in circular motion with the same angular velocity. For m_1, $\frac{Gm_1m_2}{d^2} = m_1 r\omega^2$ ---- (1) For m_2, $\frac{Gm_1m_2}{d^2} = m_2(d-r)\omega^2$ ---- (2) Solving (1) and (2), $r = \frac{m_2}{m_1+m_2}d$

11 The escape speed of an oxygen molecule at the Earth's surface is 1.1×10^4 m s^{-1}.
What is the escape speed at a height of 0.2*R* above the Earth's surface, where *R* is the radius of the Earth?

A 0.5×10^4 m s^{-1}
B 1.0×10^4 m s^{-1}
C 1.1×10^4 m s^{-1}
D 1.2×10^4 m s^{-1}

Ans: **B**

By conservation of energy,
Total initial energy = Total final energy
$KE_i + PE_i = 0 + 0$
½ mv_i^2 + (-GMm/R) = 0

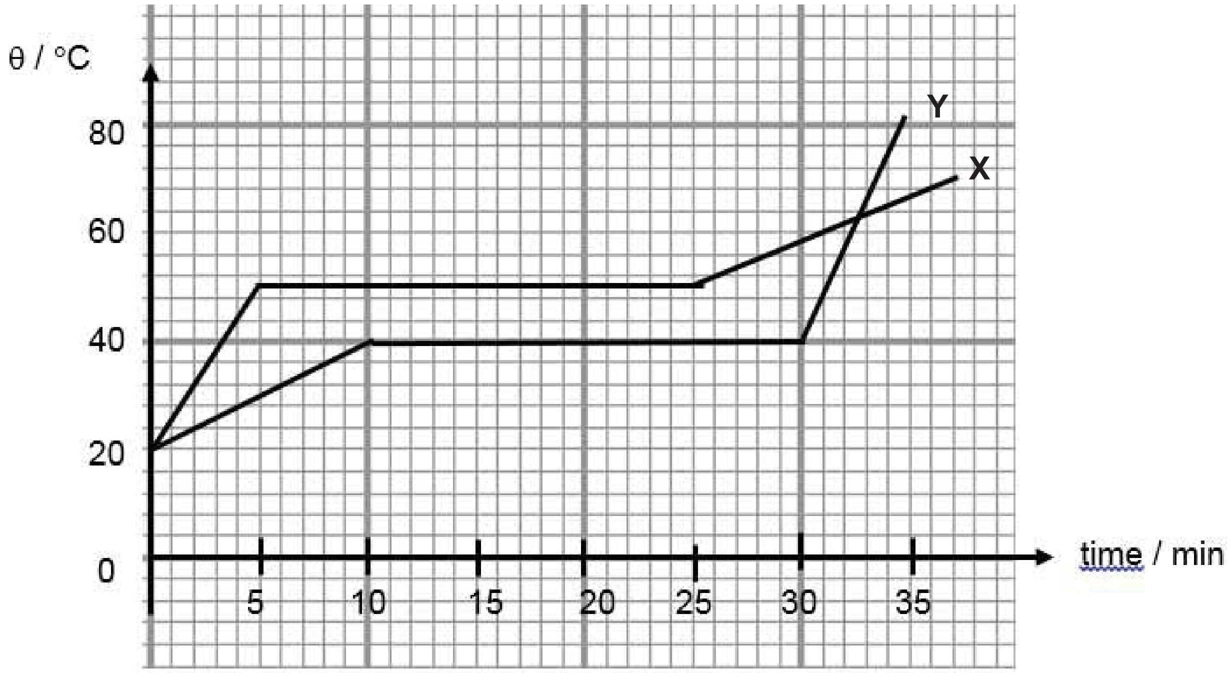
$$\frac{1}{2}mv_{iR}^2 + \left(-\frac{GMm}{R}\right) = 0 + 0$$

$$v_{iR} = \sqrt{\frac{2GM}{R}}$$

$$\frac{v_{i0.2R}}{v_{iR}} = \frac{\sqrt{\frac{2GM}{(1+0.2)R}}}{\sqrt{\frac{2GM}{R}}}$$

$$v_{i0.2R} = \sqrt{\frac{1}{1.2}}(1.1\times10^4) = 1.0\times10^4 \text{ m s}^{-1}$$

12 2.0 kg of solid X and 1.0 kg of solid Y are separately heated by two heaters of the same power. The power output of the heaters is the same throughout the whole experiment. The following graphs show the variation of the temperatures of X and Y with time.

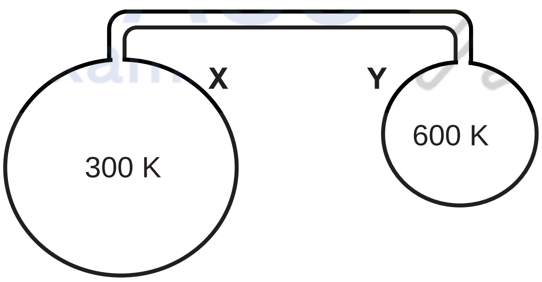


What is the ratio of the specific heat capacity of solid X to solid Y ?

A 1:3 **B** 1:6 **C** 2:3 **D** 3:2

Ans : **B**
Since power is the same,
$m_x c_x \Delta\theta_x / t_x = m_y c_y \Delta\theta_y / t_y$
$2 c_x (30) / 5 = 1 c_y (20)/10$
Therefore, $c_x / c_y = 1 : 6$

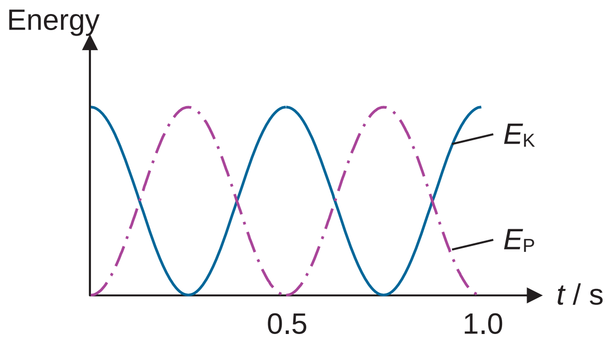
13 The volume of Bulb X is twice that of Bulb Y. They are filled with the same ideal gas and are connected by a narrow tube, as shown. A steady state is established with Bulb X held at 300 K and Bulb Y at 600 K. If there are *n* moles of gas in Bulb X, how many moles of gas are there in Bulb Y?



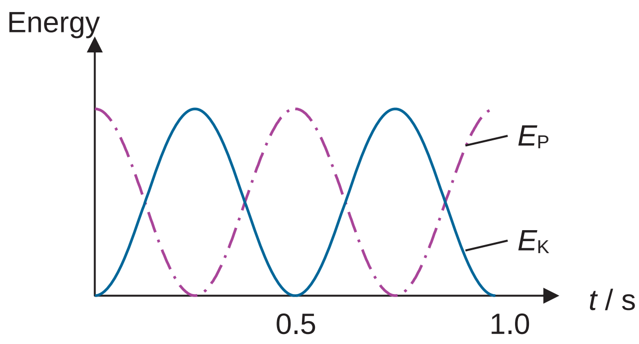
A ¼ *n* **B** ½ *n* **C** *n* **D** 2*n*

Ans : A
PV = nRT
Since gases are connected, $P_x = P_Y$
Therefore, $\frac{V_X}{V_Y} = \frac{n_X T_X}{n_Y T_Y}$
#
$$2 = \frac{n(300)}{n_Y(600)}$$
$n_Y = ¼\, n$

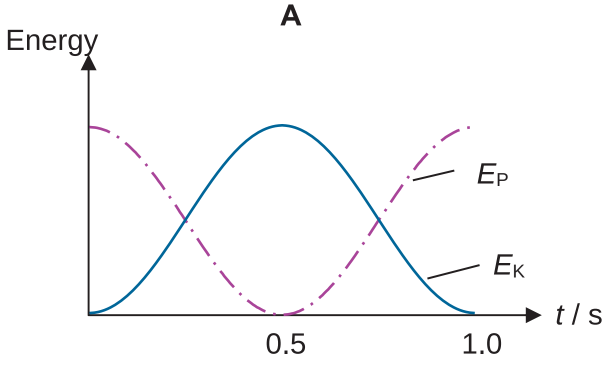
14 A certain simple pendulum swings with a period of 1.0 s. The bob of such a pendulum is given a small displacement and released at t = 0. Which diagram correctly shows the bob's kinetic energy E_K and its potential energy E_P varies with time?



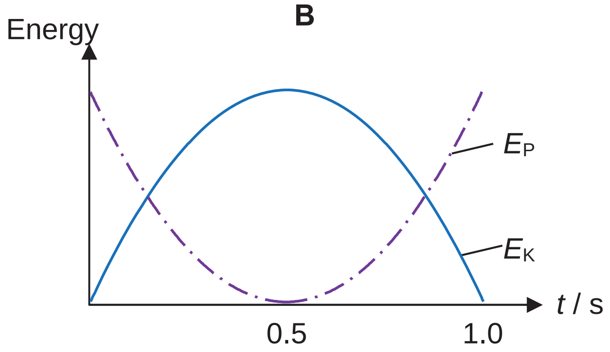
A



B



C

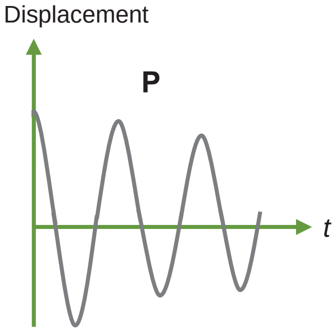


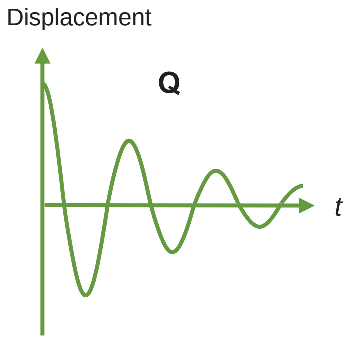
D

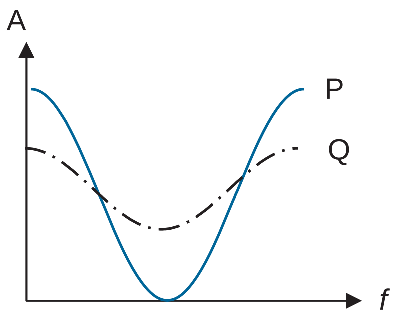
Ans : B
Eqns of the 2 graphs are given by :

$$E_K = \frac{1}{2} m v^2$$
$$= \frac{1}{2} m \omega^2 x_0^{\,2} \cos^2 \omega t$$
$$E_P = \frac{1}{2} m \omega^2 x^2$$
$$= \frac{1}{2} m \omega^2 x_0^{\,2} \sin^2 \omega t$$

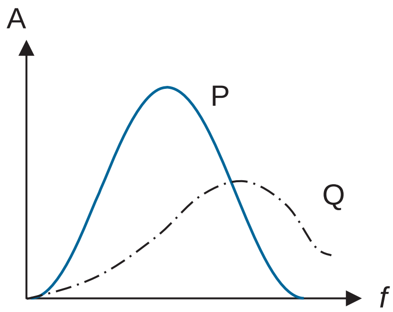
15 Two objects P and Q are given the same initial displacement and then released. The variation of their displacements with time *t* are as shown in the given graphs. The two objects are then driven by sinusoidal driving forces of the same constant amplitude and of variable frequency *f*. Which of the following graphs correctly shows how the amplitudes A of P and Q varies with *f* ?



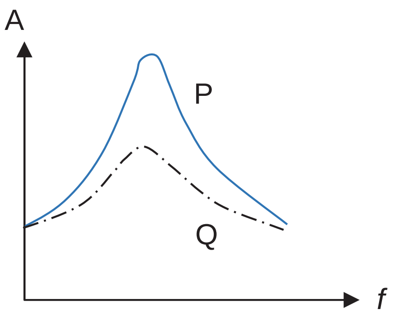




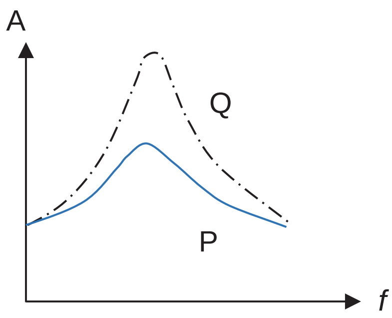
A



B



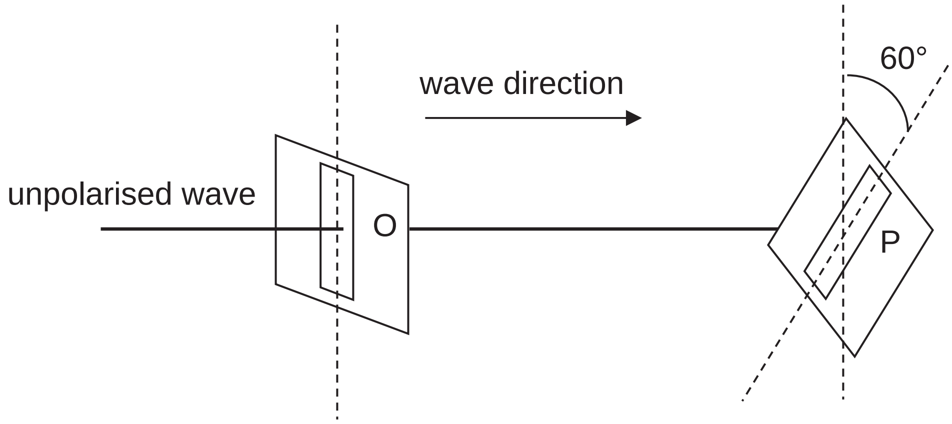
C



D

Ans : C
Amplitude-frequency graph should increase to a peak at the natural frequency and decrease thereafter. P and Q appears to have similar natural frequencies. P is lightly damped while Q has greater degree of damping. Therefore, amplitudes of P and Q will peak at similar frequencies with peak for Q lower and occurring at a slightly lower frequency.

16 An unpolarised wave passes through polariser O such that the emerging wave is plane-polarized with an intensity of 2.0 W m^{-2}. A second polariser P is placed further such that the plane-polarised wave is incident normally on it. Polariser P is rotated clockwise by an angle of 60°.

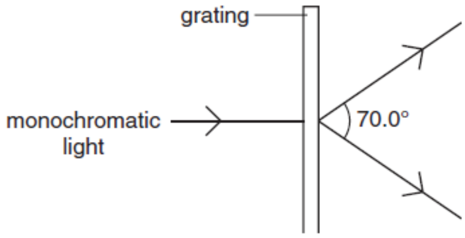


What is the intensity of the wave after passing through polariser P ?

A 0.25 W m^{-2} **B** 0.5 W m^{-2} **C** 1.0 W m^{-2} **D** 2.0 W m^{-2}

Ans : B
Using Malus' Law, $I_p = I_o \cos^2 \theta$
$= 2.0 (\cos^2 60^o) = 0.5$ W m^{-2}

17 A diffraction grating is used to measure the wavelength of monochromatic light as shown below.



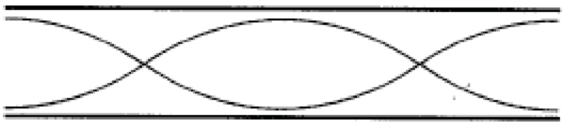
The spacing of the slits in the grating is 1.00 x 10^{-6} m. The angle between the first order diffraction maximas is 70.0°.

What is the wavelength of the light?

A 287 nm **B** 470 nm **C** 574 nm **D** 940 nm

Answer: C
Using, $d \sin \theta = n\lambda$
$\lambda = (d \sin\theta) / n$
For the question, $n = 1$, $\theta = 70 / 2 = 35^o$, $d = 10^{-6}$ m,
$\lambda = (10^{-6}) (\sin 35^o) / (1)$
$= 574$ nm

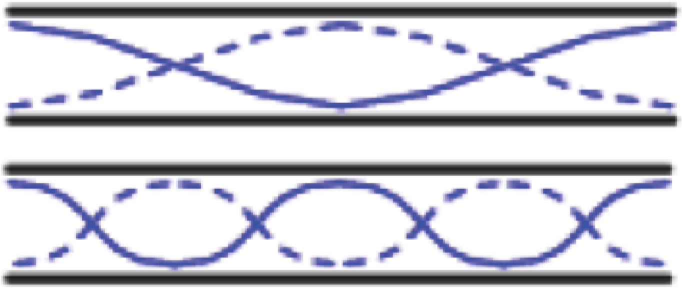
18 A stationary wave is formed in an open tube as represented in the diagram.



How many antinodes are formed by a stationary wave of twice the frequency?

A 2 **B** 4 **C** 5 **D** 6

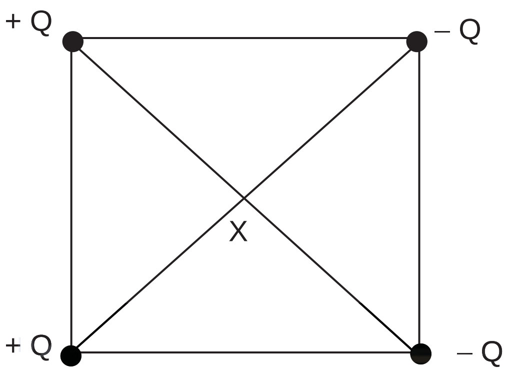
Ans: C
By drawing the stationary waves that has twice the frequency of f_1, it can be counted that there are 5 antinodes.



f_1

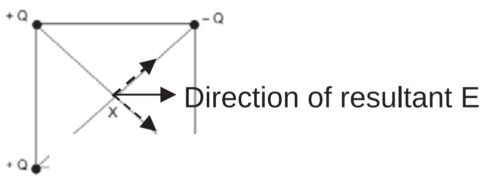
$2f_1$

19 The diagram shows four point charges arranged in the corners of a square. What are the values of the electric field strength *E* and the electric potential *V* at a point X in the middle of the square ?



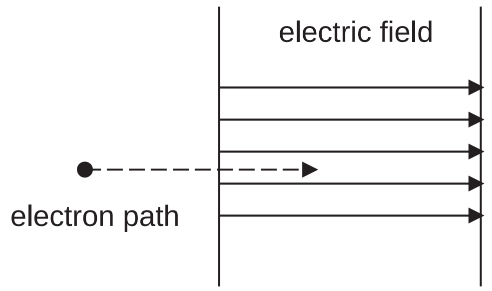
	E	*V*
A	not zero	zero
B	not zero	not zero
C	zero	not zero
D	zero	zero

Ans : **A**



Let the distance from charge to X be r.
Vnet = +Q/4πεr + (+Q/4πε)
+ (-Q/4πε) + (-Q/4πε)
= 0

20 An electron has a de Broglie wavelength of 5.6 x 10^{-11} m. It enters an electric field with strength of 2.3 x 10^4 V m^{-1} as shown.

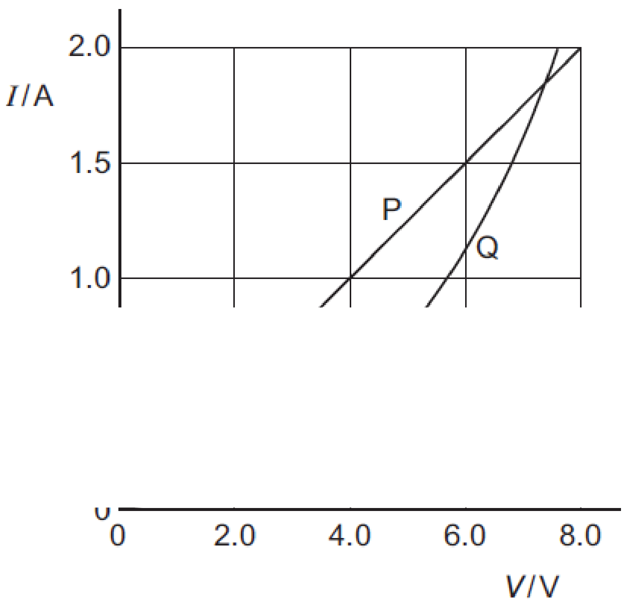


How long will it take for the electron to stop after it enters the electric field?

A 5.0 x 10^{-28} s **B** 2.0 x 10^{-15} s **C** 3.2 x 10^{-9} s **D** 4.2 x 10^{-2} s

Ans : C
λ = h/p = h/mv
Therefore, v = h/mλ -----(1)
F = qE = ma
a = qE/m -----(2)
Using v = u + at where v = 0, and u = h/mλ and a = -qE/m
0 = h/mλ - (qE/m) t
Therefore, t = h/λqE = 6.63 x 10^{-34}/(5.6 x 10^{-11} x 1.6 x 10^{-19} x 2.3 x 10^4)
= 3.2 x 10^{-9} s

21 The *I*-*V* characteristics of two electrical components P and Q are shown below.



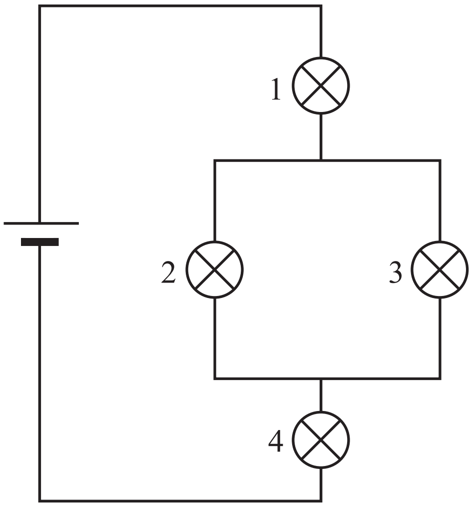
Which statement is correct?

A P is a resistor and Q is a filament lamp.
B The resistance of Q increases as the current in it increases.
C At 1.9 A the resistance of Q is approximately half that of P.
D At 0.5 A the power dissipated in Q is double that in P.

SRJ

Ans: **D**
A. Q is a thermistor.
B. Resistance of Q decreases as current in it decreases.
C. At 1.9 A, the resistance
D. P = IV. When the curren at Q is double that at P.

22 An ideal cell and four identical bulbs are connected as shown.



Bulb 3 is removed. Which of the following describes the changes in the brightness of bulbs 1, 2 and 4?

	Bulb 1	**Bulb 2**	**Bulb 4**
A	dimmer	brighter	brighter
B	dimmer	brighter	dimmer
C	brighter	dimmer	brighter
D	dimmer	dimmer	dimmer

Ans: B

With bulb 3 in parallel to bulb 2, the potential difference across bulb 2 is a smaller fraction of the cell's e.m.f as compared to that of bulbs 1 and 4.

With bulb 3 removed, the potential difference across bulb 2 increases while those of bulb 1 and bulb 4 decrease correspondingly. With fixed resistance, power dissipated increases as potential increases, hence bulbs 1 and 4 became dimmer and bulb 2 became brighter.

Alternatively,

Before bulb 3 was removed,

$$R_{total} = R + \left(\frac{1}{R} + \frac{1}{R}\right) + R = 2.5R$$

$$I_{total} = \frac{V}{2.5R} = 0.4\frac{V}{R} = I_{bulb1} = I_{bulb4}$$

$$I_{bulb2} = I_{bulb3} = 0.2\frac{V}{R}$$

After bulb 3 was removed,

$$R_{total} = R + R + R = 3R$$

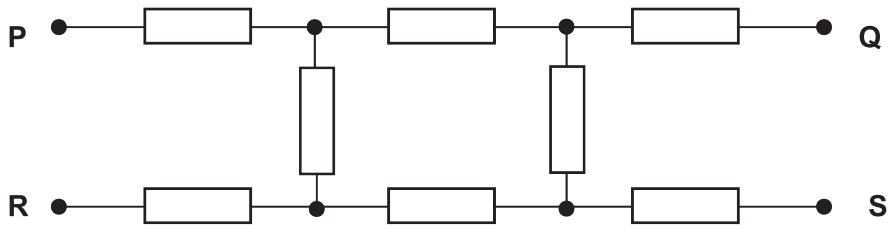
$$I_{total} = \frac{V}{3R} = 0.33\frac{V}{R} = I_{bulb1} = I_{bulb2} = I_{bulb4}$$

$\therefore I_{bulb1}$ and I_{bulb4} decreased, I_{bulb2} increased

since brightness $\propto$ power dissipated $= I^2R$

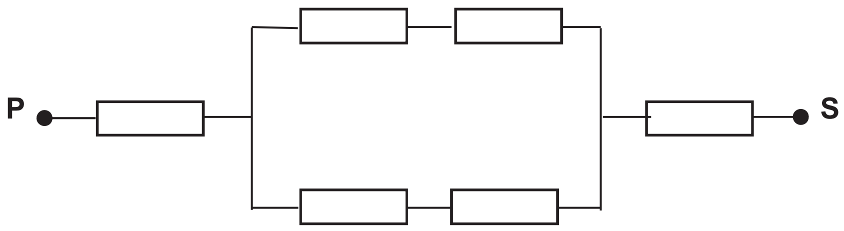
bulbs 1 and 4 became dimmer, bulb 2 became brighter

23 Each resistor has a similar resistance of 10 Ω. What is the equivalent resistance of the circuit shown in the figure below between points **P** and **S**?



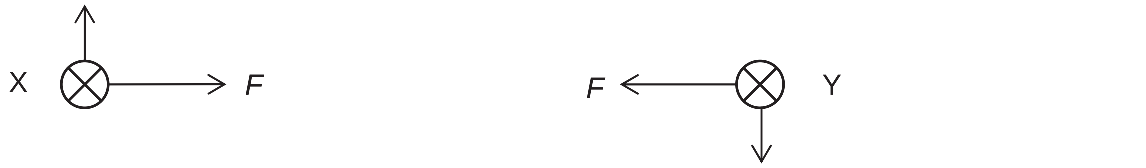
A 10 Ω **B** 20 Ω **C** 30 Ω **D** 40 Ω

Ans: **C**



R_{eff} = 10 + [1/20 + 1/20]$^{-1}$ +10 = 30 Ω

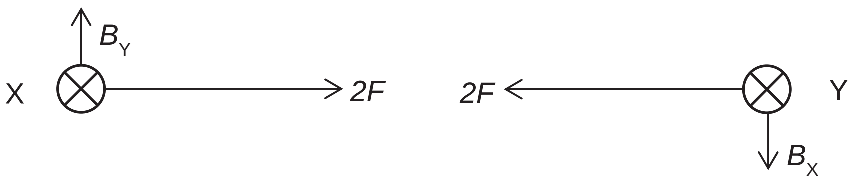
24 Two long, parallel, straight wires X and Y carry equal currents into the plane of the page as shown. The diagram shows arrows representing the magnetic field strength *B* at the position of each wire and the magnetic force *F* on each wire.



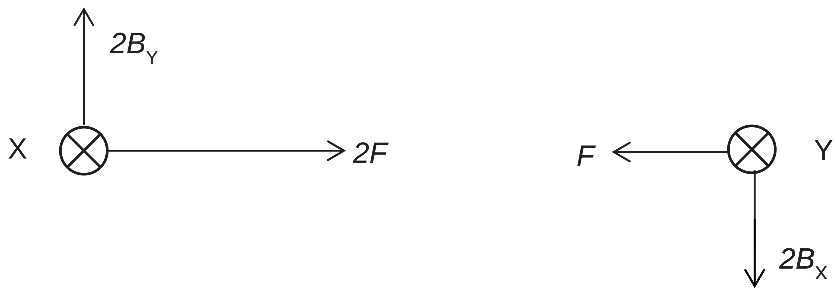
The current in wire Y is doubled. Which diagram best represents the magnetic field strengths and forces?

A

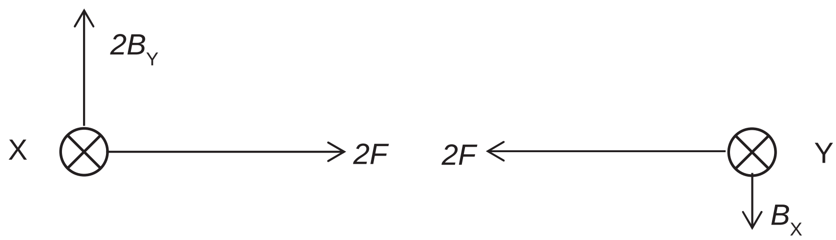
B



C



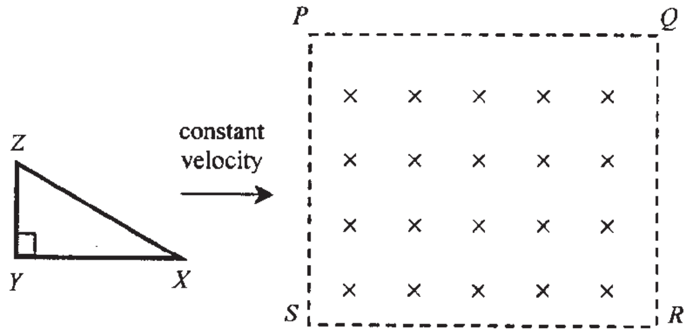
D



Ans: D

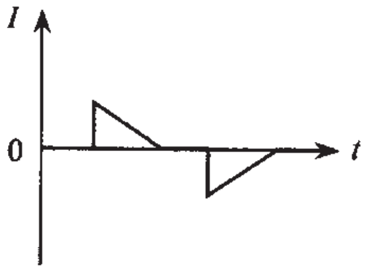
When current in wire Y doubled, field strength at X due to Y = $2B_Y$,
the magnetic force on X due to Y = $2B_Y(I)(L) = 2F$,
The magnetic force on Y due to X = $B_X(2I)(L) = 2F$, opposite in direction.
(obeying Newton's 3rd L

25

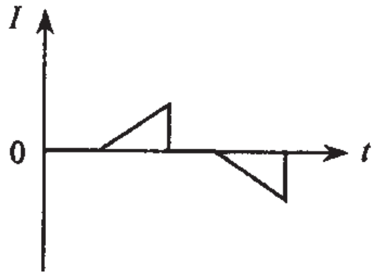


In the diagram above, *XYZ* is a small right-angled triangular metal frame moving with a constant velocity across a rectangular region *PQRS* with a uniform magnetic field pointing into the paper. Which of the following graphs best shows the variation of the current *I* induced in the frame with time *t*?

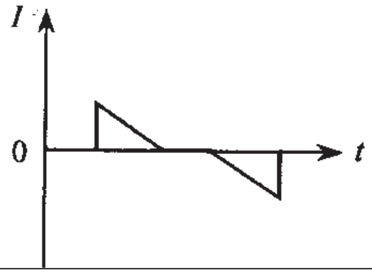
A



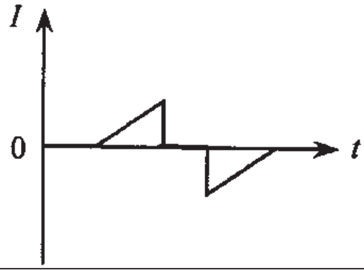
C



B



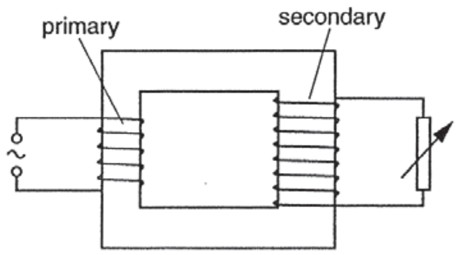
D



Ans: C

As triangle enters into magnetic field, area increases at an increasing rate, thus induced emf increases and induced current increases until the whole triangle is inside the magnetic field. As triangle exits from the magnetic field, area decreases at an increasing rate, and induced current increases to maximum until the triangle leaves the magnetic field.

26 The primary coil of a transformer is connected to an alternating voltage supply. The secondary coil is connected across a variable resistor.



Which change will cause a decrease in the p.d. across the secondary coil?

A increasing the number of turns of the primary coil

B increasing the current in the primary coil

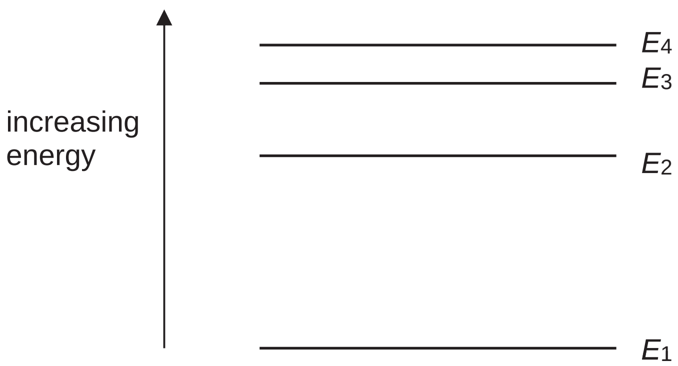
C increasing the cross-sectional area of the secondary coil

D increasing the resistance of the variable resistor

Ans: **A**

$V_s/V_p = N_s/N_p$

27 Some of the energy levels of the hydrogen atom are represented in simplified form by the given diagram which has a linear scale. The emission of blue light is associated with the transition of an electron from E_4 to E_2. Which of the following transitions could be associated with the absorption of the red light ?



A E_2 to E_3

B E_1 to E_4

C E_3 to E_2

D E_4 to E_1

Ans : A
Absorption transition is in the direction of increasing energy.
$\Delta E = hf$
Since $f_{red} < f_{blue}$, therefore $\Delta E_{red} < \Delta E_{blue}$

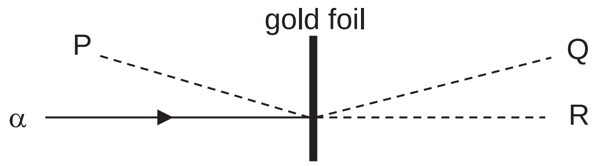
28 The momentum of a proton is measured with an uncertainty of 1.0%. Given that it has kinetic energy of 1.00 MeV, which of the following is the minimum uncertainty in its position?

A 1.1×10^{-11} m **B** 2.9×10^{-12} m **C** 1.1×10^{-12} m **D** 7.0×10^{-13} m

Ans : B
$E = p^2/2m$,
$p = \sqrt{(2mE)}$
$= \sqrt{(2 \times 1.67 \times 10^{-27} \times 1.6 \times 10^{-13})}$
$= 2.312 \times 10^{-20}$ kg m s^{-1}
Therefore uncertainty in p = $0.01 \times 2.312 \times 10^{-20}$
$= 2.312 \times 10^{-22}$ kg m s^{-1}
$\Delta x \Delta p > h$
$\Delta x > 6.63 \times 10^{-34} / 2.312 \times 10^{-22}$
$= 2.87 \times 10^{-12}$ m

29 In an experiment on α-particle scattering, α-particles are directed onto a gold foil, and detectors are placed at positions P, Q and R as shown in the diagram below.

What is the distribution of α-particles as recorded at P, Q and R respectively?



	Position P	Position Q	Position R
A	none	none	all
B	none	some	most
C	most	some	fewer than at position Q
D	fewer than at position Q	some	most

Answer: D
Majority of the α-particles managed to pass through the gold foil without being deflected since the atom consists of mostly empty space.

30 Which statement about alpha, beta and gamma radiation is correct?
A Alpha radiation has the greatest ionising power.
B Beta radiation has the greatest ionising power.
C Gamma radiation has the greatest ionising power.
D Alpha, beta and gamma radiation have nearly equal ionising powers.

Answer: A
Ionisation power
Alpha radiation > beta radiation > gamma radiation

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

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INDEX NO.

PHYSICS 9749/02

Preliminary Examination **11th September 2017**
Paper 2 Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 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.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 8
Q2	/ 9
Q3	/ 15
Q4	/ 9
Q5	/ 20
Q6	/ 19
Total marks	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	ϕ	$= -\frac{GM}{r}$
temperature	T /K	$= T$ /ºC + 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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 In order to determine the value of the gravitational acceleration g, a student throws a ball at a speed of 15 m s^{-1} horizontally from a building.

(a) The student collects the following data for the ball when it reaches the ground.

Quantity	**Value**	**Absolute Uncertainty**
Vertical displacement	122.500 m	0.002 m
Horizontal displacement	75.000 m	0.002 m

(i) Show that the time taken to reach the ground is 5.0 s. [1]

Consider the horizontal direction,

$s_x = u_x t$

$t = \dfrac{75.0}{15}$ [M1]

$= 5.0$ s

(ii) The uncertainty of the time taken is 0.4 s.

Determine the value of g, with its associated uncertainty.

Consider the vertical direction,

$s_y = u_y t + \frac{1}{2}gt^2 = \frac{1}{2}gt^2$

$g = \dfrac{2s_y}{t^2} = \dfrac{2(122.5)}{5.0^2} = 9.80$ m s^{-2} [M1]

$\dfrac{\Delta g}{g} = \dfrac{\Delta s_y}{s_y} + 2\dfrac{\Delta t}{t} = \dfrac{0.002}{122.5} + 2(\dfrac{0.4}{5.0})$ [M1]

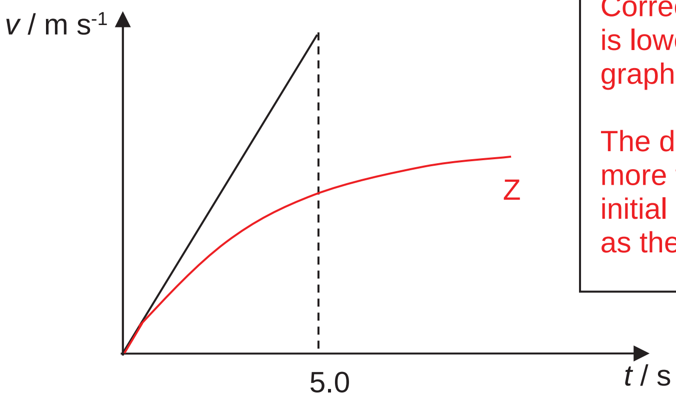
$\Delta g = 2$ m s^{-1} (1 s.f.)

$g \pm \Delta g = (10 \pm 2)$ m s^{-2} [A1]

g = ………………… ± ……………….. m s^{-2} [3]

For Examiner's Use

(b) In the absence of air resistance, the variation of the vertical speed *v* of the ball with time *t* is shown in Fig. 1.1.



Correct shape – a curve that is lower than the original graph [B1]

The duration of motion is more than 5.0 s, and the initial gradient is the same as the original graph [B1]

Fig. 1.1

(i) In reality, there is air resistance. Sketch the graph of variation of vertical speed with time on Fig. 1.1, and label this graph Z. [2]

(ii) Explain the shape of the graph Z.

As the ball falls downwards, its speed increases and therefore upward air resistance acting on it also increases. [B1]
The net force acting on the ball decreases, therefore the acceleration decreases, resulting in the gradient of graph Z being gentler than that of the original graph. [B1]

.... [2]

2 Truck X of mass 22 000 kg and moving at a speed of 3.0 m s^{-1}, catches up and collides with Truck Y moving at 1.0 m s^{-1} moving in the same direction as shown in Fig. 2.1.

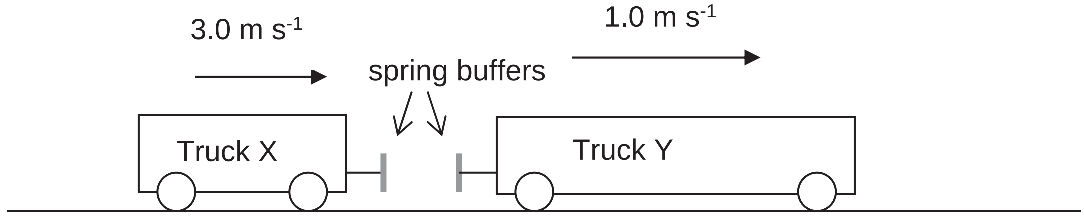


Fig. 2.1

Fig. 2.2 shows how the speeds of the trucks vary with time *t* before, during and after the collision.

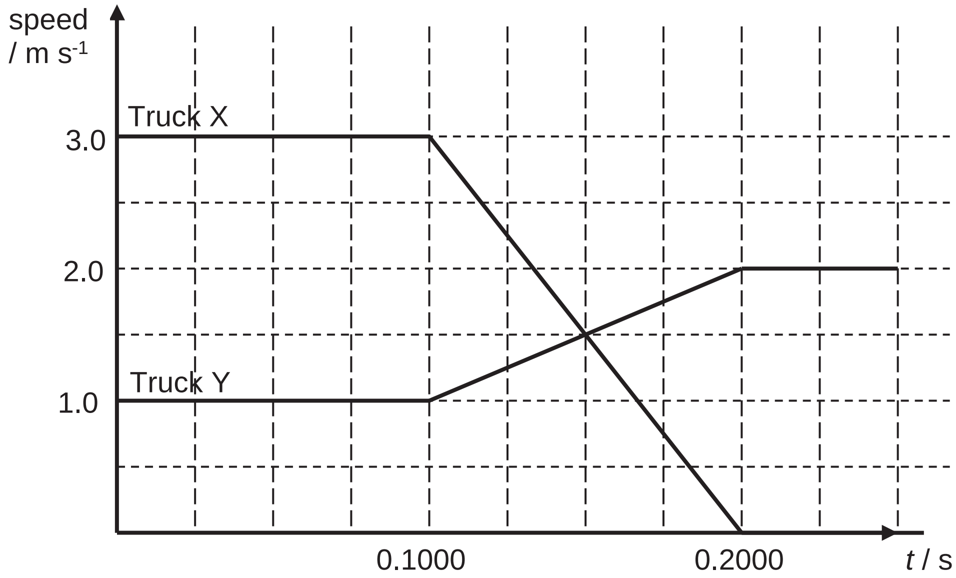


Fig. 2.2

(a) Using Fig. 2.2, show that the mass of Truck Y is 66000 kg. [1]

Using Principle of Conservation of Linear Momentum,
Total momentum before collision = Total momentum after collision
or
$m_X u_X + m_Y u_Y = m_X v_X + m_Y v_Y$
$22000(3.00) + m_Y(1.00) = 0 + m_Y(2.00)$ [M1]
$m_Y = 66000$ kg

(b) Showing your working clearly, explain whether this collision is elastic. [2]

Total kinetic energy before collision = ½ x 22000 x 3^2 + ½ x 66000 x 1^2
= 99000 + 33000
= 132 000 J
Total kinetic energy after collision = 0 + ½ x 66000 x 2^2 = 132 000 J
[M1 for both total KE before and after]
Since total kinetic energy of the system is conserved, collision is elastic. [A1]

OR

Relative speed of approach = $u_X - u_Y$ = 3 - 1 = 2 m s^{-1}
Relative speed of separation = $v_Y - v_X$ = 2 – 0 = 2 m s^{-1}
[M1 for both RSA and RSS]
Since the speed of ap , collision is elastic.[A1]

For Examiner's Use

(c) **(i)** State the time at which the trucks are closest to each other.

At 1.500 s, when the relative speed is 0 m s^{-1}.

t = ………………… s [1]

(ii) **1.** Calculate the total kinetic energy of the two trucks at the time stated in **(c)(i).**

At 1.500 s,

$$\text{Total KE} = \frac{1}{2}m_X v_X^{\ 2} + \frac{1}{2}m_Y v_Y^{\ 2}$$

$$= \frac{1}{2}(22000)(1.5)^2 + \frac{1}{2}(66000)(1.5)^2$$

No ecf from (c)(i)

$= 99000$ J [A1]

total kinetic energy = ………………… J [1]

2. Hence, calculate the maximum elastic potential energy stored in the spring buffer during the collision.

Using Principle of Conservation of Energy from 0.100 s to 0.150 s,
Gain in EPE
= Loss in KE

$$= \frac{1}{2}(22000)(3.0)^2 + \frac{1}{2}(66000)(1.0)^2 - 99000$$

$= 33000$ J [A1]

OR

Using Principle of Conservation of Energy from 0.150 s to 0.200 s,
Loss in EPE
= Gain in KE

$$= \frac{1}{2}(66000)(2.0)^2 - 99000$$

$= 33000$ J [A1]

maximum elastic potential energy stored = ………………… J [1]

(d) **(i)** Calculate the magnitude of the impulse exerted by Truck X on Truck Y.

Impulse
= change in momentum of Y
= 66 000 x (2 – 1) [M1]
= 66 000 N s [A1]

magnitude of impulse = ………………… N s [2]

(ii) If the duration of the collision is reduced, with initial and final speed of both trucks remain unchanged, state and explain how this affects your answer in **(i)**.

The <u>change in momentum of Truck Y remains the same</u> since there is no change in the initial and final speeds of both trucks.
By <u>Impulse-momentum Theorem</u>, the impulse remains <u>unchanged</u>. [B1]

..

[1]

3 **(a)** State what is meant by *coherent sources*.

Coherent sources are sources that emit waves with constant phase difference. [B1]
This means that the waves have the same frequency/wavelength/speed (any 2). [B1]

…………………………………………………………………………………………….…

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

(b) A stereo system in a large hall has two identical speakers, S_1 and S_2, placed 1.2 m apart as shown in Fig. 3.1. The amplitude of the output of each speaker is proportional to the potential difference across its terminals, which is adjusted by means of a balance control.

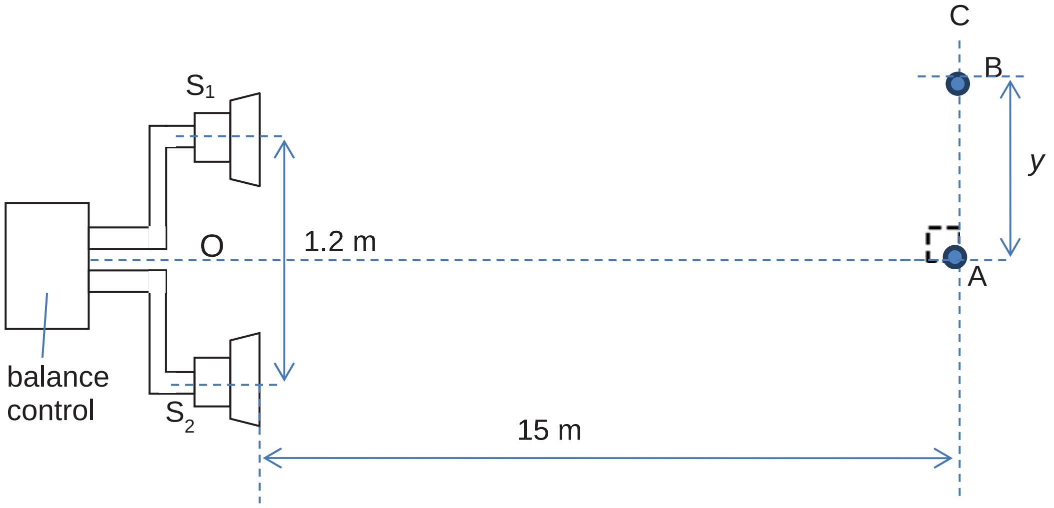


Fig. 3.1 (not to scale)

Initially, the speakers are emitting signals of frequency 1000 Hz which are in phase. The balance control is set such that the potential difference across the terminals of both speakers are the same.

Line AC is 15 m away from the speakers. An observer hears a loud sound of intensity I_{max} at A. As he moves along the line AC, 15 m away from the speakers, he observes that the intensity of the sound first falls to zero at point B, a distance *y* from A. The speed of sound in air is 330 m s^{-1}.

(i) Determine the distance *y*.

y = 0.5 x where $x = \frac{\lambda D}{a}$ [M1] and $\lambda = \frac{v}{f}$ since B is at minimum intensity.

$$y = \frac{(\frac{330}{1000})(15)}{(1.2 \times 2)}$$

y = 2.1 m [A1]

y = ……………. m [2]

For Examiner's Use

(ii) By calculating the path difference of the two sound waves arriving at B, determine the next higher frequency of the speaker such that point B would also be a point of zero intensity.

Since B is a point of minimum intensity, the path difference of S_1 and S_2 at point B,

$S_1B - S_2B = \frac{\lambda}{2} = \frac{0.33}{2} = 0.165\ m$ [M1]

For other wavelengths λ, point B will be at zero intensity if the path difference is $\left(n+\frac{1}{2}\right)\lambda$.

Therefore,

$\left(n+\frac{1}{2}\right)\lambda = 0.165m$ where n = 1 [M1]

$\lambda = 0.11m$

Using $f = \frac{v}{\lambda}$,

$f = \frac{330}{\lambda}$

f = 3000 Hz [A1]

Alternatively,

For different wavelengths λ, point B will be at zero intensity if the path difference is $\left(n+\frac{1}{2}\right)\lambda$.

As frequency increases, wavelength decreases.
Hence, since path difference is unchanged [M1],

$\left(0+\frac{1}{2}\right)\lambda_0 = \left(1+\frac{1}{2}\right)\lambda_1$ [M1]

$\lambda_0 = 3\lambda_1$

Since $f = \frac{v}{\lambda}$,

$f_1 = 3f_0 = 3000Hz$ [A1]

frequency = …………………. Hz [3]

(iii) With the speakers emitting the original signal frequency of 1000 Hz, the balance control is now adjusted such that the potential difference across the terminals of S_1 is reduced while the potential difference across the terminals of S_2 is unchanged. Suggest and explain any changes to the sound heard at B.

A sound is now heard at B (or the intensity of the sound at B is larger). [B1]
This is because there is now a difference between the amplitudes of the sounds at B, resulting in incomplete destructive interference. [B1]

……………………………………………………………………………………………

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

For Examiner's Use

(c) Monochromatic light is passed through a rectangular slit of width b of 0.20 mm. The light is observed on a screen placed 0.75 m from the slit, as shown in Fig. 3.2.

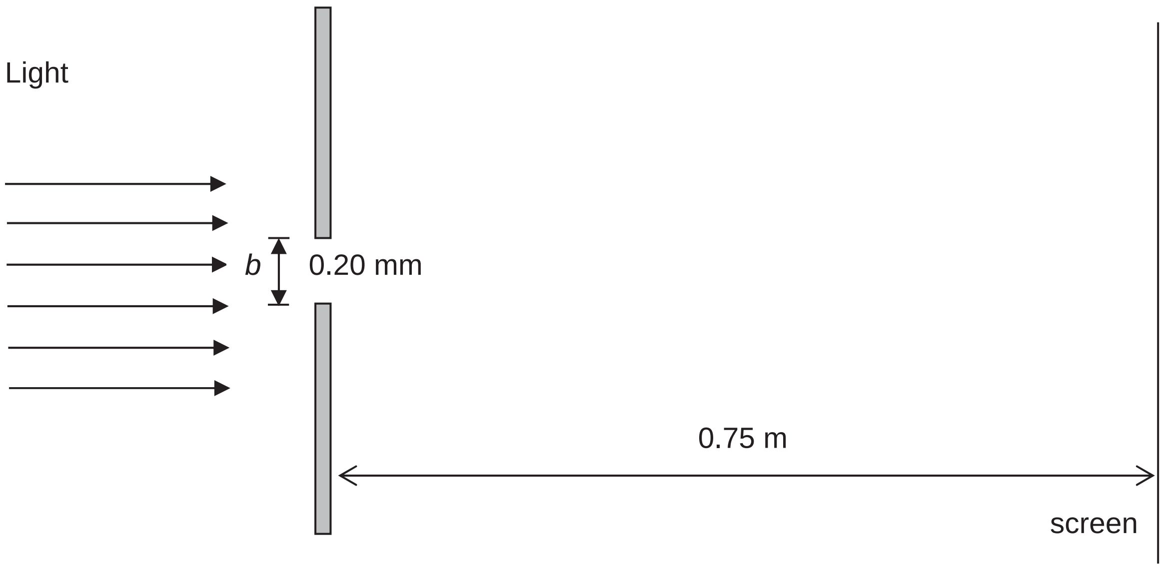


Fig. 3.2

Light passing through the slit is diffracted through an angle θ.

The variation of the intensity I of the light with the angle θ of diffraction is shown in Fig. 3.3.
The maximum value of intensity is I_0.
The angular separations between successive minima are the same.

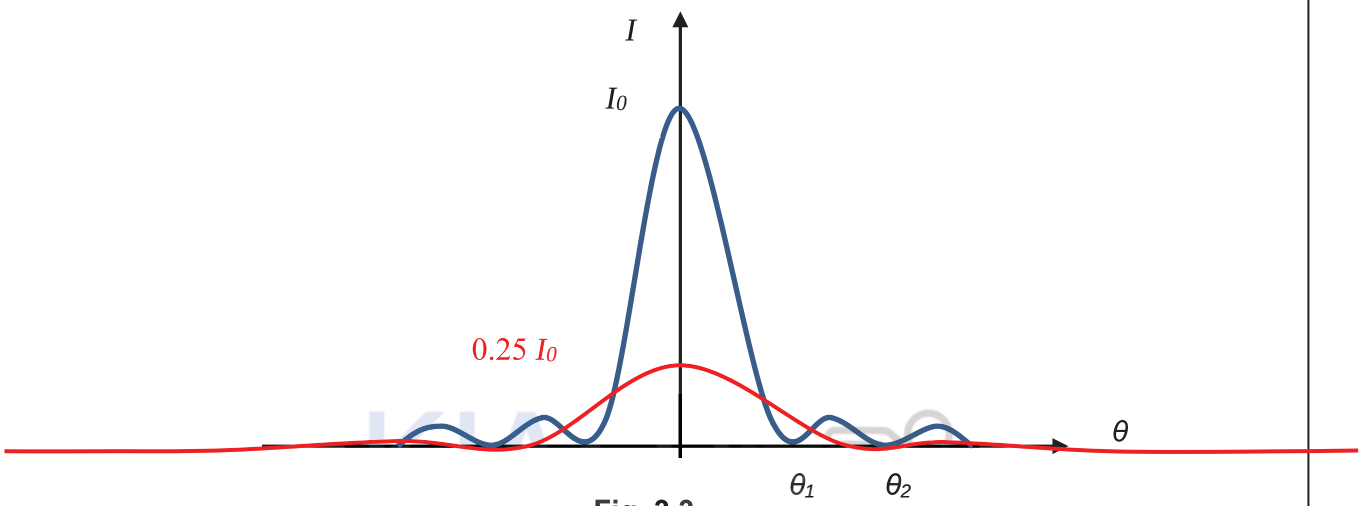


Fig. 3.3

(i) The value of θ_2, the location of the second order minima, is 0.338°.
Determine the wavelength of the monochromatic light.

$\sin\theta = \frac{\lambda}{b}$
$\lambda = b \sin \theta_1$ [M1]
$= (0.2 \times 10^{-3}) \sin (0.338°/2)$
$= 590$ nm [A1]

wavelength = …………… nm [2]

For Examiner's Use

(iii) Determine the angle between two beams of light incident on the slit, each of the same wavelength as in **(i)**, such that their diffraction patterns are just resolved. Explain your working.

[B1]: 0.169°
[B1]: For patterns to be just resolved, central maximum of one beam must lie on the first minimum of the other.

angle = …………….° [2]

(iii) Sketch, on the axes of Fig. 3.3, how the intensity of the light varies with θ if the slit width is halved. Label any relevant intercepts on your sketch. [2]

[B1]: Maximum intensity = 0.25 I_0
[B1]: First order minimum occurs at 0.338°.

For Examiner's Use

4 (a) Define the tesla.

If a straight conductor carrying a current of 1 ampere [B1] is placed at right angles to a uniform magnetic field of flux density 1 tesla [B1], then the force per unit length on the conductor is 1 newton per metre. [B1]

…………………………………………………………………………………………………

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

(b) Ions, all of the same element, are travelling in a vacuum with a speed of 9.6×10^4 m s^{-1}. The ions are incident normally on a uniform magnetic field B of flux density 320 mT. The ions follow semicircular paths A and B before reaching a sensor, as shown in Fig. 4.1.

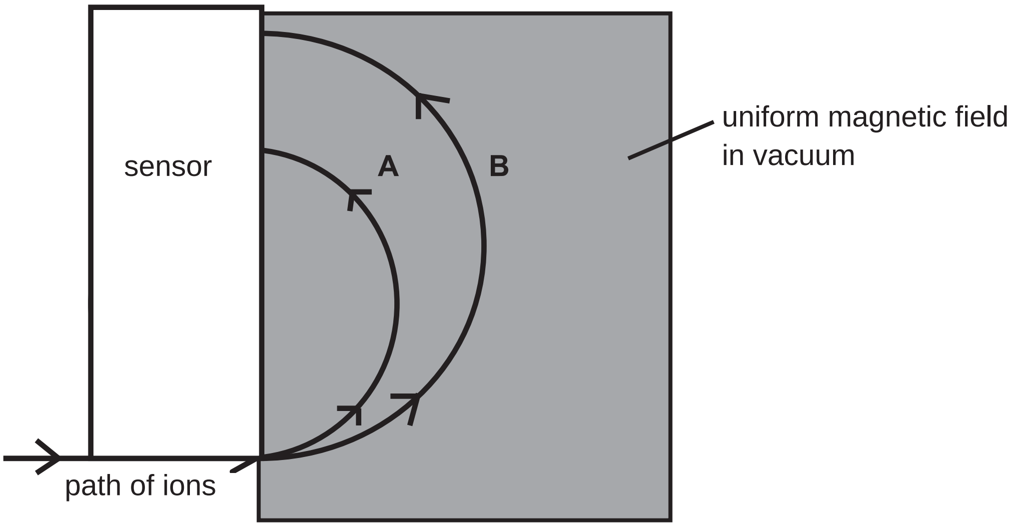


Fig. 4.1

The diameters of paths A and B are 6.2 cm and 12.4 cm respectively. The ions in path B each have charge $+1.6 \times 10^{-19}$ C.

(i) Explain why the path of the ions in the magnetic field is an arc of a circle.

The magnetic force provides the centripetal force for the ions. [B1]
It is always perpendicular to the velocity of the particle (using the Fleming's Left Hand Rule), thus it changes only the direction but not the magnitude of the velocity. [B1]
Since the particle's speed remains constant, the magnitude of the magnetic force will also remain the same, with the direction of the force towards a fixed centre of rotation/with the radius remaining the same, resulting in its path being the arc of a circle. [B1]

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

For Examiner's Use

(ii) Calculate the mass of the ions in path B.

$Bqv = mv^2/r$ [B1]
m = *Bqr*/*v*
= $(320 \times 10^{-3} \times 1.6 \times 10^{-19} \times 6.2 \times 10^{-2}) / (9.6 \times 10^{4})$
= 3.31×10^{-26} kg [B1]

mass = …………….kg [2]

(iii) Explain reasons for the difference in radii of the paths A and B of the ions.

The radius of the paths depends on the mass-charge ratio of the ions, since the velocity of the ions, and the magnetic field strength is the same.
Hence, path A has a smaller radius because of the ions having the <u>same charge but smaller mass</u> compared to those in path B [B1].
OR
Hence, path A has a smaller radius because of the ions having the <u>same mass but larger charge</u> compared to those in path B [B1].

For Examiner's Use

5 **(a)** **(i)** Define *binding energy*.

Binding energy is the amount of energy required to completely separate a nucleus into its constituent nucleons such that the nucleons are infinitely far apart.

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

(ii) Sketch a graph in Fig. 5.1 to show the variation of the binding energy per nucleon with nucleon number. Label the value of nucleon number and binding energy per nucleon for the isotope that has the highest binding energy per nucleon. [2]

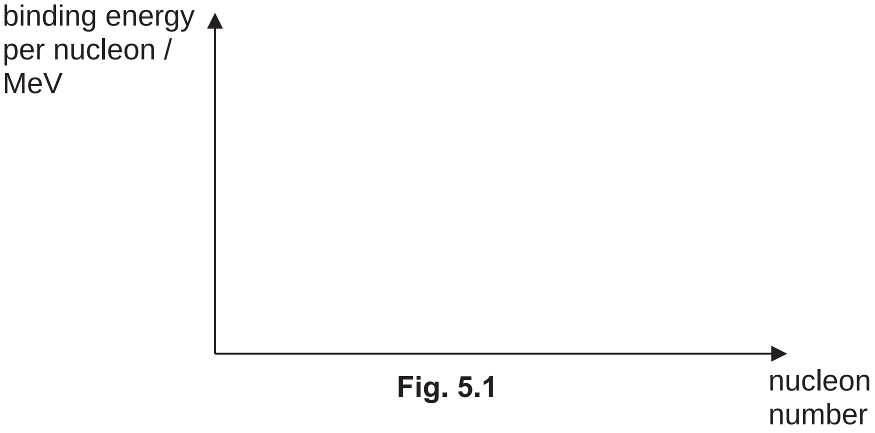
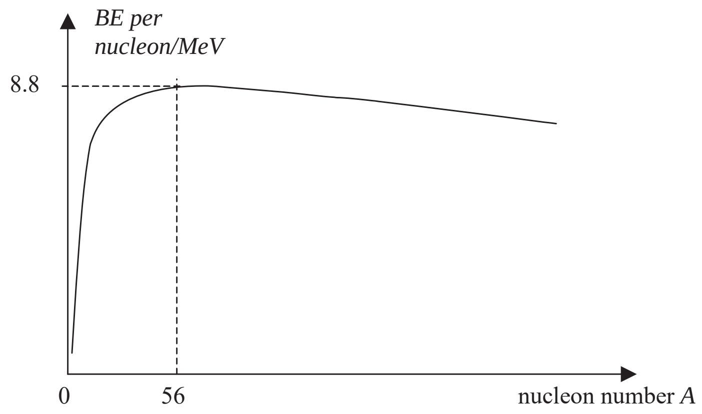


Fig. 5.1



Shape of graph [B1]

Labelling Fe-56 and the value of its BE per nucleon [B1]

(iii) With reference to your graph drawn in Fig. 5.1, explain how fission can be a potential source of energy.

In nuclear fission, a heavy nucleus splits to give two daughter nuclei of greater binding energy per nucleon. [B1]

Binding energy is the product of the binding energy per nucleon and the number of nucleons. Since the binding energy of the products is greater than the binding energy of the reactants, energy is released. [B1]

For Examiner's Use

(iv) A typical nuclear fission reaction that involves uranium-235 is represented by the equation

$$^{235}_{92}U + n \rightarrow Kr + ^{141}_{56}Ba + 3n$$

Data for the binding energy per nucleon for the different nuclei are given in the table below:

Nuclei	**Binding energy per nucleon / MeV**
$^{235}_{92}U$	7.59
Kr	8.51
$^{141}_{56}Ba$	8.33

1. Deduce the number of protons and neutrons in the Kr nucleus.

No. of nucleons = 235 + 1 – 141 – 3 = 92
No. of protons = 92 – 56 = 36 [A1]
No. of neutrons = 92 – 36 = 56 [A1]

number of protons = ………………….

number of neutrons = ………………….[2]

2. Calculate the energy released in the above reaction.

Energy released = $BE_{products}$ - $BE_{reactants}$
= 92(8.51) + 141(8.33) - 235 (7.59) [M1]
=173.8 MeV
= 173.8 x 1.6 x 10^{-13} J
= 2.78 × 10^{-11} J [A1]

energy released = ………………… J [2]

For Examiner's Use

(b) A stationary $^{228}_{88}\mathrm{Ra}$ nucleus undergoes beta minus decay to form an actinium isotope. The actinium isotope and beta particle move as shown in Fig. 5.2.

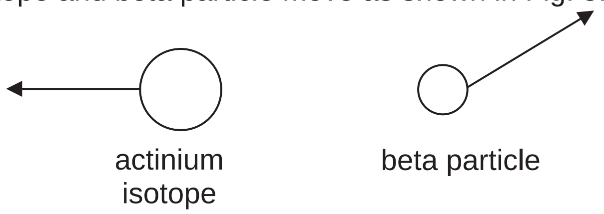


Fig. 5.2

Explain why a neutrino must also be released in this process.

Initial momentum of the Ra nucleus is zero. According to the Principle of Conservation of Linear Momentum, a neutrino with a vertical momentum that is in opposite direction to that of the beta particle must be released in order that the final momentum of the system is zero.

……[2]

(c) Scientists have worked out the age of the Moon by dating rocks brought back by the Apollo missions. They use the decay of potassium $^{40}_{19}\mathrm{K}$ to argon $^{40}_{18}\mathrm{Ar}$, which is stable. The decay constant of potassium-40 is 5.3×10^{-10} per year.

(i) Explain what is meant by the decay constant of potassium-40 being 5.3×10^{-10} per year.

The probability that <u>a particular potassium-40 nucleus</u> will decay within a year is 5.3×10^{-10}.

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

(ii) Sketch a labelled graph on Fig. 5.3 to show how the activity of $^{40}_{19}\mathrm{K}$ changes with time if the initial activity is A_o. Mark on your graph the value of the half-life of $^{40}_{19}\mathrm{K}$. [2]

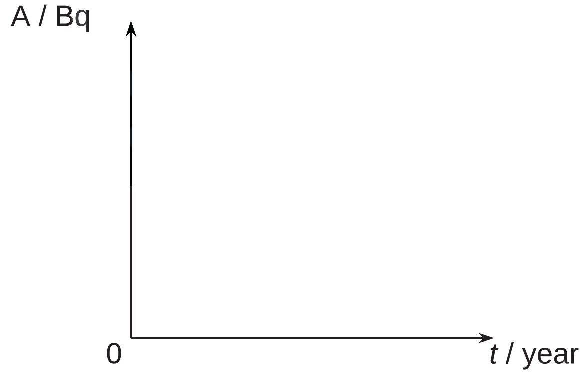
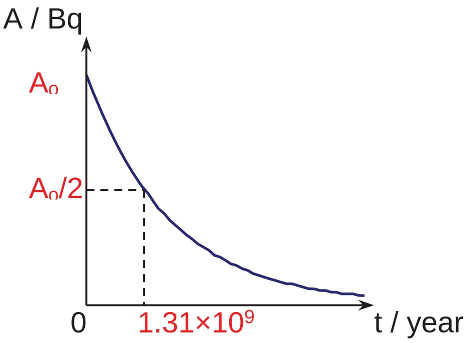


Fig. 5.3

Shape [B1]

$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \frac{\ln 2}{5.3 \times 10^{-10}} = 1.31 \times 10^{9}$ years [B1]



(iii) In one rock sample the scientists found 0.84 μg of argon-40 and 0.10 μg of potassium-40.

1. Calculate the activity of the potassium-40 in the rock sample.

$A = \lambda N$

$= \frac{5.3 \times 10^{-10}}{365 \times 24 \times 60 \times 60}\left[\frac{0.1 \times 10^{-6}}{40} \times 6.02 \times 10^{23}\right]$ [M1]

$= 0.0253$ Bq [A1]

activity = ………………… Bq [2]

2. Calculate the age of the rock sample in years.

$N = N_o e^{-\lambda t}$

Since molar mass is the same for both K-40 and Ar-40,

$M = M_o e^{-\lambda t}$

$0.1 = (0.1 + 0.84)e^{-(5.3 \times 10^{-10})t}$ [M1]

$t = 4.23 \times 10^{9}$ years [A1]

age of rock sample = ………………… years [2]

3. State any assumption that you have made for the calculation in **2**.

All the argon-40 is formed from the decay of potassium-40. [B1]

……………………………………………………………………………………[1]

(iv) Explain why the determination of the decay constant by measuring the mass and activity of a sample is not suitable for nuclides that have relatively large decay constants.

(The activity in radioactive decay is not a constant value, but decreases with time as the number of radioactive nuclide remaining decreases.) If the decay constant is large, then the half-life is short ($T_{1/2} = \ln 2 / \lambda$). Thus over a relatively short time of measurement, the activity and mass would not remain fairly stable. [B1]

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

6 A capacitor is an electrical device which can store charges and energy. A simple parallel plate capacitor consists of two parallel conducting plates separated by an insulator, as shown in Fig. 6.1.

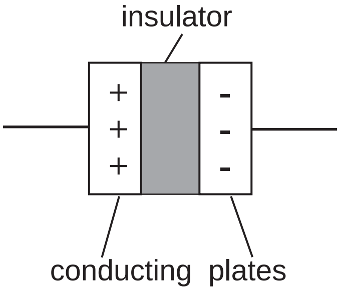


Fig. 6.1

When charged, the two plates carry opposite charges of the same magnitude. The relationship between the amount of charge stored *Q*, the potential difference *V* between the plates and the capacitance *C* is given by the equation

$$Q = CV$$

(a) Deduce the base units of C.

[Q] = [CV]
[C] = [Q] / [V] = [Q] / [W/Q] = $[Q^2]$ / [W] [M1]
= A^2s^2 / kg m^2 s^{-2} [M1]
= $A^2kg^{-1}m^{-2}s^4$ [A1]

base units = ... [3]

For Examiner's Use

(b) The capacitor is now charged. Fig. 6.2 shows the values of potential difference *V* and the corresponding amount of charge *Q*.

***V*/ V**	***Q*/ μC**
0.0	0.0
0.4	1.9
1.3	6.1
3.0	14.3
3.3	15.5
4.2	19.7
5.1	23.5

Fig. 6.2

On Fig. 6.3,

(i) plot the missing data points from Fig. 6.2. [2]

(ii) sketch the best fit line to show the variation of the amount of charge *Q* with the potential difference *V* between the plates. [1]

For Examiner's Use

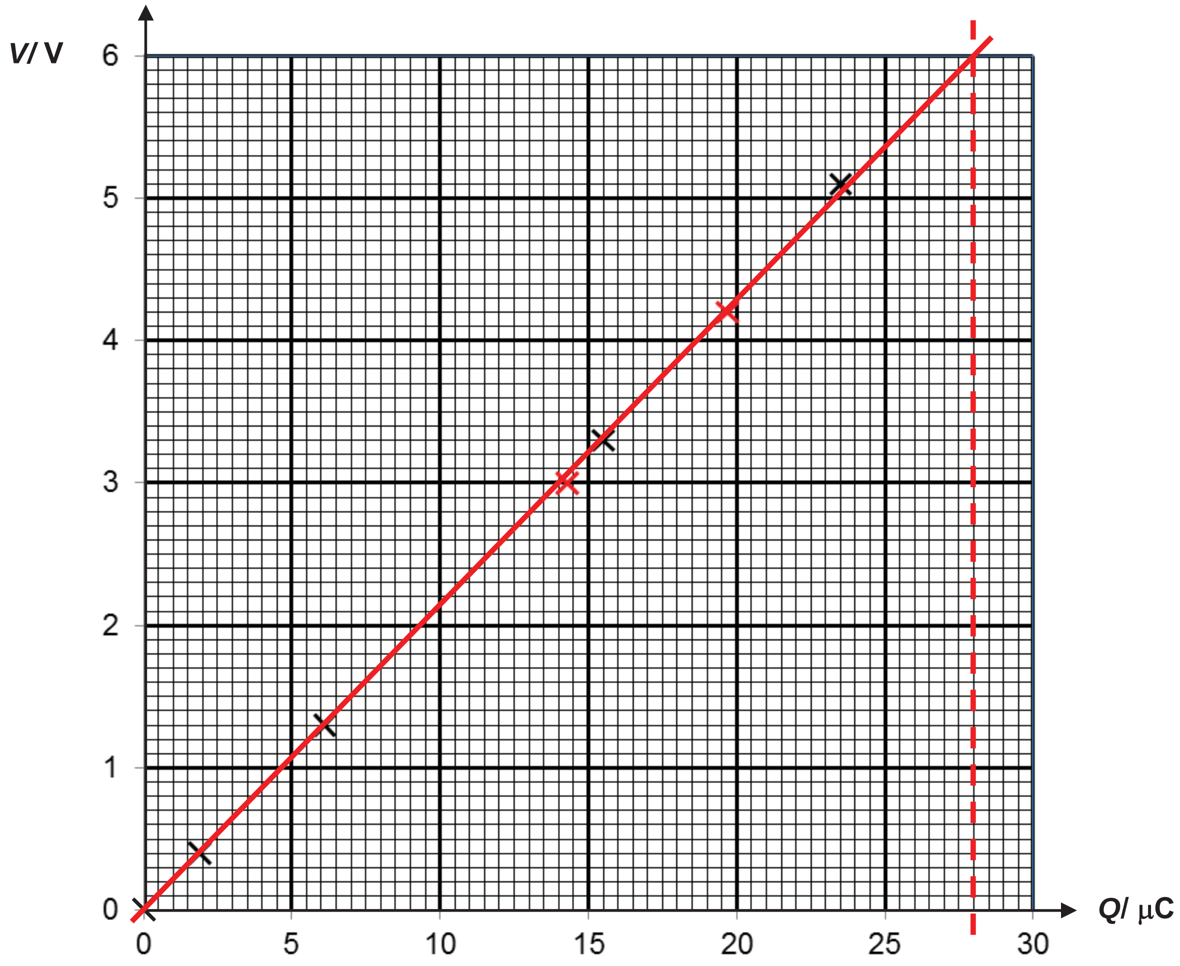


Fig. 6.3

(iii) State the quantity represented by the:

1. gradient of the graph,

1/C or reciprocal of capacitance C .... [1]

2. area under the graph.

Electrical energy stored in capacitor .... [1]

(iv) Hence, show that the energy *E* stored in a capacitor is ½ CV^2.

Area = ½ Q V [1]
= ½ CV^2

[1]

(c) The capacitor is now discharged by connecting it across a resistor of resistance *R* as shown in Fig. 6.4.

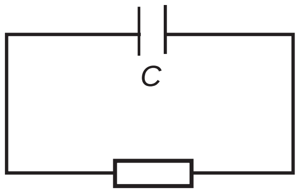


Fig. 6.4

Fig. 6.5 shows the variation with time *t* of the potential difference *V* across the resistor.

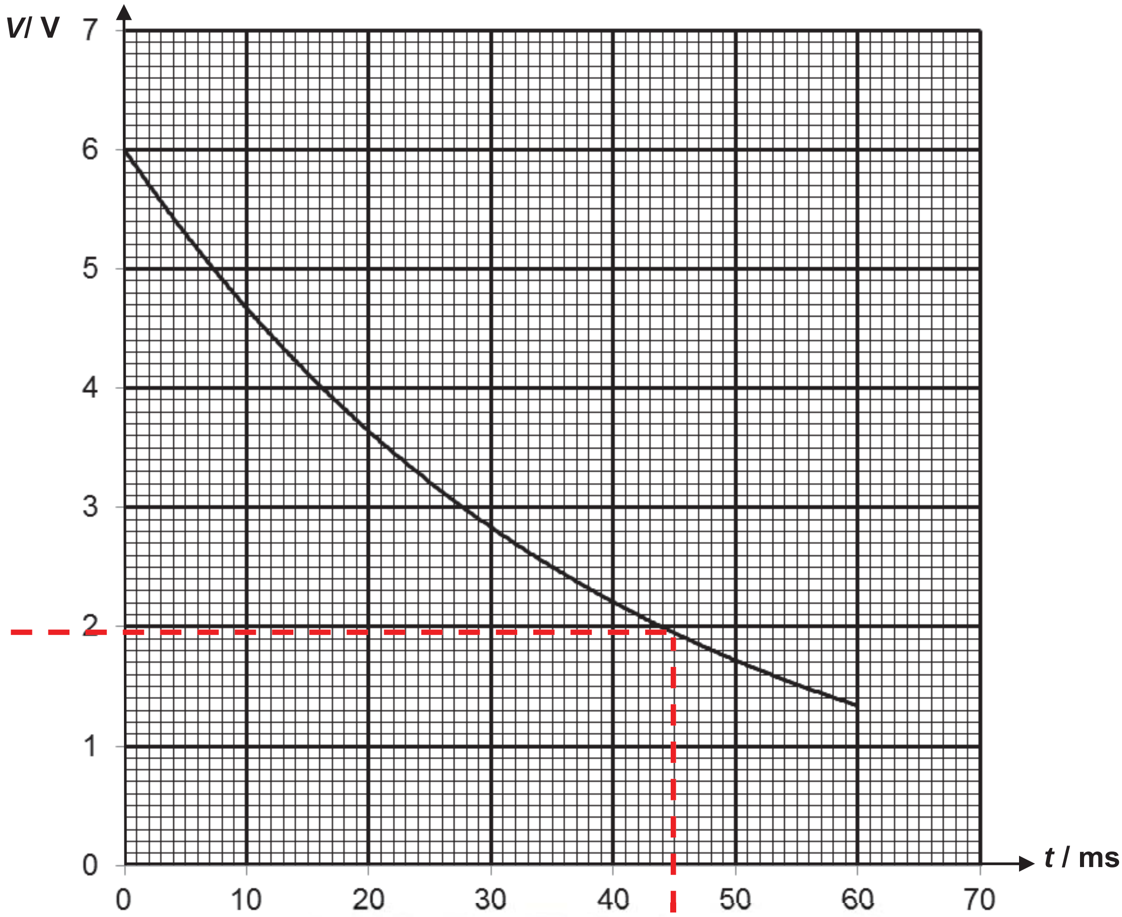


Fig. 6.5

(i) Using Fig. 6.3 and Fig. 6.5, determine the initial amount of charge stored.

From Fig 6.5, at t = 0, V = 6.00 V [M1]

From Fig 6.3, read off best fit line. At 6.00 V, Q = 28.00 μC [A1]

-1m overall for wrong d.p.

charge = ... μC [2]

For Examiner's Use

(ii) Hence, calculate the capacitance C.

Q = CV
C = Q/V
= $28.00 \times 10^{-6} / 6.00$ [M1]
= 4.67×10^{-6} C V^{-1} [A1]

capacitance = ... C V^{-1} [2]

(iii) Calculate the energy lost when the capacitor has been discharged for 45 ms.

At 45 ms, V = 1.95 V [M1]

Energy lost = $\frac{1}{2} C (V_i^2 - V_f^2)$ [M1]
= $\frac{1}{2} (4.67 \times 10^{-6}) (6.00^2 - 1.95^2)$
= 7.52×10^{-5} J [A1]

-1m overall for wrong d.p.

energy lost = ... J [3]

(d) The graph in Fig. 6.5 can be represented by the following equation, where V_o is the initial potential across the resistor R.

$$V = V_o e^{-t/RC}$$

State how the value of RC affects the rate of discharge of the capacitor.

A greater value of *RC* slows down the rate of discharge.

.... [1]

(e) Fig 6.6 shows an A.C. supply connected to resistor-capacitor (RC) circuit containing an ideal diode. Fig 6.7 shows the potential difference measured by the CRO.

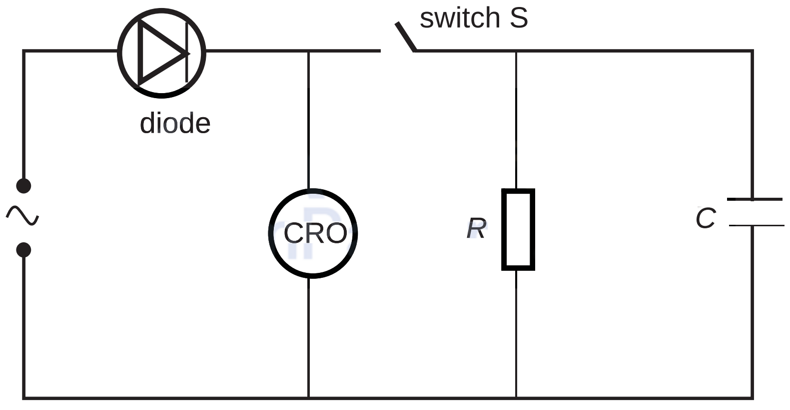


Fig. 6.6

For Examiner's Use

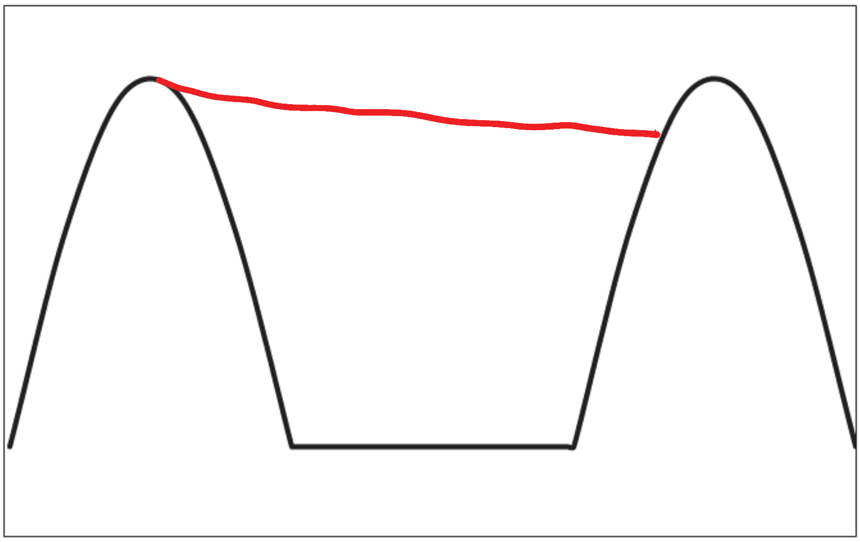


Fig. 6.7

Switch S is now closed. When the diode is in forward bias, current flows through both the resistor and the capacitor. When the diode is in reverse bias, the capacitor discharges through the resistor.

(i) Sketch on Fig. 6.7, the expected display on the CRO. [1]

(ii) State what the RC circuit does to the wave on the CRO.

Smoothen the ripples (of a half wave rectified signal). .... [1]

END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG | **INDEX NO.**

PHYSICS 9749/03

Preliminary Examination **15th September 2017**
Paper 3 Longer Structured Questions **2 hours**

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

READ THIS INSTRUCTIONS FIRST

Write your name, civics group and index number 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 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 in Section A, and **one** of the two questions in Section B.

At the end of the examination, fasten all your work securely together.
The number of marks is given in bracket [ ] at the end of each question or part question.

For Examiners' Use	
Q1	/ 7
Q2	/ 13
Q3	/ 20
Q4	/ 20
Q5	/ 20
Q6	/ 20
Total marks	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$\frac{1}{36\pi} \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

DATA AND FORMULAE

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	ϕ	$= -\frac{GM}{r}$
temperature	T /K	$= T$ /ºC + 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	$= Anqv$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R}$	$= \frac{1}{R_1} + \frac{1}{R_2} + \cdots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/ voltage	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \frac{ln2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A: Answer all questions

1 A uniform rod of weight 20 N is freely hinged to a wall at P as shown in Fig. 1.1. It is held horizontal by an elastic cord made of material X of force constant 10 N cm^{-1}, attached at Q at an angle of 15˚ to the rod.

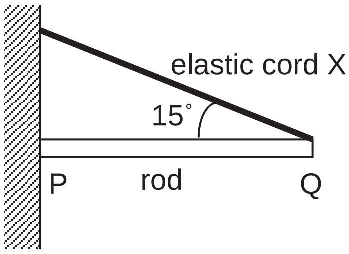


Fig. 1.1

(a) Show that the extension of the elastic cord X is 3.86 cm. [2]

Let L be the length of the rod and x be the extension of elastic cord.
Using Principle of Moments, taking moments about point X
Sum of clockwise moment = Sum of anticlockwise moment
Or
$W\,(0.5\,L) = (T \sin 15°)\,L$ [B1]
$20\,(0.5\,L) = (10x \sin 15°)\,L$ [B1]
$x = 3.86$ cm

(b) Determine the magnitude of the resultant force acting at P.

Consider vertical forces
Taking upwards positive
$T \sin 15° + R_2 + (-W) = 0$
$38.6 \sin 15° + R_2 + (-20) = 0$ [M1]
$R_2 = 10.0$ N

Consider horizontal forces
Taking rightward positive
$R_1 + (-T \cos 15°) = 0$
$R_1 + (-38.6 \cos 15°) = 0$ [M1]
$R_1 = 37.2$ N

$R = \sqrt{R_1^2 + R_2^2} = \sqrt{10.0^2 + 37.2^2} = 38.5$ N [A1]

magnitude of resultant force at P = …………………. N [3]

For Examiner's Use

(c) The elastic cord X is now replaced by two other identical elastic cords of the same unstretched length as elastic cord X. These two elastic cords are connected in parallel. The rod PQ remains horizontal.
State and explain the value of the force constant of each of the new elastic cords.

Each elastic cord experiences half of the tension as that in elastic cord X. Since the extension of each cord is the same as that of elastic cord to keep rod PQ horizontal [M1], therefore the force constant of each of the new cord is 5 N cm^{-1}. [A1]
OR
Since the elastic cords are connected in parallel, their effective force constant is same as that of elastic cord X, and the effective force constant is the sum of the force constants of the two cords [M1]. The force constant of each of the new cord is 5 N cm^{-1}. [A1]

…..

…..

..[2]

For Examiner's Use

2 (a) State the *first law of thermodynamics*, indicating the directions of all energy changes.

Increase in internal energy of a system is the sum of the heat supplied to (or absorbed by) the system, and work done on the system.
[1 mark for $\Delta U = Q + W$, 1 mark for indicating correct direction, ie increase in internal energy, supplied to and work done on]

[2]

(b) A heat pump contains a fixed mass of ideal gas undergoing a cycle of changes of pressure, volume and temperature as illustrated in Fig. 2.1.

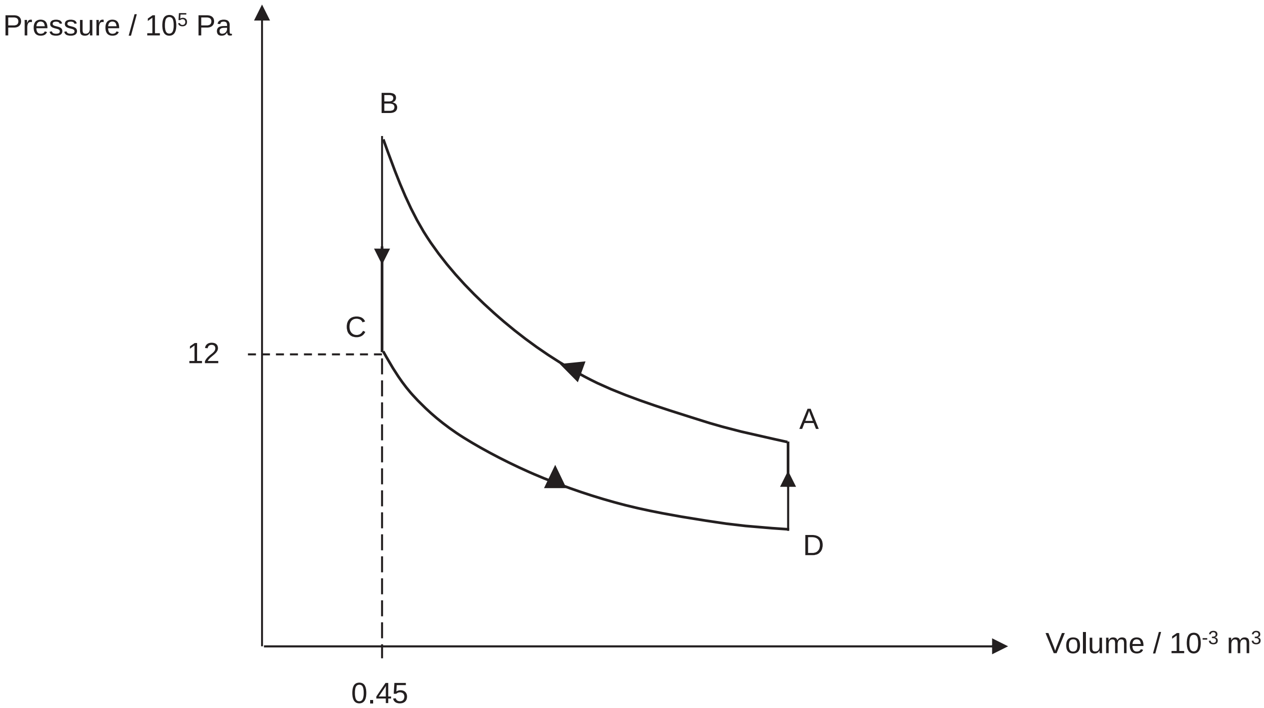


Fig. 2.1

The increase in internal energy which takes place during three of the changes are as shown in Fig. 2.2. It is also known that no heat is supplied in the changes A → B and C → D.

(i) Complete Fig. 2.2.

Change	Increase in internal energy / J	Heat supplied to gas / J	Work done on gas / J
A → B	720	0	720
B → C	-810	-810	0
C → D	- 360	0	-360
D → A	450	450	0

Fig 2.2

0.5 marks for each correct answer except for Q for A→B and C→D, combined 0.5 marks

[4]

For Examiner's Use

(ii) Given that the temperature at C is 360 K, calculate the number of molecules, N, in the heat pump.

PV = NkT
$(12 \times 10^5)(0.45 \times 10^{-3}) = N (1.38 \times 10^{-23})(360)$ [M1]
$N = 1.09 \times 10^{23}$ [A1]

number of molecules = ……………………………….[2]

(iii) Given that the total kinetic energy of the gas molecules, E_K is given as $E_K = 3/2\ NkT$, using your answers in **(i)** and **(ii)**, determine the temperature at D.

Since this is an ideal gas, $\Delta U = \Delta E_K$.
Considering the process C to D,
$\Delta U = -360$, $\Delta E_K = 3/2 Nk\Delta T$,
Therefore, $-360 = 3/2 Nk\Delta T$ [M1]
$= 3/2\ (1.09 \times 10^{23})(1.38 \times 10^{-23})\ \Delta T$
$\Delta T = -160$K [M1]
Therefore, temp at D = 360 + (- 160)
= 200 K [A1].

OR

E_K at C = $3/2\ NkT = 3/2\ (1.09 \times 10^{23})(1.38 \times 10^{-23})(360) = 810$ J [M1]
E_K at D = 810 – 360 = 450 J [M1]
Using $E_K = 3/2\ NkT$
$450 = 3/2\ (1.09 \times 10^{23})(1.38 \times 10^{-23})\ T_D$
$T_D = 200$ K [A1]

temperature = …………………… K [3]

For Examiner's Use

(iv) Given that the gas is Helium-4, calculate the root-mean-square speed of the Helium molecules at C.

$\frac{1}{2} m\langle c^2\rangle = 3/2kT$

$\sqrt{\langle c^2\rangle} = \sqrt{3kT/m}$

$= \sqrt{3(1.38 \times 10^{-23})(360)/(4 \times 1.66 \times 10^{-27})}$ [M1]

$= 1{,}500 \text{ m s}^{-1}$ [A1]

OR

$pV = 1/3\, Nm\langle c^2\rangle$

$\sqrt{\langle c^2\rangle} = \sqrt{(3pV) / (Nm)}$

$= \sqrt{3(12 \times 10^5)(0.45 \times 10^{-3}) / (1.09 \times 10^{23})(4 \times 1.66 \times 10^{-27})}$ [M1]

$= 1{,}500 \text{ m s}^{-1}$ [A1]

OR

E_K at C = $3/2\, NkT = 3/2\,(1.09 \times 10^{23})(1.38 \times 10^{-23})(360) = 810$ J

$$\frac{1}{2}Nm\langle c^2\rangle = 810$$

$$c_{rms} = \sqrt{\frac{2(810)}{1.09\times10^{23}(4\times1.66\times10^{-27})}} \quad \text{[M1]}$$

$$= 1500 \text{ m s}^{-1} \quad \text{[A1]}$$

OR

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

$$c_{rms} = \sqrt{\frac{3RT}{M_r}} \text{ where } M_r \text{ is molar mass}$$

$$= \sqrt{\frac{3(8.31)(360)}{4\times10^{-3}}} \quad \text{[M1]}$$

$$= 1500 \text{ m s}^{-1} \quad \text{[A1]}$$

r.m.s speed = ……………… m s^{-1} [2]

For Examiner's Use

3 (a) A satellite is in a geostationary circular orbit of radius *r* about the Earth of mass *M*, and appears to remain above the same point on the Earth. The mass of the Earth may be assumed to be concentrated at its centre.

(i) State two features of a geostationary satellite of the Earth.

1. ……

Any 2:
1. Period of orbit is 24 hours
2. Satellite lies on a plane containing the Earth's equator
3. Satellite rotates from west to east
4. Satellite's orbital radius is 42300 km

2. ……

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

(ii) Show that the period *T* of the orbit of the satellite is given by the expression

$$T^2 = \frac{4\pi^2 r^3}{GM}$$

where G is the gravitational constant. Explain your working.

Gravitational force provide the centripetal force [B1]
$GMm/r^2 = mr\omega^2$ [M1]
and since $\omega = 2\pi/T$ [M1]

Therefore, $T^2 = 4\pi^2r^3/GM$

[3]

(iii) The mass *M* of the Earth is 6.0×10^{24} kg. Determine the radius of the geostationary orbit.

Using $T^2 = 4\pi^2r^3/GM$
$(24 \times 3600)^2 = 4\pi^2r^3/(6.67 \times 10^{-11} \times 6.0 \times 10^{24})$ [M1]
$r = 4.2 \times 10^7$ m [A1]

radius = …………………………………….. m [2]

(b) The variation of the resultant gravitational potential due to the Earth and the Moon along a line XY joining the centres of the Earth and Moon is as shown in Fig. 3.1.

For Examiner's Use

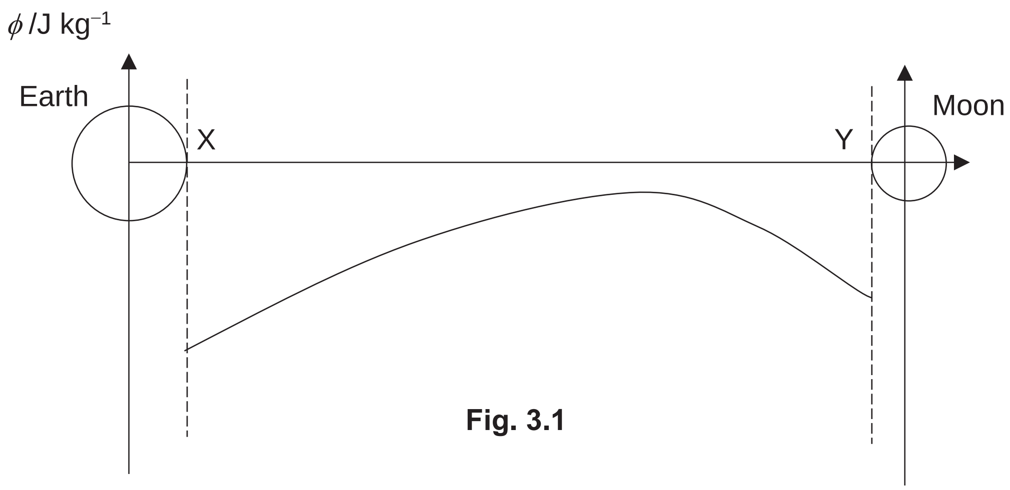


Fig. 3.1

(i) Given that the mass of the Moon is 7.3×10^{22} kg and the distance between the centres of the Earth and Moon is 380 000 km, show that the distance from the centre of the Earth along XY, where the net gravitational field strength is zero, is 342 000 km.

Let x be the distance in km.
Magnitude of Gravitational field strength due to Earth = magnitude of gravitational field strength due to Moon
$GM_E/x^2 = GM_M/(380{,}000 - x)^2$
$6.0 \times 10^{24} / x^2 = 7.3 \times 10^{22} / (380{,}000 - x)^2$ [M1]
x = 342,000 km

[1]

(ii) Hence, sketch the corresponding net gravitational field strength due to the Earth and the Moon in Fig. 3.2. [2]

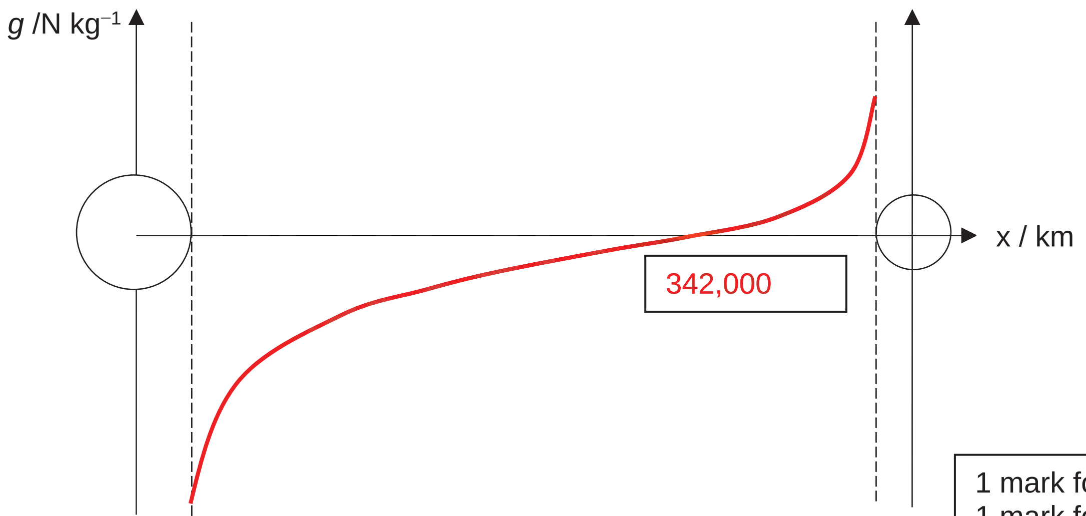


Fig. 3.2

1 mark for correct shape
1 mark for marking the x-intercept correctly

(c) Two point charges A and B are separated by a distance of 8.0 cm in a vacuum, as illustrated in Fig. 3.3.

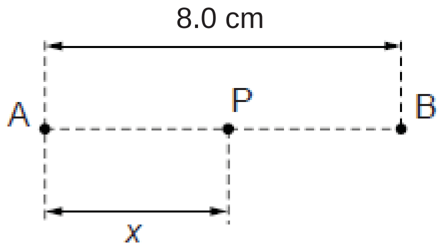


Fig. 3.3

Point P is at a distance *x* from A along AB. The variation of the resultant potential due to charge A and B is as shown in Fig. 3.4.

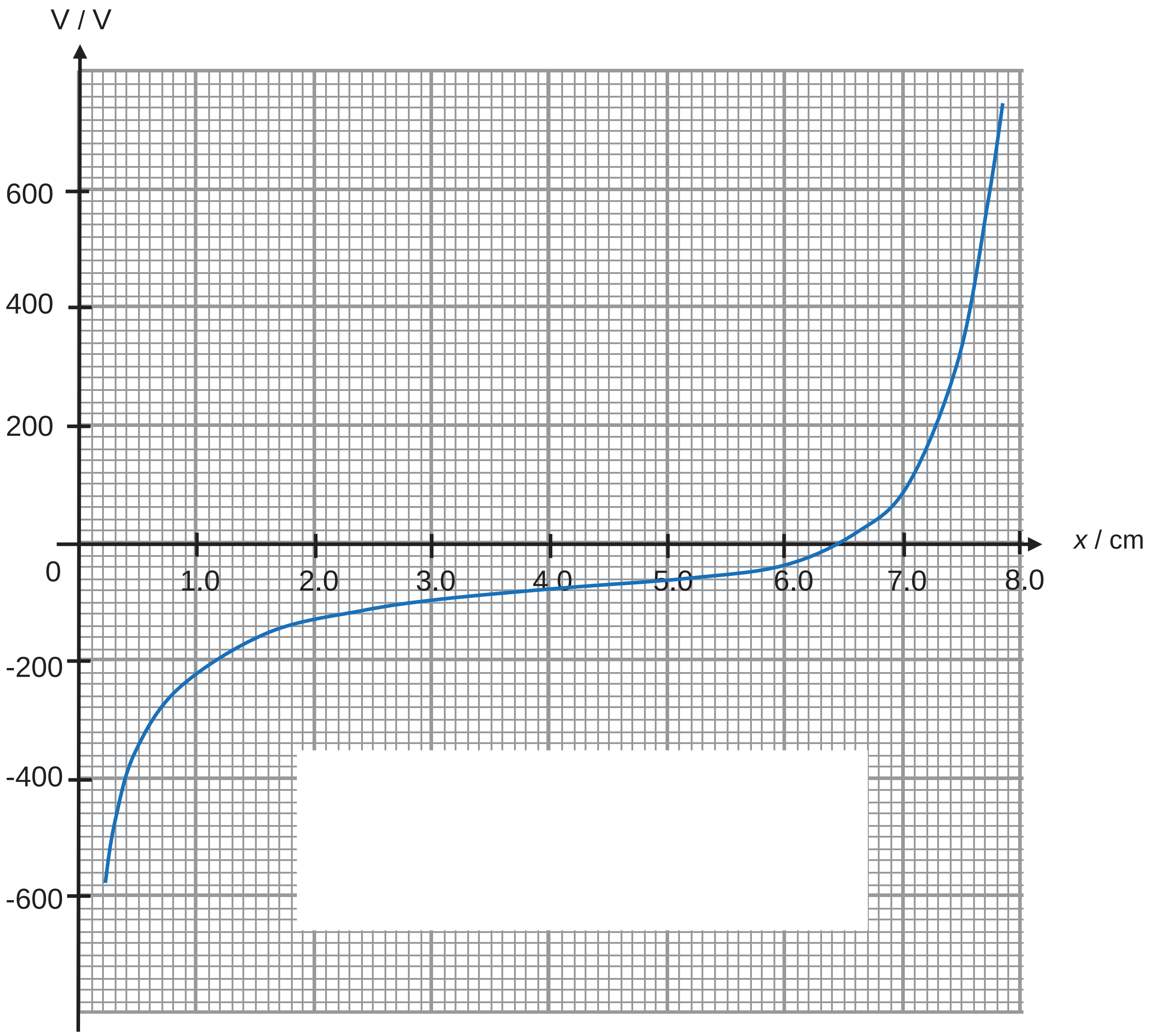


Fig. 3.4

For Examiner's Use

(i) State and explain whether the two charges are of the same sign.

The 2 charges are of different sign [A1] as the resultant electric potential varies from negative to positive [M1], or there is a point where the net electric potential is 0 [M1].

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

(ii) Calculate the ratio of the numerical value of $\frac{\text{Charge of } A}{\text{Charge of } B}$

At x = 6.50 cm , $V_A + V_B = 0$
Therefore,
$|Q_A/4\pi\varepsilon_o(6.50)| = |Q_B/4\pi\varepsilon_o(8.00-6.50)|$ [M1]
Therefore $|Q_A/Q_B| = 4.33$ [A1]

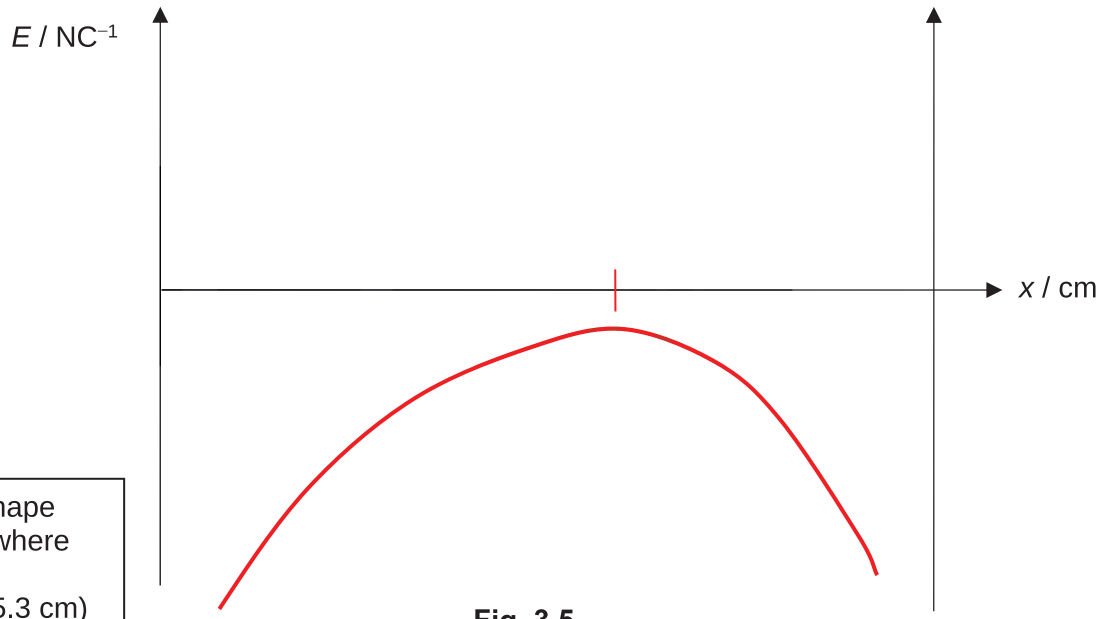
ratio = ………..[2]

(iii) State and explain the direction of the electric field at the point P, where x = 2.0 cm.

Direction is towards the charge A (or to the left) [A1]
Reason :
Electric field strength points towards decreasing potential [M1], **or** since charge A is a negative charge and charge B is a positive charge, the electric field strengths due to A and B are both towards the left at point P [M1] **or**
Since E = -dV/dx, since dV/dx is positive, E is negative [M1]

…[2]

(iv) Sketch the variation of the electric field strength with x in Fig. 3.5. Label where appropriate.



1 mark for correct shape
1 mark for marking where the turning point is
(accept from 4.5 to 5.3 cm)

Fig. 3.5

[2]

For Examiner's Use

(v) When a -2.0 nC charge is moved from *x* = 3.0 cm to 6.0 cm, calculate the change in kinetic energy of the -2.0 nC charge.

Change in EPE
= $q\Delta V$
= -2.0×10^{-9} (-40-(-100)) [M1]
= -1.2×10^{-7} J
Since change in EPE is a loss, hence change in KE is a gain of 1.2×10^{-7} J [A1].

change in kinetic energy = ………………………… J [2]

For Examiner's Use

4 (a) By reference to the photoelectric effect, explain

(i) what is meant by *work function*,

Minimum (photon) energy that is required to remove an electron from the surface

....[1]

(ii) why, even when the incident light is monochromatic, the emitted electrons have a range of kinetic energies up to a maximum value.

KE is maximum when electrons at the surface are ejected [B1]
KE can be lower than the maximum energy because energy is required to bring electron deeper in the metal to the surface or electron loses energy when it makes its way to the surface [B1]

....

....

....[2]

(iii) In an experiment to investigate the photoelectric effect, a student measures the wavelength λ of the light incident on a metal surface, and the maximum kinetic energy E_{max} of 1/λ as shown in Fig. 4.1.

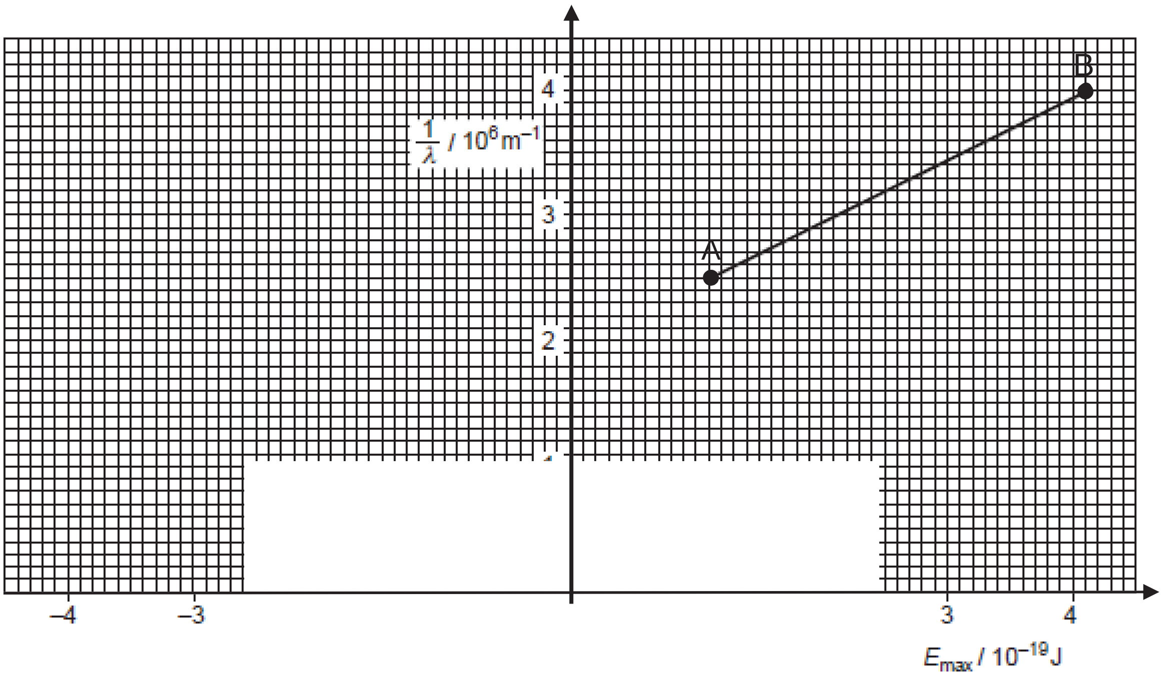


Fig. 4.1

For Examiner's Use

1. Without using the value of the Planck constant, determine the work function of the metal surface.

hc/λ = Φ + E_{max}
1/λ = Φ/hc + E_{max}/hc
At x-intercept, Φ = - E_{max}
Either extend line to intersect on x-axis [M1]
Or form eqn of straight line to solve [M1]
Φ = 4.0 x 10^{-19} J (allow $\pm$ 0.2 x 10^{-19} J)[A1]

work function = ……………… J [2]

2. Using points A and B, determine the Planck constant.

Gradient of line = 1/hc [M1]
Correct coordinates of points to half a square and correct calculation of gradient [M1]
Correct h = 6.6 to 6.9 x 10^{-34} J s [A1]

Planck constant = …………………….. J s [3]

(b) Fig. 4.2 shows how x-rays are produced inside an x-ray tube. The electrons emitted at the filament are accelerated from rest using an accelerating voltage to hit a target of heavy metal at the anode and produce x-rays as a result.

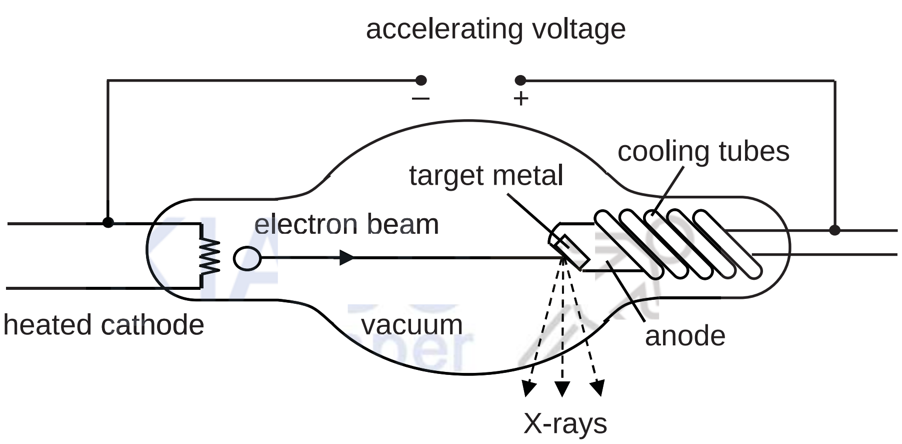


Fig 4.2

A graph of relative intensity against wavelength of the emitted radiation is as shown in Fig. 4.3.

For Examiner's Use

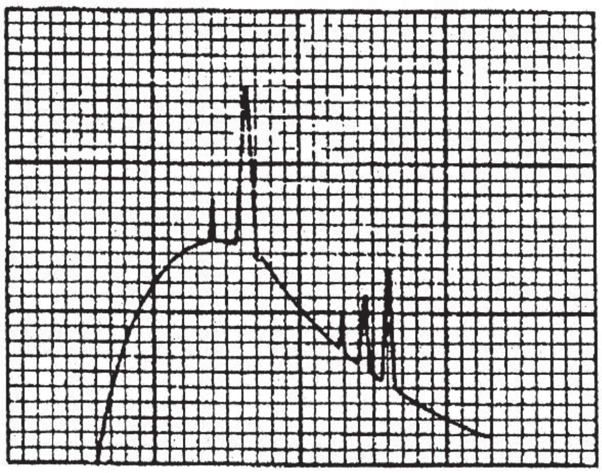


Fig. 4.3

(i) State and explain what must be done to the accelerating voltage if the minimum wavelength of the x-rays emitted is to be doubled.

The maximum energy of the X-ray photon (= hc/λ_{min}) emitted is equal to the kinetic energy of electrons upon hitting target, which is in turn equal to the loss in electric potential energy of the electrons as they are accelerated [M1].

Hence for λ_{min} to be doubled, the accelerating voltage must be halved [A1].

…………………………………………………………………………………[2]

(ii) Determine the accelerating voltage used to produce the minimum wavelength as shown in Fig. 4.3.

Solution

Max energy of x-ray photons = KE gain of electron upon acceleration = EPE loss of electron [B0]

$hc/\lambda_{min} = eV_a$ [M1]

$V_a = 6.63 \times 10^{-34} \times 3.0 \times 10^{8} / (18.0 \times 10^{-12} \times 1.6 \times 10^{-19})$

$= 69.1$ kV [A1]

Accelerating voltage = …………………….. kV [2]

For Examiner's Use

(c) Electrons, accelerated through a potential difference, are incident on a very thin carbon film, with speed v as shown in Fig. 4.4.

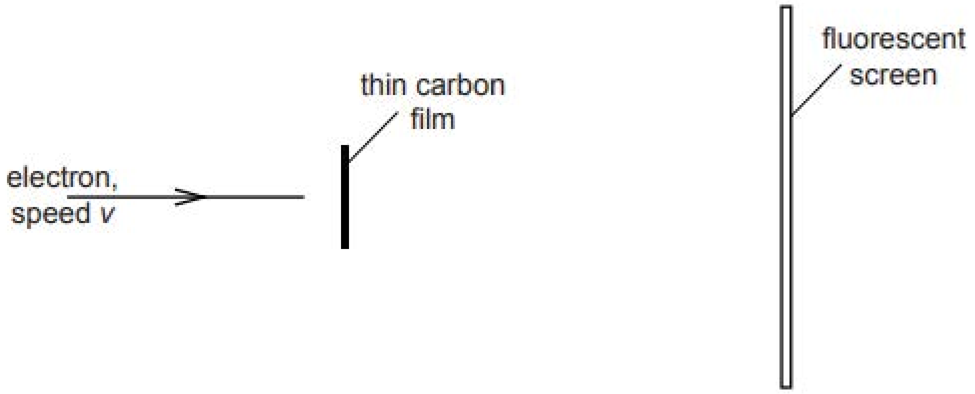


Fig. 4.4

The emergent electrons are incident on a fluorescent screen. A series of concentric rings is observed on the screen.

(i) State and explain what the observed rings suggest about the nature of the electrons.

The observed rings suggest that the electrons behave like waves (or provide evidence for the wave nature of particles) [M1]

as when light passes through suitable film, diffraction occurs and similar pattern observed [A1]
Or
concentric circles are evident of diffraction and diffraction is a wave property [A1]

……[2]

(ii) The stream of electrons is now replaced by a stream of alpha particles arriving at the thin film with the same speed v. State and explain the effect, if any, on the rings observed on the screen.

Mass is larger, hence momentum increases
$\lambda = h/p$ so λ decreases [M1]
Hence radii decrease [A1] or if wavelength is no longer comparable to the inter-atomic spacing, there will be no diffraction and hence no concentric rings will be observed.

Or
Mass is larger, hence kinetic energy increases [M1]
$\lambda = h/\sqrt{(2mKE)}$, so λ decreases [M1]
Hence radii decrease [A1] or if wavelength is no longer comparable to the inter-atomic spacing, there will be no diffraction and hence no concentric rings will be observed.

..[3]

For Examiner's Use

(iii) A proton and an alpha particle are each accelerated from rest through the same potential difference. Determine the ratio

$$\frac{\text{de Broglie wavelength of the proton}}{\text{de Broglie wavelength of the alpha particle}}$$

Since proton and alpha particle are accelerated from rest through the same potential difference and the charge of the alpha particle is double that of the proton, the ratio of their kinetic energy, KE is:

$\frac{E_p}{E_\alpha} = \frac{eV}{2eV}$ = ½ [M1]

Since E = $p^2/2m$ or p = √(2m KE) and λ α 1/p,
Therefore, λ α 1√(m KE) [M1]

Therefore ratio = $\sqrt{\frac{m_\alpha}{m_p}} \times \sqrt{\frac{E_\alpha}{E_p}}$
= √4 x √2
= 2.83 [A1]

Or

Gain in KE = $\frac{p^2}{2m}$

Loss in EPE = qV

Since gain in KE = loss in EPE

$\frac{p^2}{2m}$ = qV

p = $\sqrt{2mqV}$

Since λ α 1/p and V is constant, therefore ratio = #
$\sqrt{\frac{m_\alpha q_\alpha}{m_p q_p}}$
= $\sqrt{4 \times 2}$
= 2.83

……… [3]

For Examiner's Use

Section B: Answer ONE out of TWO questions.

5 (a) The headlights of a car are switched on. The distance along the copper connecting wires between the car battery and one of the headlights is 1.5 m.

(i) The current in the wire is 3.0 A, the cross-sectional area of the wire is 3.0 × 10^{-7} m^2, and the number density of electrons in copper is 8.5 × 10^{28} m^{-3}.
Determine the average time that an individual electron will take to drift from the battery to the headlight.

$$v = \frac{I}{nAe} = \frac{3}{(8.5\times10^{28})(3\times10^{-7})(1.6\times10^{-19})} = 7.3529\times10^{-4}\ \text{m s}^{-1} \quad \text{[M1]}$$

Therefore time taken,

$$t = \frac{\text{distance}}{\text{speed}} = \frac{1.5}{7.3529\times10^{-4}} = 2040\ \text{s} \quad \text{[A1]}$$

time taken = …………………….. s [2]

(ii) Using your answer in **(i)**, comment on how the light of the headlamp comes on almost immediately when switched on.

Although the time taken for the electron to travel from the car battery to headlamp is very long (or the drift velocity is very small), ALL the electrons in the entire complete circuit have a net movement in a single direction [B1] from lower to higher potential. Thus light comes on almost instantaneously.

……………………………………………………………………………………… [1]

(b) An electric heater consists of three similar heating elements A, B, C, connected as shown in Fig. 5.1.

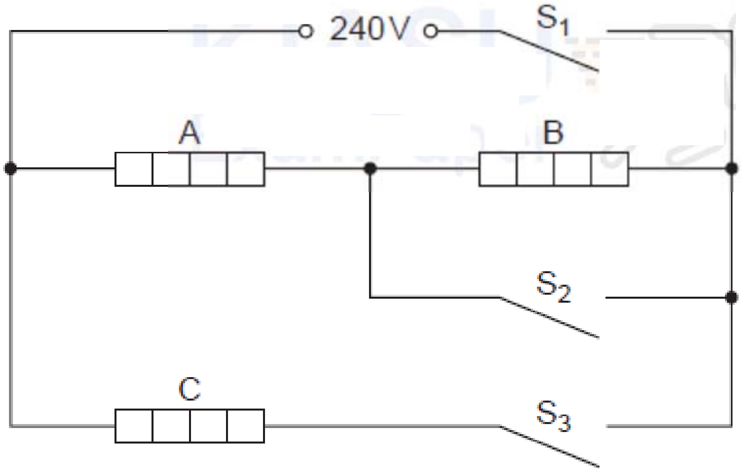


Fig. 5.1

For Examiner's Use

Each heating element is rated as 1.5kW, 240V and may be assumed to have constant resistance.
The circuit is connected to a 240 V supply.

(i) Calculate the resistance of one heating element.

$$P = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} = \frac{240^2}{1500} = 38.4\ \Omega$$

[M1 for formula, A1 for substitution and answer]

resistance = …………………………..Ω [2]

(ii) The switches S_1, S_2 and S_3 may be either open or closed.

1. When S1, S2 and S3 are all closed, state the total power dissipation of the heater.

B is bypassed and current flows through A and C. P.d. across A and C is 240V. So A and C dissipates 1.5 kW each, and collectively 3.0 kW.

total power dissipation = ……………………….. kW [1]

2. When S1 is closed, S2 is open, and S3 is open, determine the total power dissipation of the heater. [2]

Current flows through A and B, but not C. P.d. across A and B is 120V each. Since $P=V^2/R$, power is proportional to V^2 (for constant R).

$$\frac{P_{120}}{P_{240}} = \frac{V_{120}^2}{V_{240}^2}$$

$$\Rightarrow P_{120} = P_{240}\frac{V_{120}^2}{V_{240}^2} = 1.5\frac{120^2}{240^2} = 0.375\text{ kW} \quad \text{[M1]}$$

$$\Rightarrow P_{total} = 0.375 + 0.375 = 0.750\text{ kW} \quad \text{[A1]}$$

For Examiner's Use

3. Hence, determine the total power dissipation of the heater when S1 is closed, S2 is open, and S3 is closed.

Current flows through A, B and C. P.d. across A and B is 120V each, and as found in part (2) previously the power dissipated in A and B collectively is 0.75 kW.
P.d. across C is 240V, so power dissipated in C is 1.5kW.
Thus, all together, the total power dissipated in A, B and C
= 0.75 + 1.5 [M1]
= 2.25 kW [A1]

total power dissipation = ……………………….. kW [2]

(c) A circuit used to measure the power transfer from a battery is shown in Fig. 5.2. The battery has an electromotive force (e.m.f.) E and an internal resistance r. The power is transferred to a variable resistor of resistance R, when the potential difference (p.d.) across it is V, and the current through it is I.

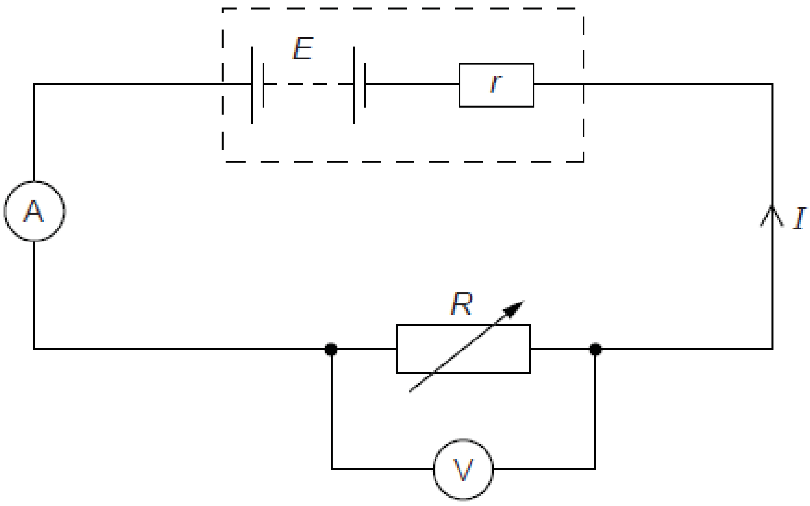


Fig. 5.2

(i) By reference to the circuit shown in Fig. 5.2, distinguish between the definitions of e.m.f. and p.d.

The electromotive force of a source is the electrical energy converted from other forms of energy per unit charge delivered round a complete circuit. [B1]

The potential difference between two points in a circuit is the amount of energy converted from electrical to other forms of energy per unit charge passing from one point to the other. [B1]

-1m if no "per unit charge"

[2]

For Examiner's Use

(ii) The variation with current *I* of the p.d. *V* across *R* is shown in Fig. 5.3.

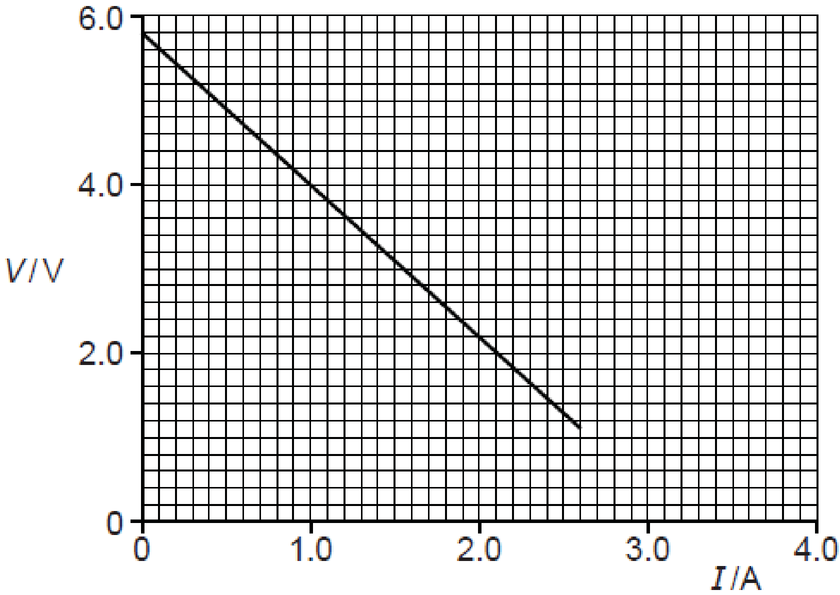


Fig. 5.3

Use Fig. 5.3 to determine

1. the e.m.f. *E*,

E = IR + Ir
IR = E – Ir
V = – rI + E (*where gradient is –r and y-intercept E*)

E = 5.8 V [B1] (*-1m overall if not in 1 d.p.*)

..V [1]

2. the internal resistance *r*.

Evidence of gradient calculation or calculation with values from graph
e.g. 4.0 = –r(1.00) + 5.8 [M1]
r = 1.8 Ω [A1]
OR
r = - gradient =| (5.8 – 2.2) / (0.00 – 2.00) | [M1]
= 1.8 Ω [A1]

(*-1m overall if V not in 1 d.p. or I not in 2 d.p.*)

r = ……………………………..Ω [2]

(iii) **1.** Using data from Fig. 5.3, show that the power transferred to *R* for a current of 1.6 A is 4.64 W. [1]

P = VI
= 2.9 x 1.6 [M1]
= 4.64 W [A1]

For Examiner's Use

2. Use your answers from **(ii)1** and **(iii)1** to calculate the efficiency of the battery for a current of 1.6 A.

power from battery = 1.6 x 5.8 = 9.28 W [M1]
efficiency = (4.64 / 9.28) x 100 = 50 % [A1]

efficiency = …………………………..% [2]

(iv) The variable resistor *R* in Fig. 5.2 is replaced by a few identical lamps connected in parallel. A student claims that as the number of lamps connected in parallel is increased, the lamps become dimmer. Comment on the student's claim.

With more lamps connected in parallel, the effective resistance across the lamps is lower than before. [M0]

Hence, the ratio of this effective resistance to the internal resistance falls, resulting in a smaller potential difference across the lamps. [M1]

The power dissipated by them will be lower (assuming the individual resistances of the lights remain the same). Thus, they become less bright. [A1]
So, the student's claim is valid. [A0]

6 **(a)** A composite block of mass 10 kg, made of woods of different densities ρ_1 and ρ_2, floats in still water of density ρ_w, as shown in Fig. 6.1. Each portion of wood is of height *x* and of a base with cross-sectional area *A*.

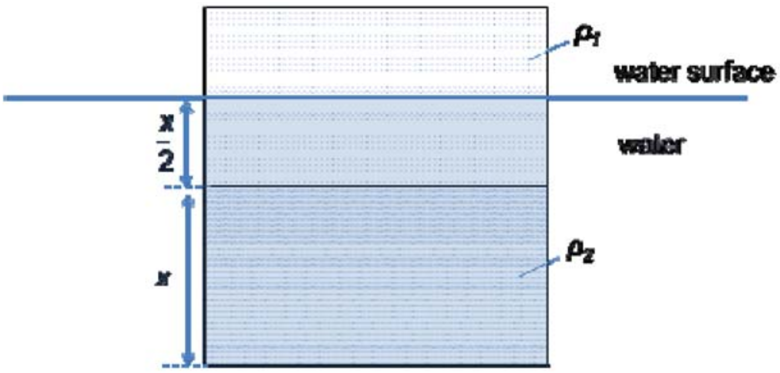


Fig. 6.1

(i) The block is pushed down by a distance *l* into the water without totally submerging it, and is then released.
It can be shown that the acceleration a of the block is given by

$$a = -\frac{\rho_w g}{(\rho_1 + \rho_2)x} l$$

Explain why the expression leads to the conclusion that the block bobs up and down in simple harmonic motion.

> The negative sign shows that the **acceleration** (upwards) **is in the opposite direction to the displacement of the block** (downwards) [B1]
> Since the three densities, *x* and *g* are constant, it can be seen that the **acceleration is directly proportional to the displacement**. [B1]
> Therefore, the block moves in simple harmonic motion.

....[2]

(ii) The depth *h* of the block is measured from below the water surface to the base of the block as shown in Fig. 6.2.

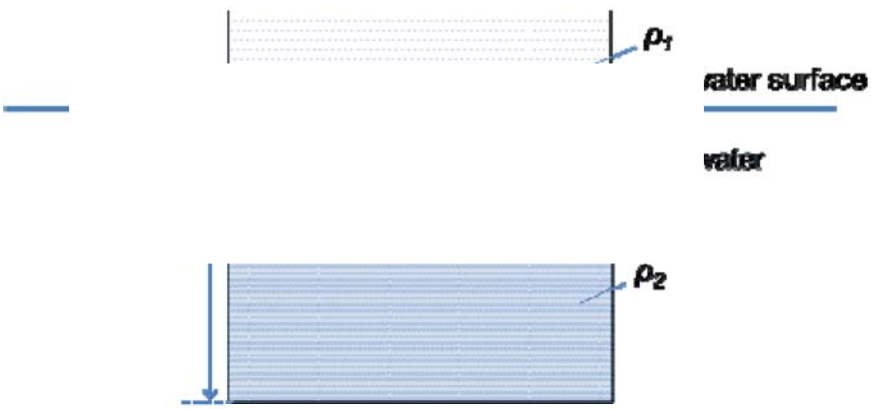


Fig. 6.2

Fig. 6.3 shows the variation with time *t* of the depth *h* of the base of the block below the surface.

For Examiner's Use

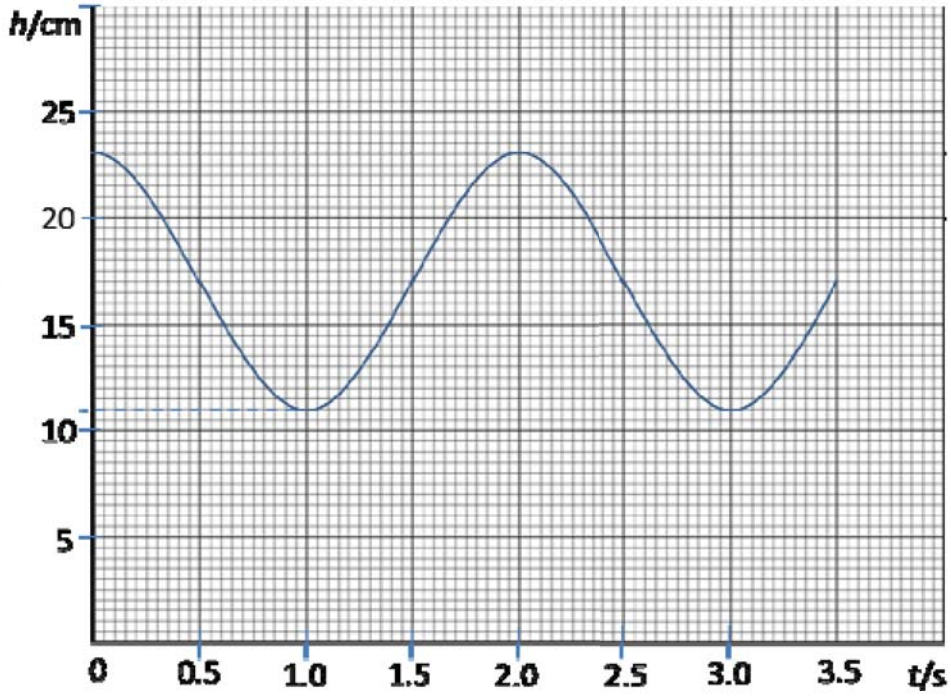


Fig. 6.3

1. Determine the amplitude of the oscillation of the block.

From the graph, maximum displacement = 23.00 cm
minimum displacement = 11.00 cm
amplitude = 0.5 (23.00 – 11.00)
= 6.00 cm = 0.0600 m [A1]

amplitude = …………… m [1]

2. Determine the angular frequency of the oscillation.

From graph,
T = 2.000 s [M1]

$$\omega = \frac{2\pi}{T} = \frac{2\pi}{2.000} = 3.14 rads^{-1}$$ [A1]

angular frequency = …………… rad s^{-1} [2]

3. Hence, show that the energy of the oscillation is 0.177J. [1]

Energy of Oscillation = Maximum KE

$$= \frac{1}{2}m\omega^2 x_0^2 = \frac{1}{2}(10)(3.14)^2(0.06)^2 = 0.177J$$ [B1]

For Examiner's Use

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

The *magnitude* of the induced e.m.f. in a coil [B1] is directly proportional to the rate of change of the magnetic flux linking the coil / rate of cutting of magnetic flux [B1].

……………………………………………………………………………………..[2]

(ii) A coil with 800 turns is placed in a uniform horizontal magnetic field of flux density 5.0 x 10^{-2} T. The area of the coil perpendicular to the field is 2.5 x 10^{-2} m^2, as shown in Fig. 6.4.

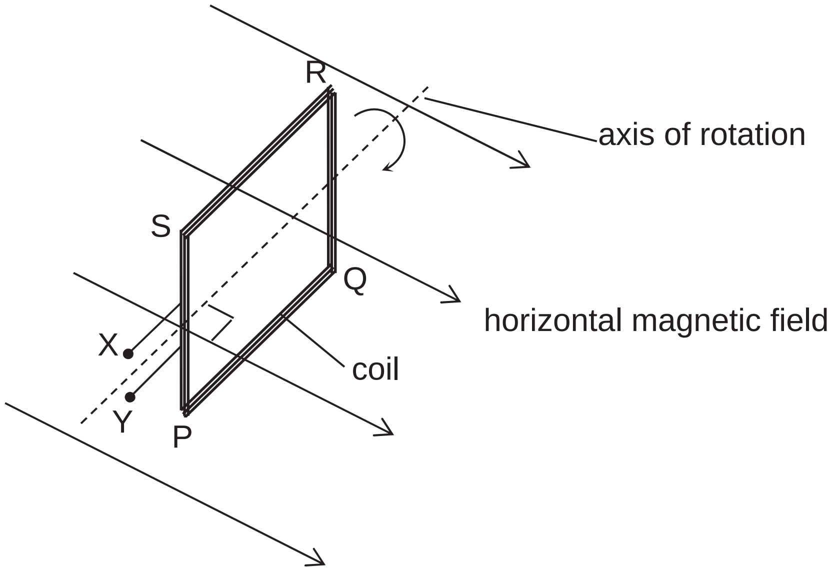


Fig. 6.4

1. Explain why an e.m.f. is induced in the coil.

The angle between the magnetic field and the plane of the coil (or the magnetic flux density perpendicular to the area of the coil, or the area of the coil perpendicular to the magnetic flux density) changes, OR the coil cuts the magnetic field lines. [B1]
Hence, there is a change in the magnetic flux linking the coil, causing an emf to be induced by Faraday's Law [B1].

2. Determine the magnetic flux linkage of the coil.

Φ = NBA [B1] = 800 x 5.0 x 10^{-2} x 2.5 x 10^{-2} = 1.0 Wb [B1]

magnetic flux linkage = ……………..……… Wb-turns [2]

For Examiner's Use

(c) The coil in **(b)** is rotated around the axis shown in Fig. 6.4. The flux linkage Φ of the coil varies with time t as shown in Fig. 6.5.

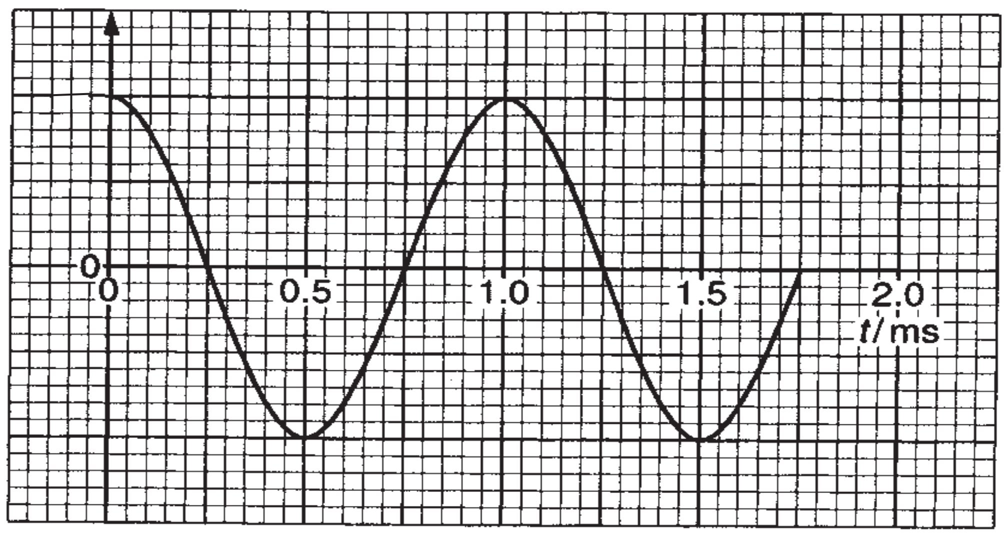


Fig. 6.5

(i) Derive the equation for the induced e.m.f. *E* of the coil, where *N* is the number of turns in the coil, *B* is the magnetic flux density, *A* is the area of coil, and ω is the angular frequency of the change in magnetic flux linkage. [2]

E.m.f. is given by

$$E = -\frac{d\Phi}{dt}$$

$$E = -\frac{d}{dt}\left(NBA\cos\omega t\right)$$ [M1 for expression for MFL, A1 for differentiation]

$$E = NBA\omega\sin\omega t$$

(ii) Sketch on Fig. 6.6 the variation with time of the e.m.f. across XY. Label the maximum value of the e.m.f. [2]

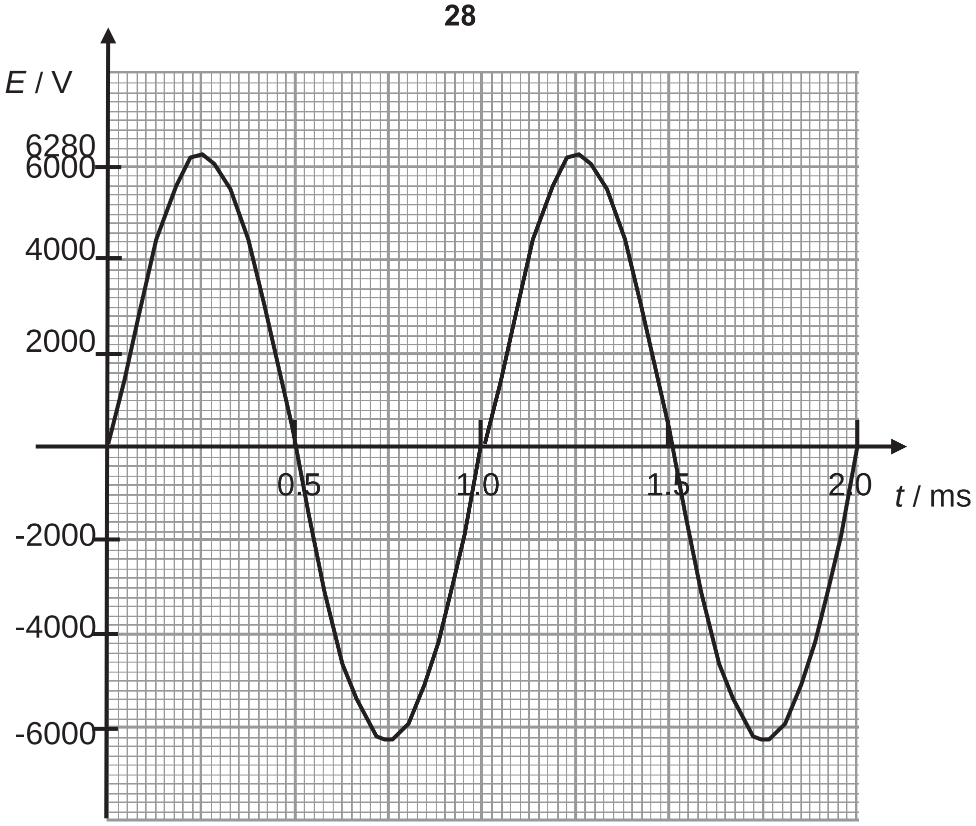


Fig. 6.6

[B1] for sine wave with same period
[B1] for labelling max e.m.f. as 6280 V (BOD wrong scale).

(d) A resistor of resistance 5000 Ω is now connected across XY.

(i) Determine the mean power dissipated in the resistor.

Mean power = $\frac{\left(\frac{V_o}{\sqrt{2}}\right)^2}{R} = \frac{\left(\frac{6280}{\sqrt{2}}\right)^2}{5000} = 3.94kW$ [B1] for formula and substitution. [B1] for answer

mean power = …………….……… kW [2]

(ii) Use energy conservation to explain why the oscillations of the coil are damped.

Induced current flowing through resistor produces heating. [B1]
Thermal energy results in loss of mechanical/kinetic energy of oscillations. [B1]

……………………………………………………………………….………………..

……………………………………………………………………………………….[2]

END OF PAPER

SERANGOON JUNIOR COLLEGE
General Certificate of Education Advanced Level
Higher 2

NAME

CG | INDEX NO.

PHYSICS 9749 / 04

Preliminary Examination **29 August 2017**
Paper 4 Practical **2 hour 30 minutes**

Candidates to answer all questions in the Question Booklet.

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and index number in the spaces at the top of this page.

Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or do not use appropriate units.

Give details of the practical shift and laboratory in the boxes provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 14
2	/ 9
3	/ 20
4	/ 12
Total	/ 55

1 This investigation considers the angles formed by the threads in a pulley system when it is in equilibrium.

(a) In this set-up, there are two threads – a long thread AB and a short thread CD, as shown in Fig.1.1. Two pulleys P and Q are identical.

Tie end A to the 100 g mass.

Pass the thread AB through pulleys P and Q.

Tie end B to the 50 g mass.

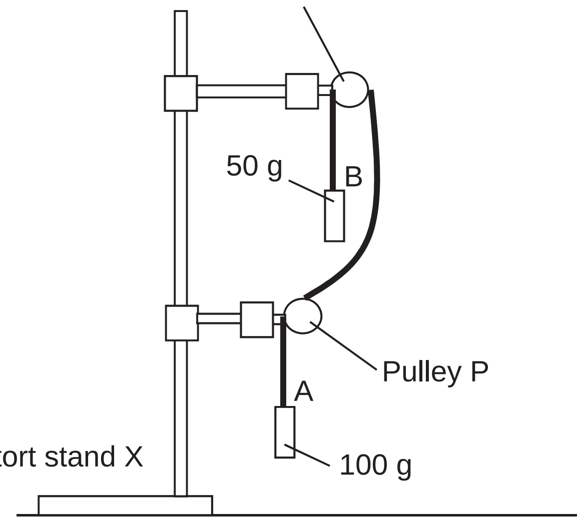


Fig.1.1

(b) Tie thread CD as shown in Fig.1.2. **Thread CD must be kept horizontal** throughout the whole experiment.

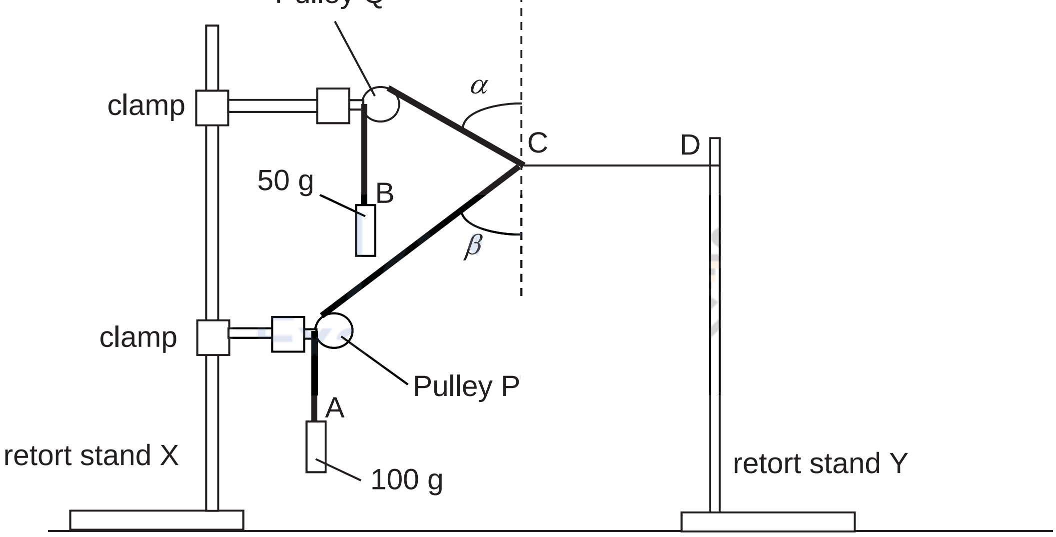


Fig.1.2

For Examiner's Use

(c) Measure the angles α and β.

Value of α and β to the correct precision with unit
Unit: ° (zero d.p.)
$\alpha < \beta$
α and β are less than 90°

α = ………………..

β = ……………….. [1]

(d) Estimate the percentage uncertainty in α.

$\Delta\alpha = 2°$ (accept 2° to 4°)

$$\frac{\Delta\alpha}{\alpha} \times 100\% = \frac{2}{40} \times 100\% = 5\%$$

[Accept $\Delta\alpha = 1 + 1$ or 2×1. Ecf α for incorrect d.p. in (c)]

n α = ……………….. [1]

(e) State one significant source of error that may have affected the accuracy of the readings of angles α and β.

1. Friction at the axle of pulleys / friction between thread and pulley.
2. Difficult to ensure that CD is horizontal.
3. Difficult to measure angles α and β due to absence of plumbline / reference line.
4. Difficult to measure the angle θ accurately because it is difficult to hold the protractor still and in position as the hands may be unsteady / because the protractor touches the threads.

……[1]

(f) Suggest one improvement that could be made to the experiment to address the error identified in **(e).** You may suggest the use of other apparatus or a different procedure.

1. Lubricate the (axle of) the pulley.
2. Use spirit level metre / Use any horizontal reference in the lab / Use set squares to ensure CD is perpendicular to the retort stand.
3. Set up a plumbline / Clamp a ruler perpendicular to CD with another retort stand / Use set squares (and clamp the protractor using another retort stand).
4. Clamp the protractor using a retort stand instead, to measure the θ.

[Accept diagram to illustrate the idea]

….[1]

For Examiner's Use

(g) It is suggested that cos α is directly proportional to cos β. Move the retort stand Y to the right and adjust thread CD so that it is horizontal. Obtain one more set of values of α and β to investigate this suggestion. State and explain whether you agree with this suggestion.

Present your measurements and calculated results clearly. Plotting of graph is not required.

α / °	β_1 / °	β_2 / °	cos (α / °)	cos (β / °)	$k = \frac{\cos(\alpha/°)}{\cos(\beta/°)}$
40	70	72	0.76	0.33	2.3
55	73	74	0.57	0.28	2.0

[Accuracy of cos α and cos β: 1 mark.]

[S.f. of cos α and cos β: 1 mark.]

[Accuracy of constant of proportionality *k*: 1 mark]

[S.f. of constant of proportionality *k*: 1 mark]

[Calculation of % difference in values of *k* (1 or 2 s.f.): 1 mark]

[Draw conclusion based on stated criterion, e.g. not obeyed because more than 20% difference in values of *k*: 1 mark]

If $|k_1 - k_2|$ / smaller of k × 100% < 20%, then the suggestion that cos α is directly proportional to cos β is valid.

[6]

(h) Let the tensions in CA, CB and CD be T_1, T_2, and T_3 respectively.

By considering the equilibrium of forces acting at point C, write two equations relating T_1, T_2, T_3, α and β. [2]

By considering vertical equilibrium, taking upwards as positive,
$T_2 \cos \alpha - T_1 \cos \beta = 0$
$T_2 \cos \alpha = T_1 \cos \beta$ [B1]
By considering horizontal equilibrium, taking rightwards as positive,
$T_3 - (T_2 \sin \alpha + T_1 \sin \beta) = 0$
$T_3 = T_2 \sin \alpha + T_1 \sin \beta$ [B1]

(i) A student suggests that when there is an increase in the ratio of the mass hung at end A to the mass hung at end B of thread AB, the ratio of cos α to cos β would increase. Suggest how you would verify this.

Keep CD horizontal. [B1]

Describe appropriate method to increase the ratio of mass at A to mass at B (e.g. increase the mass at end A while keeping the mass at end B the same)

Determine the ratio of $\frac{\cos\alpha}{\cos\beta}$. If the ratio of cos α to cos β increases when the mass ratio increases, then the statement is true. [B1]

]

2 In this experiment, you will measure the potential difference across resistor R_2 as the resistance of the circuit is varied.

(a) The Digital Multimeter (DMM) is used as a voltmeter.

Ensure that the black lead of the Digital Multimeter (DMM) is connected to the "COM" jack input, while the red lead is connected to the "V / Ω / mA" jack input.

Set the dial on the DMM to "**20 V**" mark in the "V" range.

(b) Set up the circuit as shown in Fig. 2.1. Connect one R_1 to the circuit and close the switch.

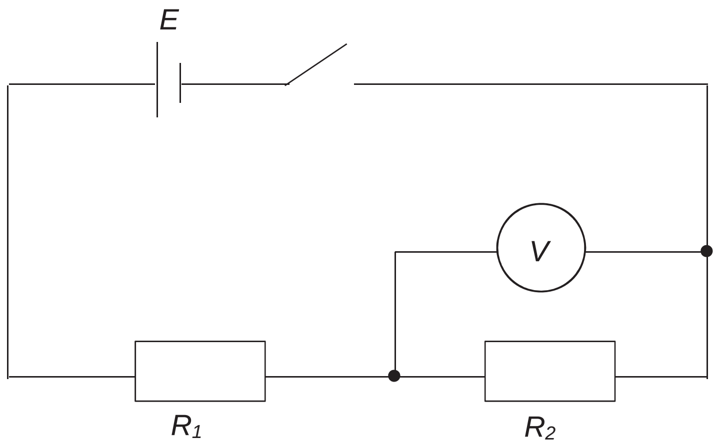


Fig. 2.1

(c) Record the potential difference across R_2, V using the voltmeter.

V measured to the correct precision with unit
Unit: V (2 d.p.)
V_1 = 2.16 V
V_2 = 2.16 V
$V_{average}$ = 2.16 V

= ………………… [1]

(d) Change *n*, the number of resistor R_1 connected **in parallel**. Obtain three further sets of values for *n* and the corresponding values of *V*. [3]

n	V_1 / V	V_2 / V
1	1.77	1.77
2	1.94	1.94
3	2.01	2.01
4	2.04	2.04

[Evidence of repeated readings: 1 mark]
Repeated measurements for V_1 and V_2 for each value of *n*.

[Headings: 1 mark]
Each column heading must contain a quantity and a unit. Ignore units in the body of the table.

[Raw data: 1 mark]
All values of V_1 and V_2 to the correct precision (V_1, V_2 unit: V, 2 d.p).

For Examiner's Use

(e) Theory suggests that V and n are related by the equation

$$\frac{1}{V} = \frac{R_1}{nER_2} + \frac{1}{E}$$

where E is the e.m.f. of the power supply.

Suggest how you would determine the ratio of $\frac{R_1}{R_2}$ without measuring the resistance of the resistors directly.

Plot a graph of $\frac{1}{V}$ against $\frac{1}{n}$. [B1]

The gradient of the graph represents $\frac{R_1}{R_2E}$. Therefore $\frac{R_1}{R_2} = \text{gradient} \times E$ [B1]

Measure E using a voltmeter. [B1]

…………[3]

(f) In the specification of a resistor, "tolerance" refers to the percentage error in the resistance of the resistor. The tolerance of each resistor that you use in this experiment is $\pm 5\%$, resulting in an absolute error of ΔR_1 for the resistance R_1, and ΔR_2 for the resistance of R_2.

Explain how the absolute error in the effective resistance of the circuit would change when a few R_1 are connected in series instead of being connected in parallel.

When R_1 are connected in series, the absolute error in the effective resistance $\Delta R_{effective} = n\Delta R_1 + \Delta R_2$. [M1]

When R_1 are connected in parallel, the absolute error in the effective resistance

$\Delta R_{effective} = \frac{\Delta R_1}{n} + \Delta R_2$. [M1]

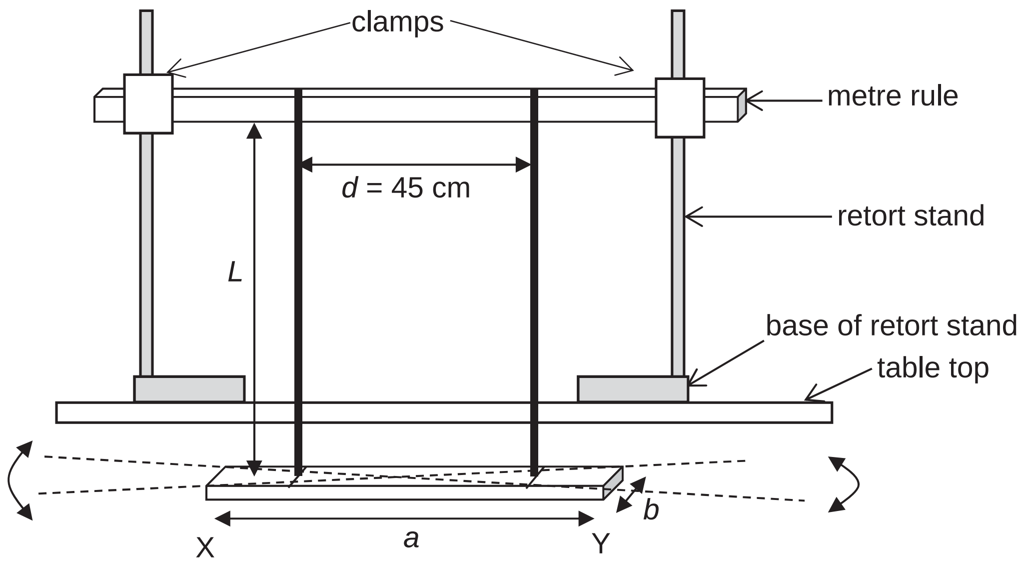
Therefore the absolute error in the effective resistance increases when the resistors are connected in series. [A1]

…………[2]

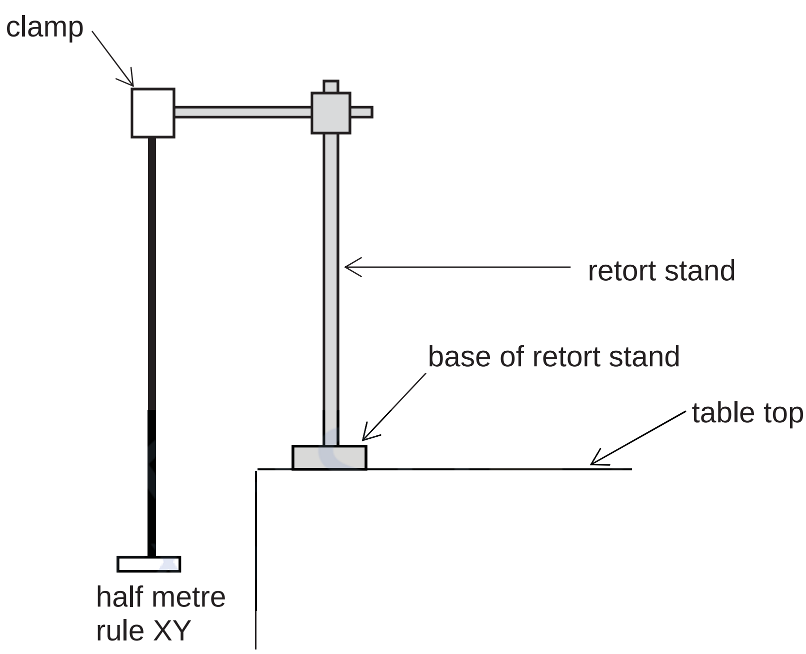
[Total: 9 marks]

3 In this experiment, you will investigate how the period of oscillation *T* of a suspended half-metre rule about a vertical axis through its centre, is related to its separation *L* from a horizontal metre rule.

(a) Suspend a half-metre rule XY symmetrically by two exactly equal lengths of threads. XY has a length of *a*, and a width of *b*. Fig.3.1 shows the front view and Fig.3.2 shows the side view of the set up.



Front view
Fig.3.1



Side view
Fig.3.2

(b) Arrange the threads at a distance *d* of 45 cm apart.

(c) Ensure that the threads are vertical. Adjust *L* to about 100 cm.

(d) Measure and record *L*.

L measured to the correct precision with unit
cm – 1 d.p.
m – 3 d.p.

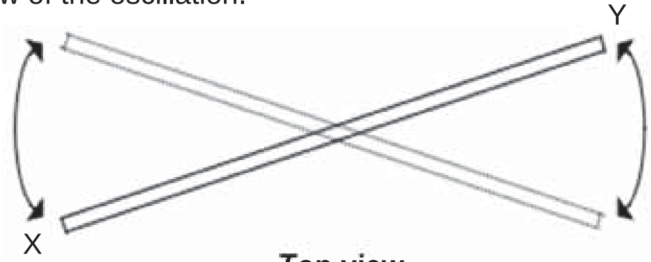
L = ……………….. [1]

(e) Estimate the absolute uncertainty in this value of *L*.

Sensible value of *L* with correct unit
Unit: cm or m (1 s.f.)
0.2 cm or 0.002 m

absolute uncertainty = ……………….. [1]

(f) Give the suspended half-metre rule XY an angular displacement about a vertical axis through its centre, and set it into small angular oscillation as shown in Fig.3.1. Fig.3.3 shows the top view of the oscillation.



Top view
Fig. 3.3

(g) Determine the period *T* of the oscillations.

n = 20
t_1 = 25.2 s
t_2 = 25.3 s

$$T = \frac{t_1 + t_2}{2n} = \frac{25.2 + 25.3}{2(20)} = 1.26 \text{ s}$$

Number of oscillations *n* chosen such that *nT* is at least 10 s.
Number of oscillations chosen should be stated.

T = ……………….. [1]

t measured to the correct precision with unit
Unit: s (1 d.p.)
Number of oscillations *n* chosen such that *nT* is at least 10 s.
Number of oscillations chosen should be stated.

For Examiner's Use

(h) Vary L and repeat **(f)** and **(g)** to obtain further sets of values for L ranging from 20.0 cm to 100.0 cm, and the corresponding values of T. [7]

[Evidence of repeated readings: 1 mark]
Repeated measurements for t_1 and t_2 for each value of L.
Number of oscillations n chosen such that nT is at least 10 s.
Number of oscillations chosen should be stated.

[Method: 2 marks]

- Award 2 marks if candidate has successfully collected 6 or more sets of data without assistance / intervention.
- Award 1 mark if candidate has successfully collected 5 sets of data without assistance / intervention.
- Award 0 mark if candidate has successfully collected 4 or fewer sets of data without assistance / intervention.
- Deduct 1 mark if candidate requires some assistance / intervention but has been able to do most of the work independently.
- Deduct 2 marks if candidate has been unable to collect data without assistance / intervention.
- Deduct 1 mark if out of range for first and last value of $\langle t \rangle$
- Deduct 2 marks if the trend is incorrect
- Maximum deduction of 2 marks

[Headings: 1 mark]
Layout: column headings (raw data and calculated quantities: L, t, T and T^2.
Each column heading must contain a quantity and a unit. Ignore units in the body of the table.
Column for n (number of oscillations timed) may be used if appropriate (though no units are expected for this column).

[Raw data: 1 mark]
All values of L, t_1 and t_2 to the correct precision (1 d.p.).

[Processed data – no. of d.p. / s.f: 1 mark]
For each calculated value of T and T^2, the number of s.f. should be the same as the number of s.f. in the raw data.
No mark if T^2 is not present.

[Processed data – accuracy: 1 mark]
Correctly calculated values of T and T^2.
No mark if T^2 is not present.

No. of oscillations n = 20

L / cm	t_1 / s	t_2 / s	T / s	T^2 / s^2
20.0	11.8	11.7	0.588	0.345
40.0	16.4	16.2	0.815	0.664
50.0	18.0	18.0	0.900	0.810
60.0	19.7	19.7	0.985	0.970
80.0	22.7	22.5	1.13	1.28
100.0	25.2	25.3	1.26	1.59

(i) It is suggested that T *and* L are related by the equation

$$g = \frac{16\pi^2(a^2+b^2)}{12d^2}\frac{L}{T^2}$$

Plot a suitable graph and hence determine the acceleration due to gravity, g. [6]

[Linearising the equation: 1 mark]
By plotting a graph of T^2 against L, a straight line graph should be obtained with gradient $\frac{16\pi^2(a^2+b^2)}{12d^2 g}$ and y-intercept = 0.
No mark if the axes are inverted.

[Graph: layout (choice of scale and labeling of axes): 1 mark]
Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed.

Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.

Scales must be labeled with the quantity which is being plotted.

No mark if the axes are inverted.

[Graph: plotting of points: 1 mark]
All observations must be plotted.
Work to an accuracy of half a small square.

[Graph: trend line (ability to draw line of best fit): 1 mark]
Straight line of best fit – judge by scatter of points about the candidate's line.
There must be a fair scatter of points either side of the line.

- If the data points are close to a straight line or a curve, there should be about the same number of points on either side of the line/ curve. Furthermore, in each half of the line/curve there should be the same number of points above it as below. The best straight line or curve is drawn by visual estimation with the aid of a transparent ruler.

[Interpretation of graph – gradient : 1 mark]
Gradient – the hypotenuse of the triangle must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square.
Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).

[Drawing conclusion : 1 mark]
Value of g calculated correctly with unit.

For Examiner's Use

For Examiner's Use

(j) Comment on any anomalous data or results you may have obtained. Explain your answer.

There is no anomalous data as all points are fairly scattered about the best fit line. *OR*
There are anomalous points at (_ , _) and (_ , _) as they lie further away from the best fit line as **compared to all the other points**.

....

....[1]

(k) State one significant source of error in this experiment.

....

....

....[1]

(l) Suggest one improvement that could be made to the experiment to address the error identified in **(k)**. You may suggest the use of other apparatus or different procedures.

....

....

....[1]

(k) Significant source of error	**(l) Improvement**
1) The vertical strings might shift during oscillation. ⇒ affect period *T*	1) Fix the strings using adhesive tape.
2) The ruler wobbles and does not oscillate about the vertical axis; unsteady oscillation. ⇒ affect period *T*	2) Switch off fans to reduce draft; ensure ruler is horizontal with CG of ruler symmetrically between the two vertical strings.
3) Metre rule is not suspended horizontally. ⇒ affect *L* and *T*	3) Use a spirit level meter to ensure the ruler is horizontal.

(m) On the graph grid on page 9, sketch a second graph to represent the results if the distance between two threads *d* is increased. Label this graph Z. [1]

When *d* increases, the gradient decreases, but y-intercept remains the same. [1 mark]

[Total: 20 marks]

For Examiner's Use

4 The history of solar energy is as old as humankind. In 1954, some scientists in the United States produced electricity from the sun. They invented photovoltaic cells, which capture the sun's energy and convert it into electricity. A photovoltaic cell is an electric cell made from two layers of different materials that can produce an electric current when light of certain frequencies shines on the cell. A solar panel is a collection of photovoltaic cells.

The frequency of the light falling on the solar panel can be varied by placing different colour filters in front of the light source as shown in Fig.4.1.

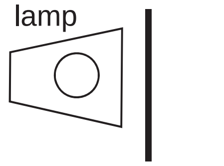


Fig.4.1

Design an experiment to investigate how the power generated by a solar panel depends on the frequency of the light falling on it.

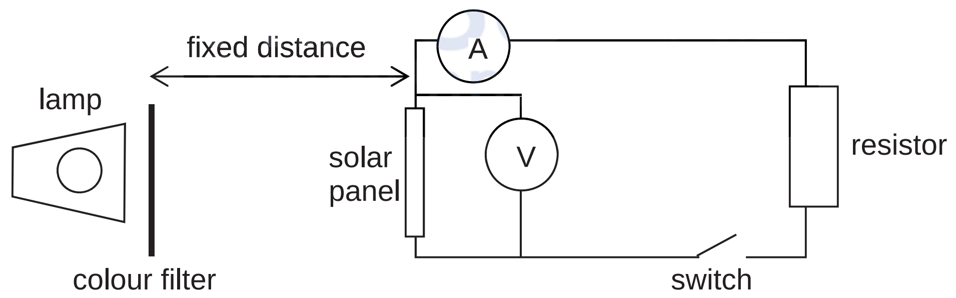
The equipment available includes the following:

Solar panel	Resistors
Colour filters	Switch
Lamp	Stopwatch
Spectrometer with diffraction grating	Rule
Ammeter	Micrometer screw gauge
Voltmeter	

You should draw a labelled diagram to show the arrangement of your apparatus and you should pay attention to

(a) the equipment you would use,
(b) the procedure to be followed,
(c) how the frequency of the light used is to be measured,
(d) how the power generated by the solar panel is to be measured,
(e) the control of variables,
(f) any precautions that would be taken to improve the accuracy, precision and safety of the experiment.

Diagram



[Total: 12 marks]

Procedure:

1. Set up as shown in the diagram.
2. [P1] Shine direct light through the colour filter at the solar panel. (Write this statement or draw in the diagram to illustrate this idea)
3. [C1] The lamp and filter is placed at a fixed distance measured using a ruler from the solar panel.
4. [C2] Solar panel is placed perpendicular to direction of light so that incident angle of light does not affect intensity. [C3] Ensure that the thickness of each filter is the same by measuring using micrometer screw gauge.
5. [A1] With the room lights switched off / In a dark room, switch on the power supply to the lamp.
6. [M1] The frequency *f* of the light through each filter is determined by using the spectrometer and diffraction grating. [P2] By taking note of the spacing *d* of the lines on the grating, angle *θ* on the spectrometer, and the order *n* of the diffracted light being observed, *f* can be calculated using $d \sin \theta = \frac{nc}{f}$, where *c* is the speed of light.
7. [P3] Connect ammeter in series with the solar panel, and a voltmeter across the solar panel (Write this statement or draw in the diagram)
8. [M2] Measure the current passing through the solar panel *I* using ammeter, and [M3] measure the potential difference across the solar panel *V* using the voltmeter.
9. [P4] Calculate the power generated by the solar panel, $P = IV$.
10. [A3] Repeat the readings of current through the solar panel and potential difference across the lamp for the same frequency of light by switching on and then off the lamp / removing and then putting back the colour filter / switching off and on the circuit connected to the solar panel.
11. Replace the filter with another colour and repeat steps (8) to (10).
12. [A2] Switching off lamp between readings to prevent solar panel from heating to maintain constant conductivity.
13. [D1] Assume $P = kf^n$, plot a graph of lg *P* against lg *f*. [D2] If a straight line graph is obtained with gradient *n* and y-intercept lg *k*, then the hypothesis is true.

Safety precautions:

- [S1] Handle the electrical circuit with care if potential difference is high (e.g. Dry hands / wear gloves when handling the circuit) so as to prevent electrocution.
- [S2] Wear protective eyewear to avoid eye injury due to intense light / in case of breaking the filter.

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Suggested Mark Scheme [PMACDS]
[Note: For each category, always think systematically of points related to IV and DV respectively.]

*Basic **P**rocedure [max 4]*

- P1: Shine direct light through the colour filter at the solar panel.
- P2: **[IV]** (By taking note of the spacing *d* of the lines on the grating, angle *θ* on the spectrometer, and the order *n* of the diffracted light being observed,) *f* can be calculated using $d \sin \theta = \frac{nc}{f}$, where *c* is the speed of light.
- P3: **[Processed DV]** Connect ammeter in series with the solar panel, and a voltmeter across the solar panel.
- P4: **[Processed DV]** Calculate the power generated by the solar panel, $P = IV$.

[Note: All formulae used for processed data should be explicitly written out.]

***M**easurement [max 3]*

- M1: **[IV]** The frequency *f* of the light through each filter is determined by using the spectrometer and diffraction grating.
- M2: **[DV]** Measure the current passing through the solar panel *I* using ammeter.
- M3: **[DV]** Measure the potential difference across the solar panel *V* using the voltmeter.

[Note: All steps involved in measurement should be explicitly written out.]

*Additional detail to improve **A**ccuracy [max 2]*

- A1: **[DV]** With the room lights switched off / In a dark room, switch on the power supply to the lamp.
- A2: **[DV]** Switching off lamp between readings to prevent solar panel from heating.
- A3: **[DV]** Repeat the readings of current through the solar panel and potential difference across the lamp for the same frequency of light by switching on and then off the lamp / removing and then putting back the colour filter / switching off and on the circuit connected to the solar panel.

[Note: Always explain exactly how (including equipment) you would improve accuracy in measurement of IV and DV.]

***C**ontrol of variables [max 2]*

- C1: The lamp and filter is placed at a fixed distance from solar panel, by measuring using a ruler / not moving the position of the lamp, filter and solar panel.
- C2: Solar panel is placed perpendicular to direction of light so that incident angle of light does not affect intensity.
- C3: Ensure that the thickness of each filter is the same by measuring using micrometer screw gauge.

[Note: Always explain exactly how (including equipment) you would keep the respective control variables constant.]

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Suggested Mark Scheme [PMACDS]

***D**ata analysis [max 2]*

- D1: Assume $P = kf^n$, plot a graph of lg P against lg f.
- D2: If a straight line graph is obtained with gradient n and y-intercept lg k, then the hypothesis is true.

[Note: Always use general equation instead of *P* = *kf*.]

***S**afety considerations [max 2]*

- S1: Handle the electrical circuit with dry hands / wear gloves, so as to prevent electrocution.
- S2: Wear protective eyewear to avoid eye injury due to intense light / in case of breaking the filter.

[Note: Focus on key safety considerations, and explain proactive actions to do with rationale.]

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