INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CLASS		INDEX NUMBER	

PHYSICS **9749/01**

Paper 1 Multiple Choice

15 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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

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

Read the instructions on the Answer Sheet very carefully.

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

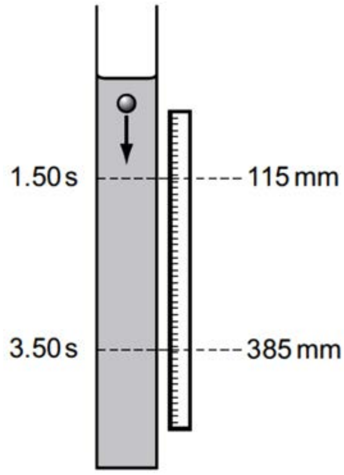
Data

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

Formulae

uniformly accelerated motion	s	$= ut + ½at^2$
	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	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^2 - x^2\right)}$
electric current	I	$= Anvq$
resistors in series	R	$= R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	$= x_0 \sin\omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 n I$
radioactive decay	x	$= x_0 \exp(-\lambda t)$
decay constant	λ	$= \frac{\ln 2}{t_{½}}$

1 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at (115 ± 1) mm on the adjacent rule and the lower mark at (385 ± 1) mm. The ball passes the top mark at (1.50 ± 0.02) s and passes the lower mark at (3.50 ± 0.02) s.

The constant speed of the ball is calculated by $\frac{385\text{-}115}{3.50\text{-}1.50} = \frac{270}{2.00} = 135\text{ mm s}^{-1}$.

Which expression calculates the fractional uncertainty in the value of this speed?

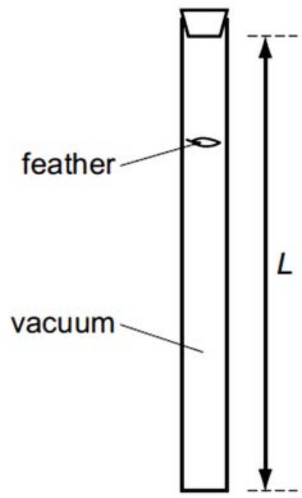
A $\frac{2}{270} + \frac{0.04}{2.00}$

B $\frac{2}{270} - \frac{0.04}{2.00}$

C $\frac{1}{270} \times \frac{0.02}{2.00}$

D $\frac{1}{270} \div \frac{0.02}{2.00}$

2 The diagram shows a laboratory experiment in which a feather falls from rest in a long evacuated vertical tube of length L.



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

How far will the feather have fallen from the top of the tube in time 0.50 t?

A 0.13 L **B** 0.25 L **C** 0.38 L **D** 0.50 L

3 A man applies a horizontal force to a supermarket trolley and the trolley accelerates uniformly in the direction of the force.

Which statement is correct?

A The force applied by the man on the trolley is greater than the force applied by the trolley on the man.

B The force applied by the man on the trolley equals the force applied by the trolley on the man.

C The forces acting on the trolley are in equilibrium.

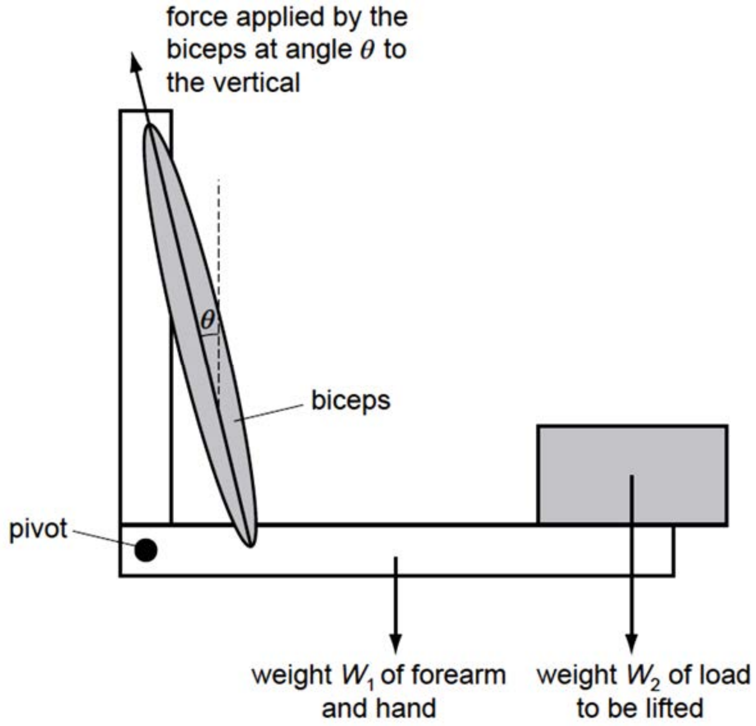
D The total frictional force acting on the trolley equals the force applied by the man on the trolley.

4 A block of ice of density 0.9 g cm^{-3} is held below the surface of water, density 1.0 g cm^{-3}. The block of ice is then released and floats to the surface.

What is the ratio $\frac{\text{upthrust when fully submerged}}{\text{upthrust when floating}}$?

A 0.1 **B** 0.9 **C** 1.0 **D** 1.1

5 The diagram shows a model of an arm. A force applied by the biceps muscle can hold the arm in equilibrium while it supports a load.



Which statement is correct when the arm is in equilibrium in the position shown?

A The force at the pivot is zero.

B The force from the biceps is bigger when the load is moved nearer to the pivot.

C The force from the biceps is equal to $W_1 + W_2$.

D The resultant force on the biceps is zero.

6 A hydroelectric power station uses the gravitational potential energy of water to generate electrical energy.

In one particular power station, the mass of water flowing per unit time is 1.5×10^5 kg s^{-1}. The water falls through a height of 120 m.

The electrical power generated is 100 MW.

What is the efficiency of the power station?

A 5.6% **B** 43% **C** 57% **D** 68%

7 A ball of mass 0.30 kg is attached to a string and moves in a vertical circle of radius 0.60 m at a constant speed of 5.0 m s^{-1}.

Which line, **A** to **D**, in the table gives the correct values of the minimum and maximum tension in the string?

	Minimum tension / N	Maximum tension / N
A	2.5	5.4
B	6.7	9.6
C	13	13
D	9.6	15

8 A particle of mass *m* moves with constant speed *v* in a circle of radius *r*. The work done on the particle by the centripetal force in one complete revolution is

A $2\pi mv$ **B** $\frac{2\pi v^2}{m}$ **C** $\frac{2\pi m}{v^2}$ **D** zero

9 Which one of the following statements is true when an object performs simple harmonic motion about a central point?

A The acceleration is always directed away from the central point.

B The acceleration and velocity are always 180° out of phase.

C The velocity and displacement are always in the same direction.

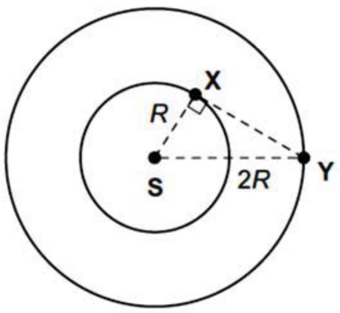
D The acceleration and displacement are always 180° out of phase.

10 A body executes simple harmonic motion of amplitude 100 mm along a line **PQ** centred on **O**. When passing through **O** the body has 50 J of kinetic energy.

When it is at a point 40 mm from **O**, which row gives the correct values of E_k and E_p?

	E_k / J	E_p / J
A	42	8
B	30	20
C	20	30
D	18	32

11 Two planets X and Y are in concentric circular orbits about a star S. The radius of the orbit of X is R and the radius of orbit of Y is $2R$.

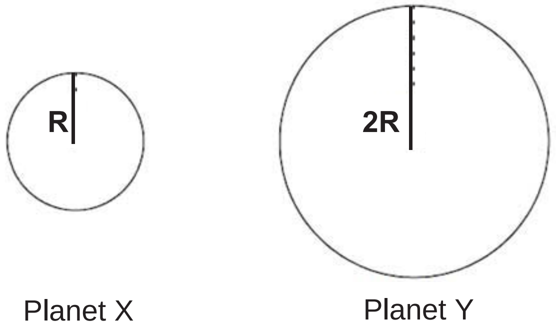


The gravitational force between X and Y is F when angle SXY is 90°, as shown in the diagram.

What is the gravitational force between X and Y when they are nearest to each other?

A $2F$ **B** $3F$ **C** $4F$ **D** $5F$

12 The diagram shows two planets X and Y.



Planet X and planet Y have the same mean density.

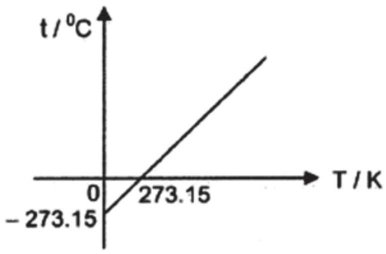
The radius of planet X is half that of planet Y.

The ratio $\dfrac{\text{gravitational field at the surface of planet X}}{\text{gravitational field at the surface of planet Y}}$ is

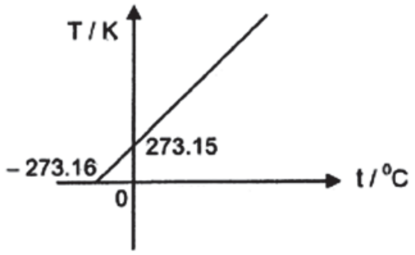
A $2\sqrt{2}$ **B** 2 **C** $\sqrt{2}$ **D** $\frac{1}{2}$

13 Which of the following graphs best shows the correct relationship between the thermodynamic temperature (K) and the Celsius temperature (°C)?

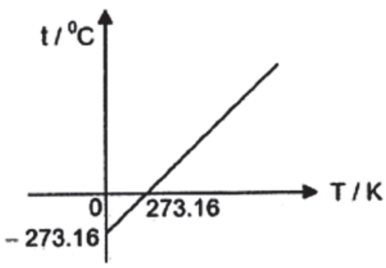
A



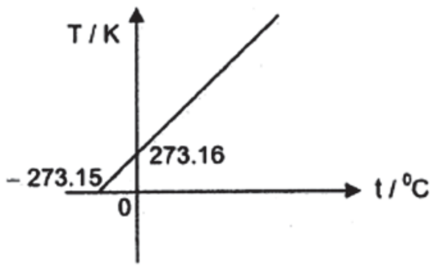
B



C



D



14 Which statement about internal energy is correct?

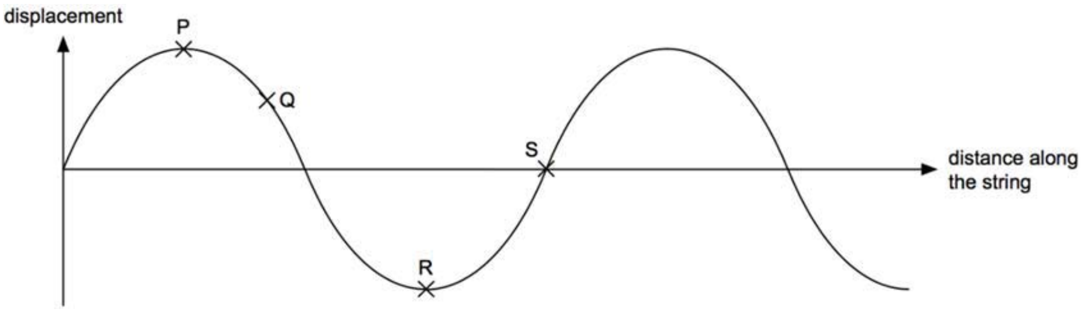
A The internal energy of a system can be increased without transfer of energy by heating.

B The internal energy of a system depends only on its temperature.

C When the internal energy of a system is increased, its temperature always rises.

D When two systems have the same internal energy, they must be at the same temperature.

15 The figure shows the shape at a particular instant of part of a transverse wave travelling from left to right along a string.



Which statement about the motion of elements of the string at this instant is correct?

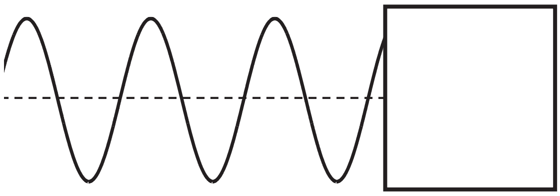
A The speed of Q is higher than S.

B Both Q and S are moving upwards.

C The energy of P and S is entirely kinetic.

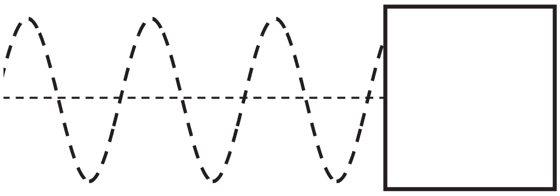
D The acceleration of P and R is a maximum.

16 A progressive wave travelling to the right hits a solid surface and gets reflected after experiencing a phase change of π rad. The figure below shows the incident wave at a particular instant of time.

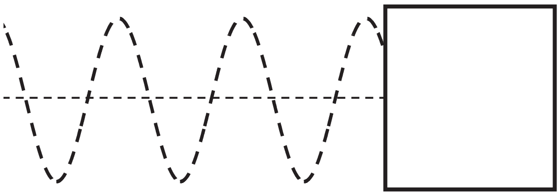


Which of the following shows the corresponding *reflected* wave?

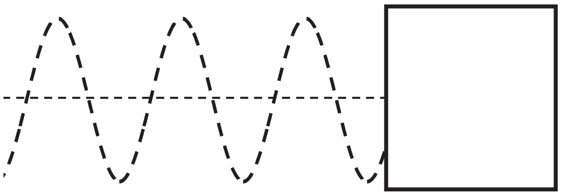
A



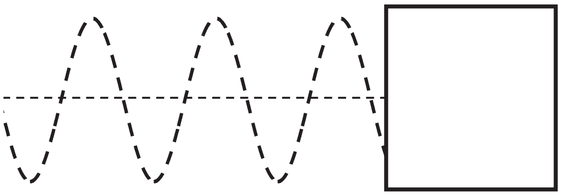
B



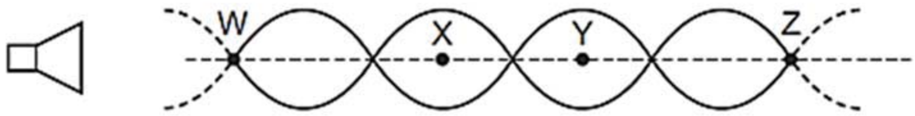
C



D



17 The diagram represents a stationary wave formed by the superposition of sound waves from a loudspeaker and their reflection from a metal sheet (not shown).



W, X, Y and Z are four points on the line through the centre of this wave.

Which statement about this stationary wave is correct?

A A displacement antinode is formed at the surface of the metal sheet.

B A node is a quarter of a wavelength from an adjacent antinode.

C The oscillations at X are in phase with those at Y.

D The particles of the waves oscillate at right angles to the line WZ.

18 The interference patterns from a diffraction grating and a double slit are compared.

Using the diffraction grating, yellow light of the first order is seen at 30° to the normal to the grating. The same light produces interference fringes on a screen 1.0 m from the double slit. The slit separation is 500 times greater than the line spacing of the grating.

What is the fringe separation on the screen?

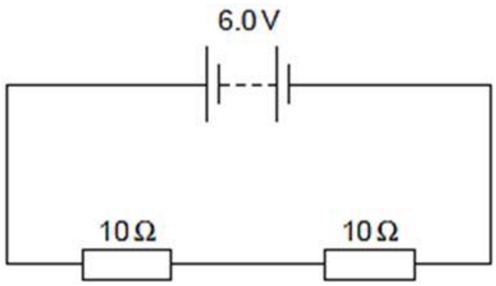
A 2.5×10^{-7} m **B** 1.0×10^{-5} m **C** 1.0×10^{-3} m **D** 1.0×10^{-1} m

19 Each of the nuclei from the four options is accelerated from rest through the same potential difference.

Which one completes the acceleration with the **lowest** speed?

A ${}^{1}_{1}H$ **B** ${}^{4}_{2}He$ **C** ${}^{7}_{3}Li$ **D** ${}^{9}_{4}Be$

20 A battery of negligible internal resistance is connected to two 10 Ω resistors in series.



What charge flows through each of the 10 Ω resistors in 1 minute?

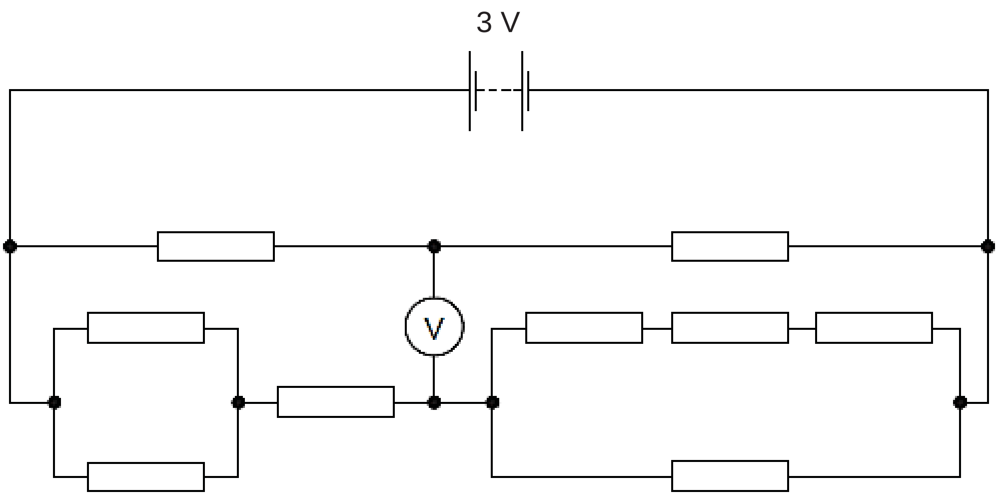
A 0.30 C **B** 0.60 C **C** 3.0 C **D** 18 C

21 When a battery is connected to a resistor, the battery gradually becomes warm. This causes the internal resistance of the battery to increase whilst its e.m.f. stays unchanged.

As the internal resistance of the battery increases, how do the terminal potential difference and the output power change, if at all?

	terminal potential difference	output power
A	decrease	decrease
B	decrease	unchanged
C	unchanged	decrease
D	unchanged	unchanged

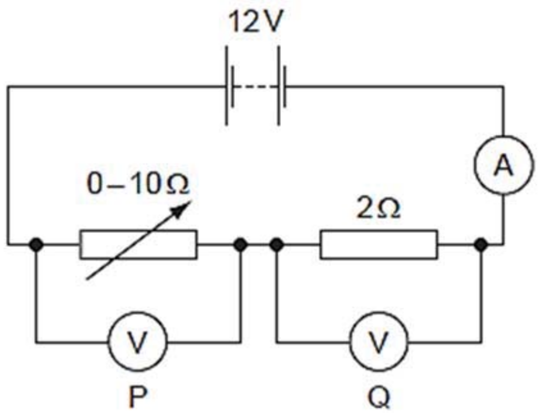
22 A circuit is set up as shown, supplied by a 3 V battery. All resistances are 1 kΩ.



What will be the reading on the voltmeter?

A 0 **B** 0.5 V **C** 1.0 V **D** 1.5 V

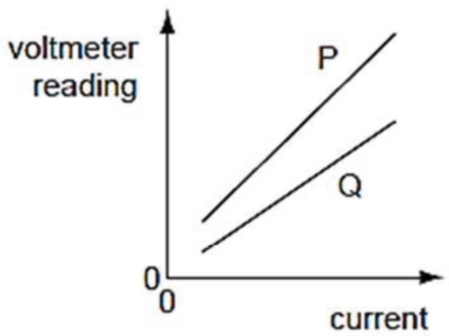
23 A 12 V battery is in series with an ammeter, a 2 Ω fixed resistor and a 0 – 10 Ω variable resistor. High-resistance voltmeters P and Q are connected across the variable resistor and the fixed resistor respectively, as shown.



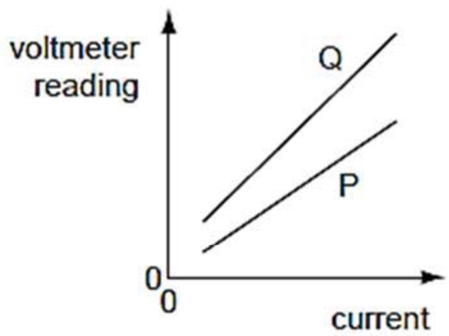
The resistance of the variable resistor is changed from its maximum value to zero.

Which graph shows the variation with current of the voltmeter readings?

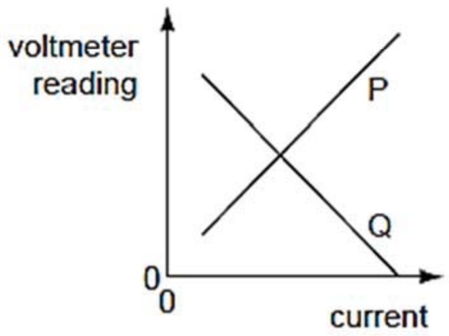
A



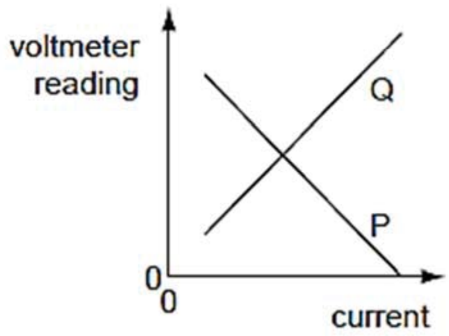
B



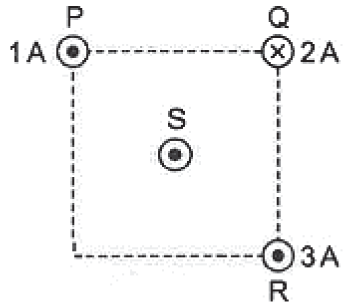
C



D



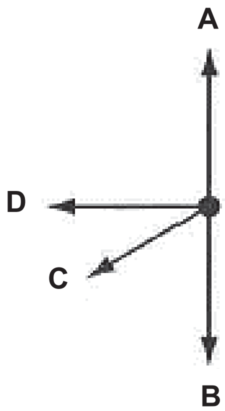
24 The diagram shows a horizontal plane through which four long straight vertical wires pass.



Wires P, Q and R are at three corners of a square and wire S is at the centre.

Wire P carries a current of 1 A out of the paper. Wire Q carries 2 A into the paper. Wire R carries 3 A out of the paper. Wire S carries a current out of the paper.

What is the direction of the resultant force acting on wire S?

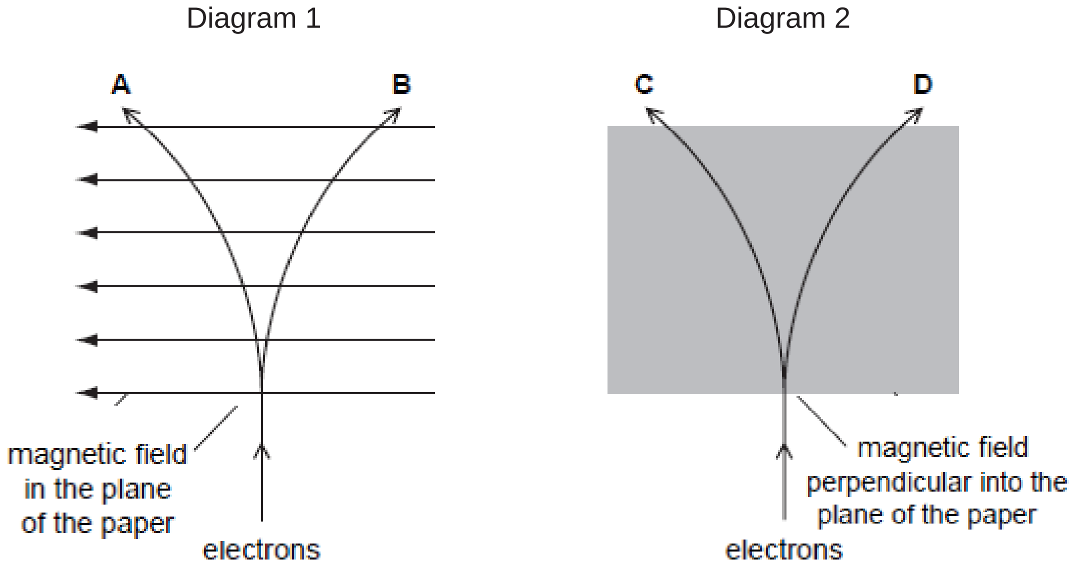


25 A beam of electrons is directed into a magnetic field and is deflected by it.

Diagram 1 represents a magnetic field in the plane of the paper.
Diagram 2 represents a magnetic field directed perpendicular into the plane of the paper.

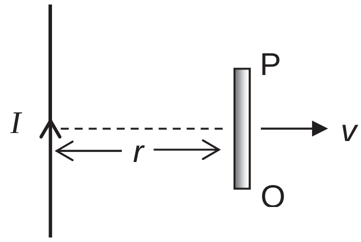
The lines **A**, **B**, **C** and **D** represent possible paths of the electron beam. All paths are in the plane of the paper.

Which line best represents the path of electrons inside the field?



26 The diagram below shows a long wire carrying a current I.

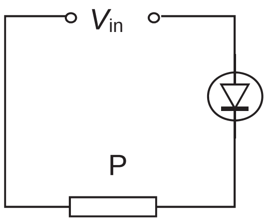
A straight conductor PQ is placed on the same vertical plane as the wire and is moved at constant speed v away from the wire.

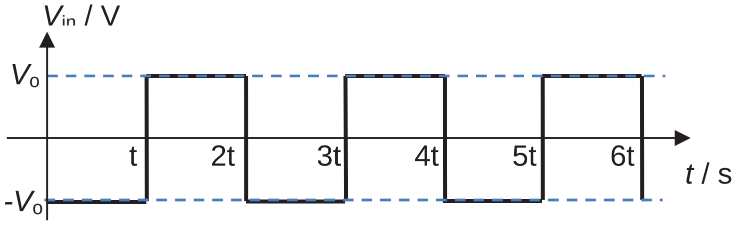


How will the magnitude of the induced e.m.f. in PQ vary and which end will be at a higher potential?

	magnitude of induced e.m.f.	end at higher potential
A	decreases	P
B	decreases	Q
C	increases	P
D	increases	Q

27 A rectifier is connected in series with load P and an alternating voltage supply as shown in the figure.





What is the value of the r.m.s. voltage across load P?

A 0.18 V_o **B** 0.50 V_o **C** 0.71 V_o **D** 1.0 V_o

28 The work function of platinum is twice that of calcium. If the *minimum* photon energy required to emit photoelectrons from the surface of platinum is E, then that for the surface of calcium would be

A $2E$

B $3E/2$

C $E/2$

D $E/4$

29 In a X-ray tube, electrons of high energy E are incident on a target of tungsten.

Which of the following three statements are correct?

(i) All the energy of the electrons is converted into X-rays.

(ii) The maximum X-ray wavelength obtained is $\frac{hc}{E}$.

(iii) The wavelengths of the characteristic X-ray spectral lines are independent of the potential difference applied to accelerate the electrons.

A (ii) only

B (iii) only

C (i) and (ii) only

D (ii) and (iii) only

30 A detector is used for monitoring an α-source and a reading of 120 counts is observed. After a time equal to the half-life of the α-source, the reading has fallen to 64 counts.

If a 5 mm thick lead sheet is inserted between the α-source and the detector, the reading would probably be

A 0 count

B 4 counts

C 8 counts

D 32 counts

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

25 August 2017

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

IMPORTANT

Answer **all** questions.
Please write down your answers in the spaces provided.

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

Marks will be deducted for using inappropriate number of significant figures or wrong value of *g*.

For Examiner's Use	
1	10
2	10
3	11
4	11
5	10
6	7
7	21
Penalty	
Total	**80**
Percentage	

This document consists of **21** printed pages and **1** blank page.

Data

speed of light in free space,	c	$= 3.00 \times 10^{8}$ m s^{-1}
permeability of free space,	μ_o	$= 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	$= 8.85 \times 10^{-12}$ F m^{-1} $(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	$= 1.60 \times 10^{-19}$ C
the Planck constant,	h	$= 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	u	$= 1.66 \times 10^{-27}$ kg
rest mass of electron,	m_e	$= 9.11 \times 10^{-31}$ kg
rest mass of proton,	m_p	$= 1.67 \times 10^{-27}$ kg
molar gas constant,	R	$= 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	N_A	$= 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	k	$= 1.38 \times 10^{-23}$ J K^{-1}
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hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	Φ	$= -\frac{GM}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	I	$= Anvq$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	$= x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay,	x	$= x_0 \exp(-\lambda t)$
decay constant,	λ	$= \frac{\ln 2}{t_{½}}$

For Examiner's Use

Answer all the questions

1 **(a)** The theory of gas flow through small diameter tubes at low pressures and at a particular temperature is used to obtain the mass flow rate, Q of gas through the tubes. One equation which occurs in theory is

$$Q = \frac{kr^3(p_1 - p_2)}{l}$$

where, k is a constant with a unit of m^{-1} s,
r is the radius of the tube,
p_1 and p_2 are the pressures at each end of the tube, and
l is the length of the tube.

Use SI base units to show that the equation is homogeneous.

[2]

(b) A ball is thrown against a vertical wall. The path of the ball is shown in Fig. 1.1.

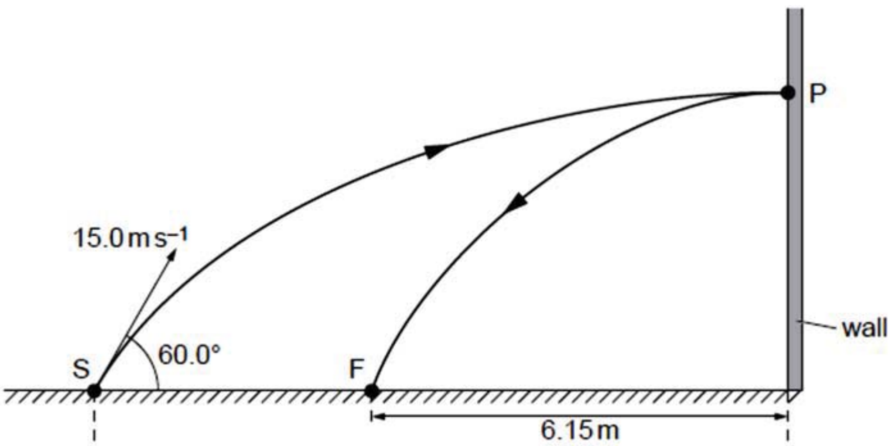

Fig. 1.1

The ball is thrown from S with an initial velocity of 15.0 m s^{-1} at 60.0° to the horizontal.

For Examiner's Use

The ball hits the wall at P with a velocity that is at right angles to the wall. The ball rebounds to a point F that is 6.15 m from the wall.

Assume that air resistance is negligible,

(i) calculate the time taken for the ball to travel from S to P.

time = ………………………………… s [2]

(ii) show that the velocity of the ball immediately after rebounding from the wall is about 4.6 m s^{-1}. Explain your working.

[2]

The mass of the ball is 60 × 10^{-3} kg.

(iii) Calculate the change in momentum of the ball as it rebounds from the wall.

change in momentum = ………………………………… N s [2]

(iv) State and explain whether the collision is elastic or inelastic.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

2 An ideal gas undergoes a cycle of change as shown in Fig. 2.1.

For Examiner's Use

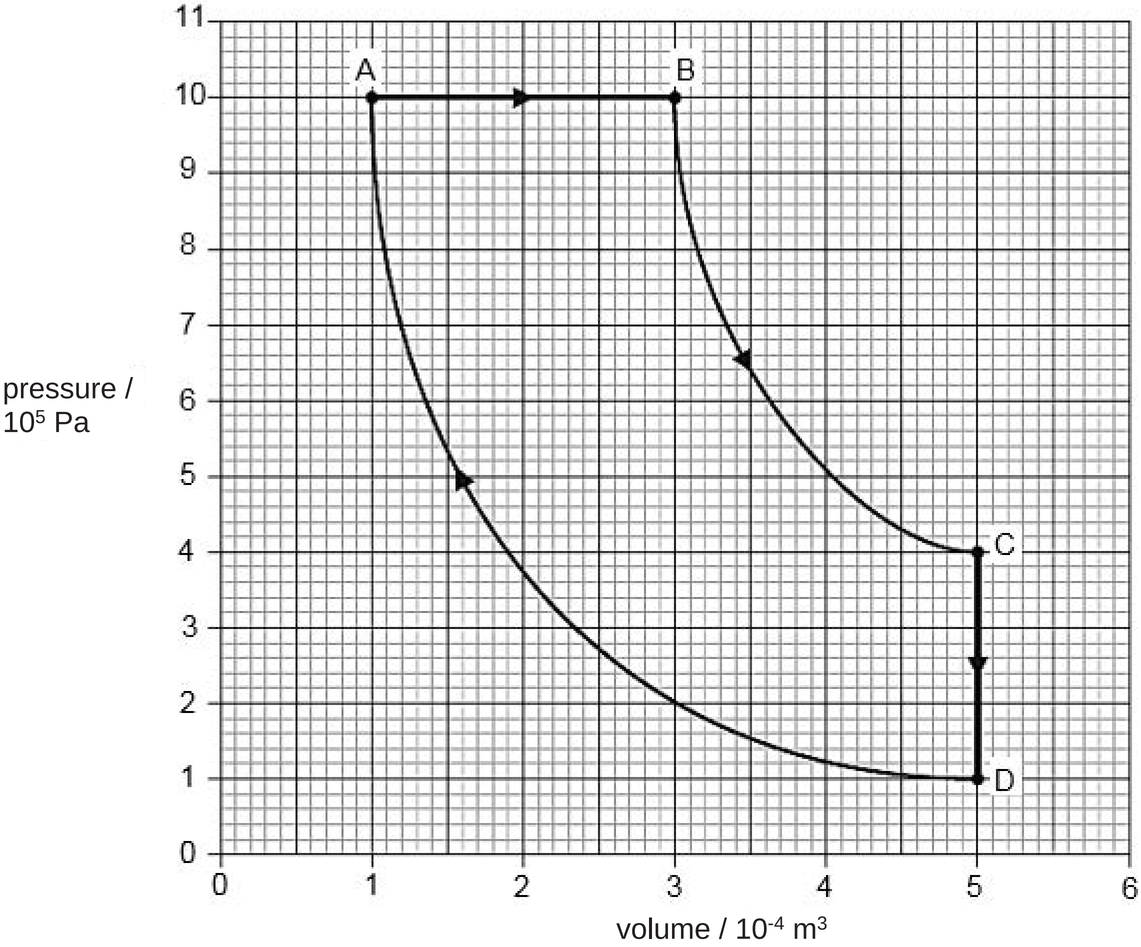

Fig. 2.1

The gas is first compressed within a very short time from D to A. During the process from A to B, it expands at constant pressure. The gas then expands within a very short time from B to C. Finally, from C to D, the volume is kept constant and thermal energy is given out.

(a) **(i)** Show that the increase in internal energy of the gas as it undergoes the process from A to B is 300 J.

[2]

For Examiner's Use

(ii) Hence, determine the heat supplied to the gas as it undergoes the process from A to B.

heat supplied = ………………………………… J [3]

(b) **(i)** State and explain the change in internal energy for the cycle DABCD**.**

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(ii) The table of Fig. 2.2 gives one of the values for the changes shown on the pressure-volume graph.

	heat supplied to gas	work done on gas	increase in internal energy of gas
$A \rightarrow B$			+
$B \rightarrow C$			
$C \rightarrow D$			
$D \rightarrow A$			

Fig. 2.2

Indicate in Fig 2.2 either '+', '-' or '0' for values that are positve, negative or zero respectively. [3]

For Examiner's Use

3 **(a)** State the Principle of Superposition.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) In an experiment to determine the speed of sound, a long tube, fitted with a tap, is filled with water. A tuning fork is sounded above the top of the tube as the water is allowed to run out of the tube, as shown in Fig. 3.1 and Fig. 3.2.

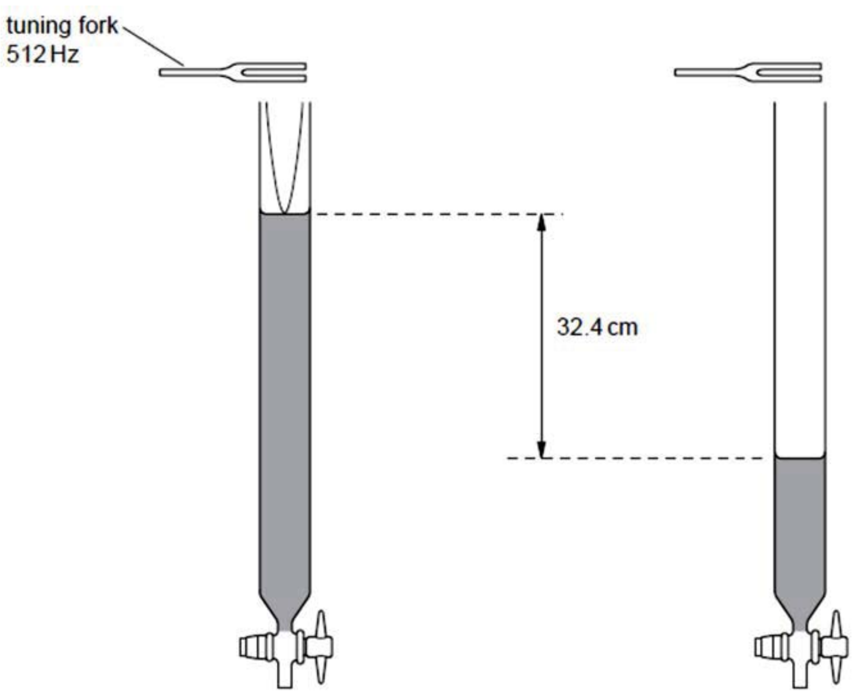

Fig. 3.1 **Fig.3.2**

A loud sound is first heard when the water level is as shown in Fig. 3.1, and then again when the water level is as shown in Fig. 3.2. Fig. 3.1 illustrates a stationary wave produced in the tube.

(i) Explain the formation of a stationary wave in the tube.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

(ii) Explain why the loudness of the sound changes as the water level changes.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(iii) The frequency of the fork is 512 Hz and the difference in the height of the water level for the two positions where a loud sound is heard is 32.4 cm. Calculate the speed of the sound in the tube.

speed of sound = ………………………………… m s^{-1} [2]

(iv) The length of the column of air in the tube in Fig. 3.1 is 15.7 cm. Suggest and explain where the antinode of the stationary wave produced in the tube in Fig. 3.1 is likely to be found.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

For Examiner's Use

4 **(a)** Define *electric field strength*.

....

.... [1]

(b) Two flat parallel metal plates, each of length 12.0 cm, are separated by a distance of 1.5 cm, as shown in Fig. 4.1.

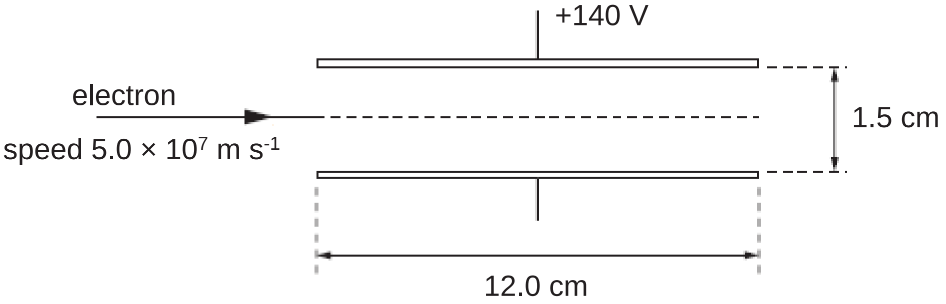

Fig. 4.1

The space between the plates is a vacuum. An upward electric field of field strength 1.40×10^4 N C^{-1} may be assumed to be uniform in the region between the plates and zero outside this region.

Given that the potential of the top plate is +140 V, determine the potential of the bottom plate.

potential = ... V [2]

(c) An electron initially travels parallel to the plates along a line mid-way between the plates, as shown in Fig. 4.1. The speed of the electron is 5.0×10^7 m s^{-1}.

For the electron between the plates,

(i) determine the magnitude and direction of its acceleration,

acceleration = ... m s^{-2}

direction = ... [3]

For Examiner's Use

(ii) calculate the time for the electron to travel a horizontal distance equal to the length of the plates.

time = ………………………………….. s [2]

(d) Use your answers in **(c)** to determine whether the electron will hit one of the plates or emerge from between the plates.

[3]

For Examiner's Use

5 A current I in a copper wire causes the charge carriers to have a drift velocity v, as shown in Fig. 5.1.

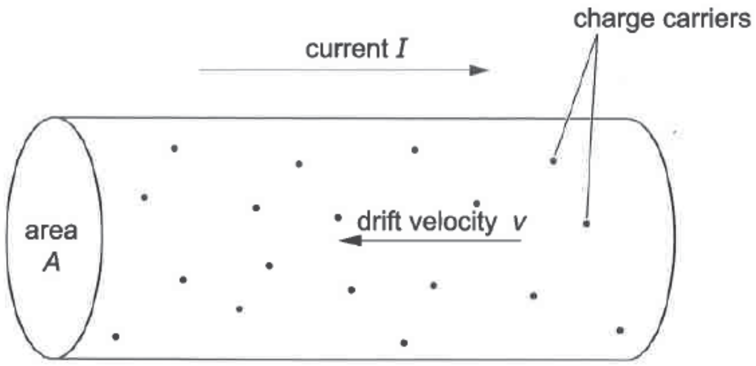

Fig. 5.1

The copper wire has an area of cross-section A. The number density of charge carriers in the wire is n. Each charge carrier has charge of magnitude q.

(a) Derive an equation relating current I to n, A, v and q.

[3]

(b) A copper wire of diameter of 1.8 mm has a uniform current of 17 mA flowing through.

(i) The density of copper is 9.0×10^3 kg m^{-3} and its atomic mass is 63.5 g. Assume that each copper atom contributes roughly one conduction electron, show that the number density of charge carriers in the copper wire is 8.5×10^{28} m^{-3}.

[2]

For Examiner's Use

(ii) Hence, determine the drift velocity *v* of the charge carriers.

v = …………………………………. m s^{-1} [2]

(iii) One segment of the copper wire is thinner compared to the rest. State and explain how the drift velocity will change when the current flows into the thinner segment.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(c) The drift velocity of the charge carriers is very small. Explain why the room lights turn on quickly when the switch is closed.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

6 A radioisotope thermoelectric generator (RTG) is used to generate electrical power. The RTG obtains its power from the radioactive decay of Plutonium-238. Plutonium-238 has a half-life of 87.7 years.

(a) Define *decay constant* of a radioactive nuclide.

………………………………………………………………………………………………

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

(b) Calculate the decay constant of Plutonium-238.

decay constant = ………………………………… s^{-1} [2]

(c) When the RTG was manufactured, it contained 1.74×10^{25} atoms of Plutonium-238.

(i) Determine the activity of the Plutonium-238 in the RTG when it was first manufactured.

activity = ………………………………… Bq [2]

(ii) Calculate the activity of Plutonium-238 in the RTG 10 years after manufacture.

activity = ………………………………… Bq [2]

For Examiner's Use

7 When a structural engineer is designing a building there will be occasion when a beam has to be used to bridge a gap. The width of the gap is called the span. The engineer makes calculations to ensure that there is not too much sag in the beam. This question concerns how the choice of beam is made.

Sometimes, when the loading is small, a plain wooden beam is sufficient, as shown in Fig. 7.1.

A beam such as this, loaded at its centre, will undergo a maximum depression x given by

$$x = \frac{WL^3}{kab^3}$$

where W is the load at the centre,
a is the width of the beam
b is the depth of the beam and
k is a constant.

When greater loads or greater spans are required, a steel beam may be used. In order to minimize the amount of steel required, the shape of the beam used is as shown in Fig. 7.2.

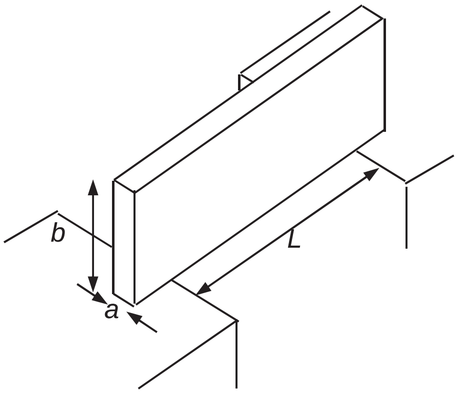

Fig. 7.1

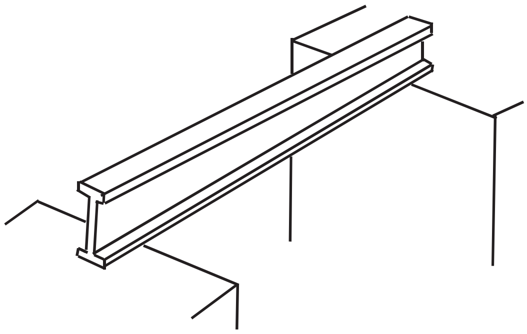

Fig. 7.2

Sometimes, the loading of the beam is uniform, along its length, as shown in Fig. 7.3.

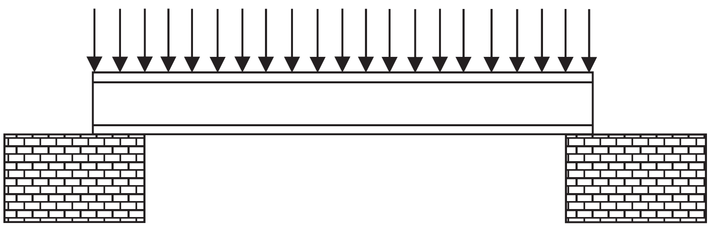

Fig. 7.3

For Examiner's Use

Sometimes, with complex loading (Fig. 7.4), the moments of the forces have to be calculated.

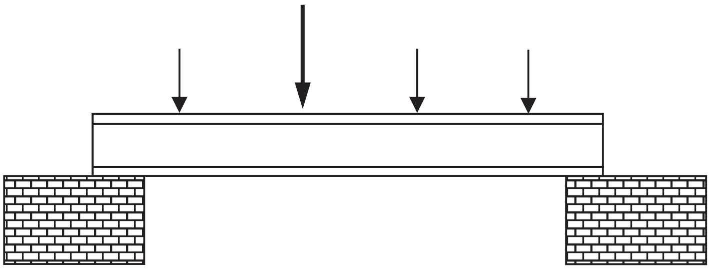

Fig. 7.4

(a) **(i)** State **one** reason why the structural engineer has to make calculations when using a beam to bridge a gap.

………………………………………………………………………………………………

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

(ii) Write down the reason given in the passage for making the steel beam the shape shown in Fig. 7.2

………………………………………………………………………………………………

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

(iii) The cross-sectional area of the beams shown in Fig. 7.5 are the same.

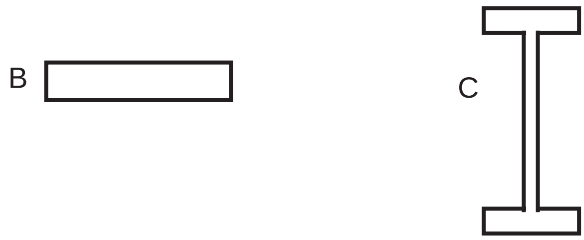

Fig. 7.5

Suggest why, for beams of the same length, arranged in this manner, one would sag more than the other.

………………………………………………………………………………………………

………………………………………………………………………………………………

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………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

For Examiner's Use

(b) A wooden beam has width 0.050 m, depth 0.10 m and spans 3.0 m. Calculate the maximum load which it can support at its centre for a maximum depression of 0.010 m. Take k to be 3.6×10^{10} Pa for this wood.

maximum load = ………………………………… N [2]

(c) A student repeated the experiment for varying spans and obtained the following data for the maximum depression x. Data for some of these are given in Fig. 7.6.

L/ m	x/ mm	$\log_{10}$ (L/ m)	$\log_{10}$ (x/ mm)
3.000	10.0	0.4771	1.00
2.750	7.7	0.4393	0.89
2.500	5.8	0.3979	0.76
2.000	3.0	0.3010	0.48
1.750	2.0		
1.500	1.3	0.1761	0.11

Fig. 7.6

(i) Complete Fig. 7.6 by calculating values for $\log_{10}$ (x/mm) against $\log_{10}$ (L/m). [1]

(ii) On the axes of Fig. 7.7, plot a graph of $\log_{10}$ (x/mm) against $\log_{10}$ (L/m). [1]

For Examiner's Use

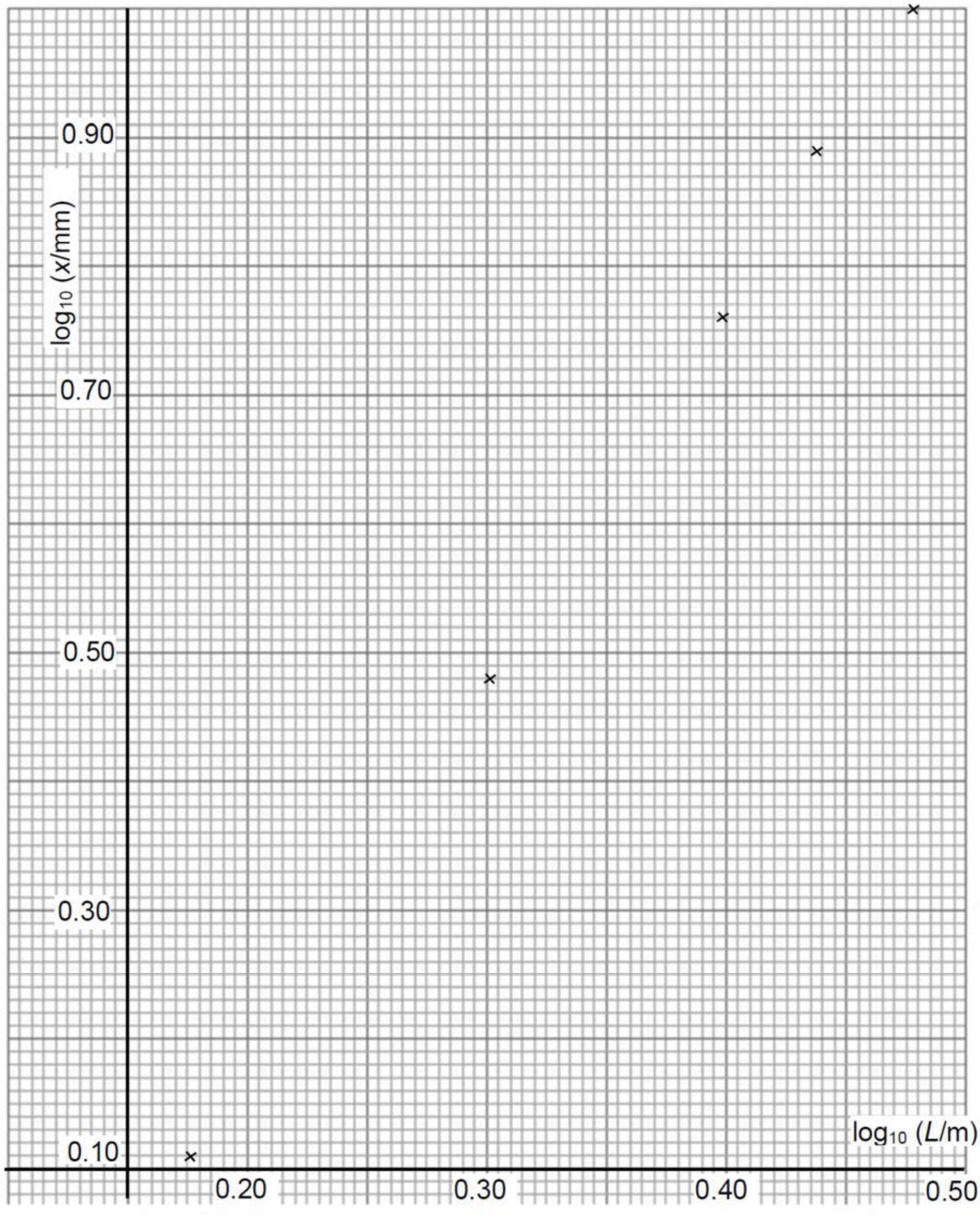

Fig. 7.7

For Examiner's Use

(iii) Determine the gradient of the graph in Fig. 7.7.

gradient = ………………………………… [2]

(iv) Hence discuss whether the data in Fig. 7.6 support the relation $x = \dfrac{WL^3}{kab^3}$.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(d) A beam across a gap is shown in Fig. 7.8, together with values of the forces acting and their distances from X.

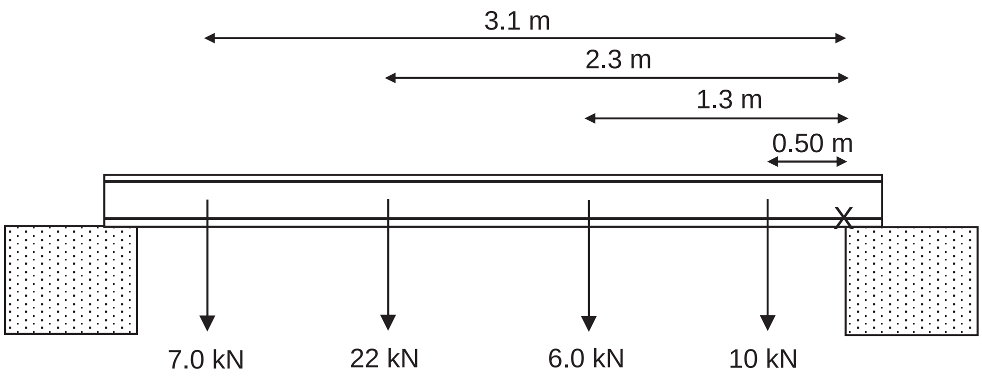

Fig. 7.8

Calculate the total moment of the forces shown about point X.

moment = ………………………………… N m [2]

For Examiner's Use

(e) A steel beam, loaded uniformly as in Fig. 7.3, is allowed to sag by a maximum of 1/360 of the gap it is spanning. A particular beam is used to carry a load of 33 000 N and to span a gap of 4.20 m. A quantity *B*, known as the bending moment for this loading pattern is given by

$B = \frac{WL}{8}$ and the depression *x* at the centre is given by

$x = \frac{BL^3}{c}$ where *c* has the value of 3.35×10^8 N m^3.

Calculate

(i) the bending moment *B*,

bending moment = ………………………………… N m [1]

(ii) the actual amount *x* of sag.

x = ………………………………… m [1]

(f) The final check on the suitability of any beam is to ensure that it is strong enough. This is done, using a table of values, to find the allowable bending stress.

(i) For the beam in **(e)**, two constants *P* and *Q*, without units, are found from the dimensions of the beam and the gap it is spanning.

For this beam *P* = 21 and *Q* = 170. Use Fig. 7.9 to find the allowable bending stress.

allowable bending stress / MPa				
	P			
Q	15	20	25	30
160	111	96	88	82
170	106	93	83	77
180	102	89	80	73

Fig 7.9

allowable bending stress = ………………………………… MPa [2]

For Examiner's Use

(ii) The beam is safe to use if

$$\frac{\text{bending moment}}{\text{allowable bending stress}} < 2.0 \times 10^{-4}\ \text{m}^3$$

Use this relationship to determine whether the beam is safe under these conditions.

…………………………………………………………………………………………………

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…………………………………………………………………………………………………

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

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For Examiner's Use

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS | INDEX NUMBER

PHYSICS 9749/03

Paper 3 Longer Structured Questions **14 September 2017**

Candidates answer on the Question Paper. **2 hours**
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer only **one** question.

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

For Examiner's Use	
Section A	
1	10
2	8
3	9
4	7
5	10
6	9
7	7
Section B	
8	20
9	20
Significant Figures	
Total	**80**

This document consists of **25** printed pages and **1** blank page.

Data

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

Formulae

uniformly accelerated motion,	s	$= ut + \frac{1}{2}at^2$
	v^2	$= u^2 + 2as$
work done on/by a gas,	W	$= p\Delta V$
hydrostatic pressure,	p	$= \rho gh$
gravitational potential,	Φ	$= -\frac{GM}{r}$
temperature,	T/K	$= T/°C + 273.15$
pressure of an ideal gas	p	$= \frac{1}{3}\frac{Nm}{V} \langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E	$= \frac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_0 \sin \omega t$
velocity of particle in s.h.m.	v	$= v_0 \cos \omega t$
		$= \pm\omega\sqrt{\left(x_o^2 - x^2\right)}$
electric current	I	$= Anvq$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential	V	$= \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	$= x_0 \sin\omega t$
magnetic flux density due to a long straight wire	B	$= \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	$= \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_0 nI$
radioactive decay,	x	$= x_0 \exp(-\lambda t)$
decay constant,	λ	$= \frac{\ln 2}{t_{½}}$

Section A

For Examiner's Use

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

1 Piling works are commonly done before construction of high rise buildings. Fig.1.1 shows a pile of mass 300 kg being driven into the ground by a pile driver of mass 100 kg.

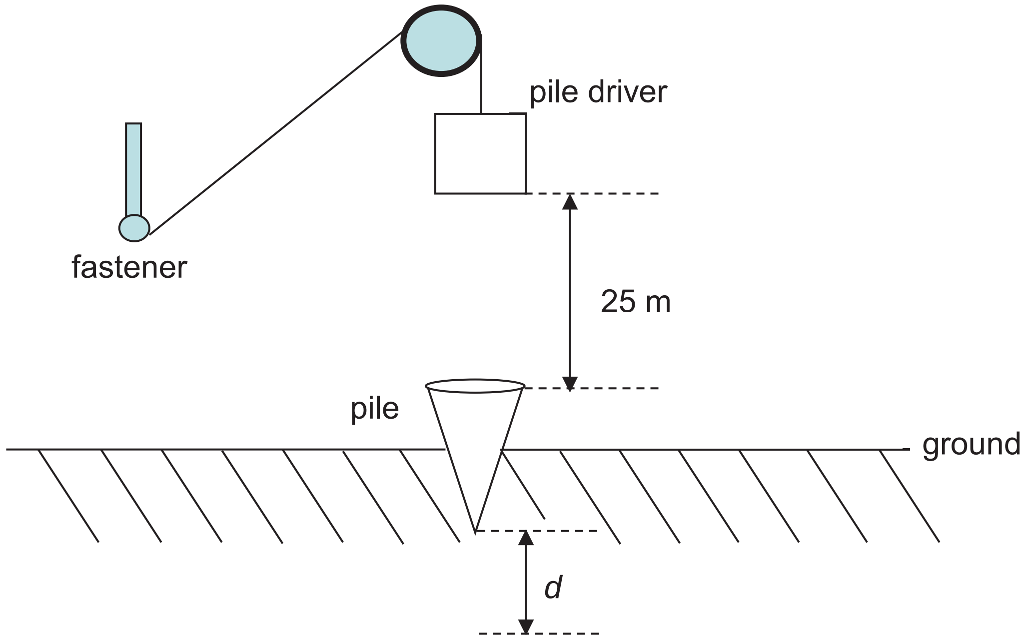

Fig. 1.1

The pile driver is lifted to a height of 25 m above the pile and the fastener is released. The pile driver then falls freely from rest and upon impact with the pile, they stick together. The pile is then driven a distance *d* into the ground before both the pile and driver comes to a stop.

(a) Neglecting air resistance, determine

(i) the speed of the pile driver just before impacting the pile and,

speed = …………………… $m\ s^{-1}$ [2]

(ii) the joint speed of the pile and pile driver after the impact.

joint speed = …………………… $m\ s^{-1}$ [2]

For Examiner's Use

(b) The variation of the external resistive force, F on the pile and driver with time immediately after impact, until they stop at a distance d into the ground 0.18 s later is shown in Fig. 1.2.

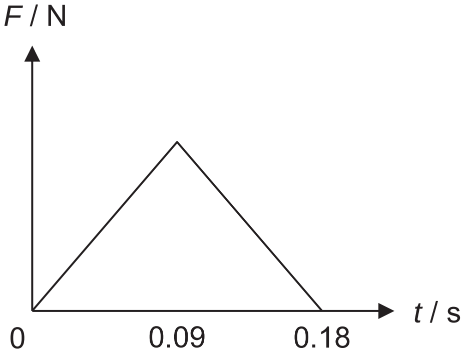

Fig. 1.2

(i) Determine,

1. the change in momentum of the pile and driver from t = 0 s to t = 0.18 s, and

change in momentum = …………………… kg m s^{-1} [2]

2. the average force, F_{ave} acting on the pile and driver during this period.

average force, F_{ave} = …………………… N [2]

(ii) Hence, by applying the principle of conservation of energy, determine the stopping distance, d of the pile and driver.

stopping distance, d = …………………… m [2]

2 **(a)** **(i)** On Fig. 2.1, draw lines to represent the gravitational field outside an isolated uniform sphere.

For Examiner's Use

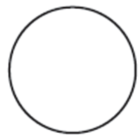

Fig. 2.1

(ii) A second sphere has the same mass but a smaller radius. Suggest what difference, if any, there is between the patterns of field lines for the two spheres.

....

....

....

.... [3]

(b) The Earth may be considered to be a uniform sphere of radius 6380 km with its mass of 5.98×10^{24} kg concentrated at its centre, as illustrated in Fig. 2.2.

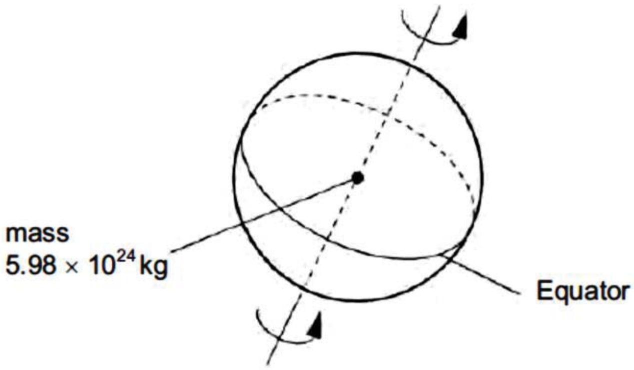

Fig. 2.2

A mass of 1.00 kg on the Equator rotates about the axis of the Earth with a period of 1.00 day (8.64×10^4 s).

Calculate, to three significant figures,

For Examiner's Use

(i) the gravitational force F_G of attraction between the mass and the Earth,

F_G = ………………………………… N [1]

(ii) the centripetal force F_C on the 1.00 kg mass,

F_C = ………………………………… N [1]

(iii) the difference in magnitude of the forces.

difference = ………………………………… N [1]

(c) By reference to your answers in **(b)**, suggest, with a reason, a value for the acceleration of free fall at the Equator.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

For Examiner's Use

3 **(a)** An ideal gas is said to consist of molecules that are hard elastic identical spheres.

State two further assumptions of the kinetic theory of gases.

....

....

....

....

.... [2]

(b) The number of molecules per unit volume in an ideal gas is n.

If it is assumed that all the molecules are moving with speed v_x in the x-direction, the pressure p exerted by the gas on the walls of the vessel is given by

$$p = nmv_x^2$$

where m is the mass of one molecule.

Explain the reasoning by which this expression is modified to give the formula

$$p = \frac{1}{3}nm\left\langle c^2 \right\rangle$$

....

....

....

.... [2]

(c) The density of an ideal gas is 1.2 kg m^{-3} at a pressure of 1.0×10^5 Pa and a temperature of 27 °C.

(i) Calculate the root-mean-square (r.m.s.) speed of the molecules of the gas at 27 °C.

speed = ... m s^{-1} [3]

For Examiner's Use

(ii) Calculate the mean-square speed of the molecules at 207 °C.

mean-square speed = ………………………………… $m^2\ s^{-2}$ [2]

For Examiner's Use

4 **(a)** State how a *polarised* transverse wave differs from an *unpolarised* transverse wave.

....

....

.... [1]

(b) Light is polarised when it passes through a sheet material known as a polaroid. Three polaroids are stacked, with the polarising axis of the second and third polaroids at θ and 62° respectively, to that of the first, as shown in Fig. 4.1.

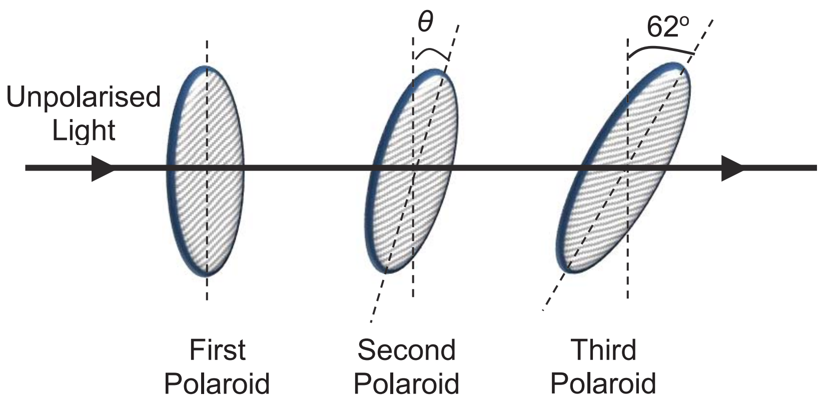

Fig. 4.1

When an unpolarised light of amplitude A_0 is incident on the stack of polaroids, the light has amplitude of A_1 after it passes through the first polaroid, A_2 after it passes through the second polaroid and A_3 after it passes through the third polaroid.

(i) If θ = 90°, determine A_3 in terms of A_1.

A_3 = ... [1]

(ii) If the second polaroid is rotated such that θ = 23°

1. Show that A_3 = 0.715 A_1.

[2]

For Examiner's Use

2. The intensity of the unpolarised light after it passes through the first polaroid is reduced to half.

Determine the percentage reduction of the intensity after the unpolarised light passes through the stack of three polaroids.

percentage reduction = ……………………………….. % [3]

5 In Fig. 5.1, S_1 and S_2 are two small loudspeakers, initially placed at position Y and Z, which emit sound waves of the same intensity and wavelength. A microphone for detecting sound intensity is placed at point P such that YP = ZP.

For Examiner's Use

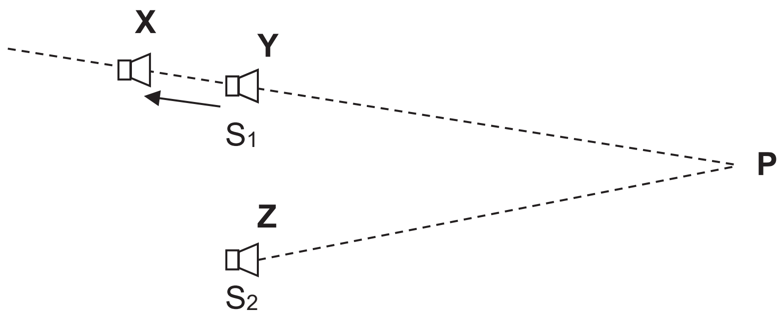

Fig. 5.1

(a) (i) One of the conditions required for the formation of a well-defined interference pattern is that the two sources are coherent.

State what is meant by coherent sources and suggest how *coherence* of S_1 and S_2 can be achieved in this case.

....

....

....

.... [2]

(ii) Given that S_1 and S_2 are in phase, the speaker S_1 is moved slowly from Y to X along the line between these two points. As S_1 is moved, the sound detected at P fluctuates in intensity.

Explain this observation.

....

....

....

....

....

.... [3]

For Examiner's Use

(iii) In moving S_1 from point Y to point X as shown in Fig. 5.1, the intensity of the sound at P changes from a maximum to a minimum. The distance YX = 0.082 m.

Calculate the wavelength of the sound emitted by the sources.

wavelength = ………………….. m [1]

(iv) S_1 remains at the point X and the frequency f of the sound emitted from both S_1 and S_2 is gradually increased until a maximum sound intensity is first detected at P. This occurs when f = 4100 Hz.

Estimate a value for the speed of sound.

speed of sound = ………………… m s^{-1} [2]

(b) Explain why for the maxima and minima to be observable, the amplitude of the two sound sources have to be approximately the same.

....

....

....

.... [2]

For Examiner's Use

6 Negatively-charged particles are moving through a vacuum in a parallel beam. The particles have speed *v*.

The particles enter a region of uniform magnetic field of flux density 930 μT. Initially, the particles are travelling at right-angles to the magnetic field. The path of a single particle is shown in Fig. 6.1.

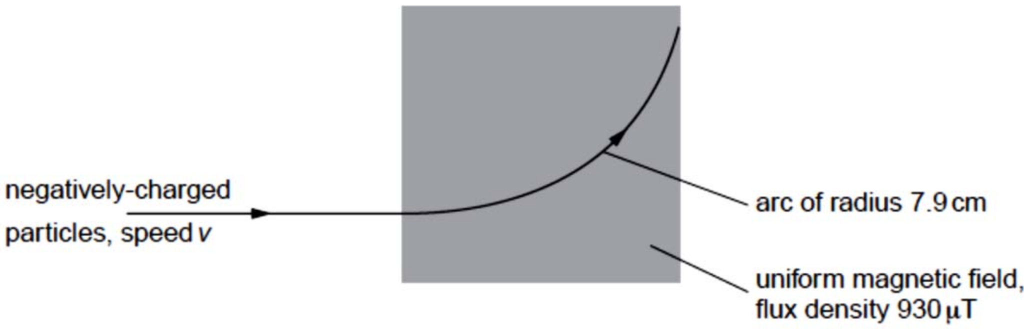

Fig. 6.1

The negatively-charged particles follow a curved path of radius 7.9 cm in the magnetic field.

A uniform electric field is then applied in the same region as the magnetic field. For an electric field strength of 12 kV m^{-1}, the particles are undeviated as they pass through the region of the fields.

(a) On Fig. 6.1, mark with an arrow the direction of the electric field. [1]

(b) For the negatively-charged particles, calculate

(i) the speed *v*,

v = ... m s^{-1} [2]

(ii) the ratio $\frac{\text{charge}}{\text{mass}}$.

Explain your working.

ratio = ... C kg^{-1} [3]

For Examiner's Use

(c) Given that the negatively charged particles in Fig. 6.1 are electrons, explain the effects on the path of the single particle if an alpha particle were to enter the region of magnetic and electric field with the same speed.

....

....

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....

....

.... [3]

For Examiner's Use

7 **(a)** The energy of the sun is produced by the thermonuclear fusion reaction represented by

$$4\,{}^{1}_{1}H \rightarrow {}^{4}_{2}He + 2\,{}^{0}_{+1}e + \text{energy}$$

You may use the following masses in answering this question:

Mass of ${}^{1}_{1}H$ = 1.007825 u

Mass of ${}^{4}_{2}He$ = 4.002603 u

Mass of ${}^{0}_{+1}e$ = 0.000549 u

(i) Determine the energy released per nuclear reaction.

Energy released per reaction = …………………… MeV [2]

(ii) Given the Earth is at a distance 1.5 x 10^{11} m away from the Sun, and 1.35 kW m^{-2} of the Sun's energy is incident on Earth per second per unit area, determine the rate at which hydrogen nuclei are undergoing thermonuclear fusion in the Sun.

Rate = ………………… s^{-1} [3]

For Examiner's Use

(b) Fig. 7.1 shows the variation with nucleon number *A* of the binding energy per nucleon *E* of nuclei.

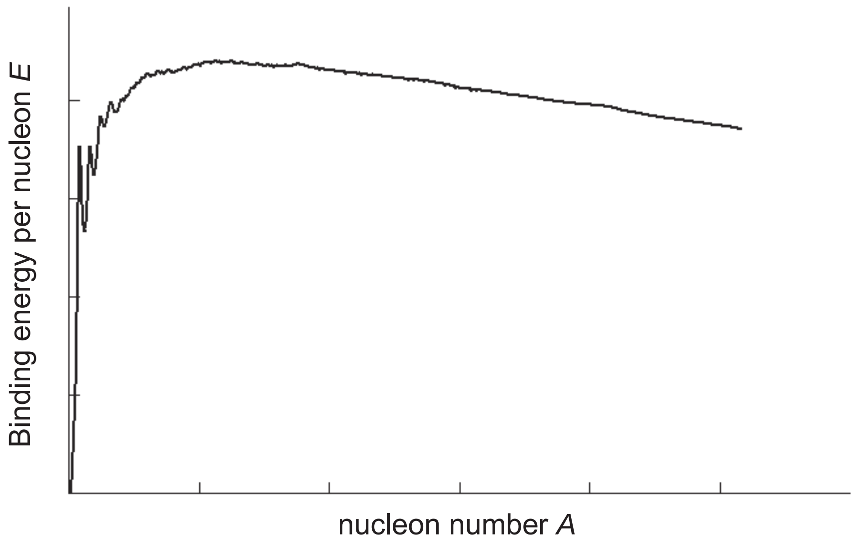

Fig. 7.1

With the aid of Fig. 7.1, explain why more energy per nucleon is released in fusion than in fission.

....

....

....

.... [2]

Section B

For Examiner's Use

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

8 A light spring is suspended from a fixed point. A bar magnet is attached to the end of the spring of spring constant k, as shown in Fig. 8.1.

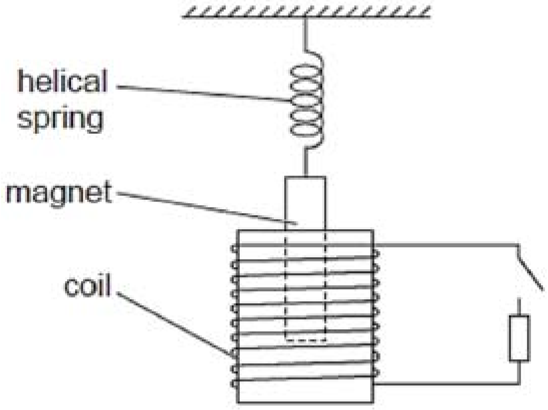

Fig. 8.1

One pole of the magnet is situated in a coil of wire. The coil is connected in series with a switch and a resistor.

(a) Initially, the switch is open. When the magnet is given a small vertical displacement and then released, the restoring force F acting on the magnet is related to its vertical displacement y by the expression

$$F = -ky$$

(i) Explain why the expression suggests that the magnet is performing simple harmonic motion.

....

....

....

.... [2]

For Examiner's Use

(ii) The variation with time *t* of the vertical displacement *y* of the magnet is shown in Fig. 8.2.

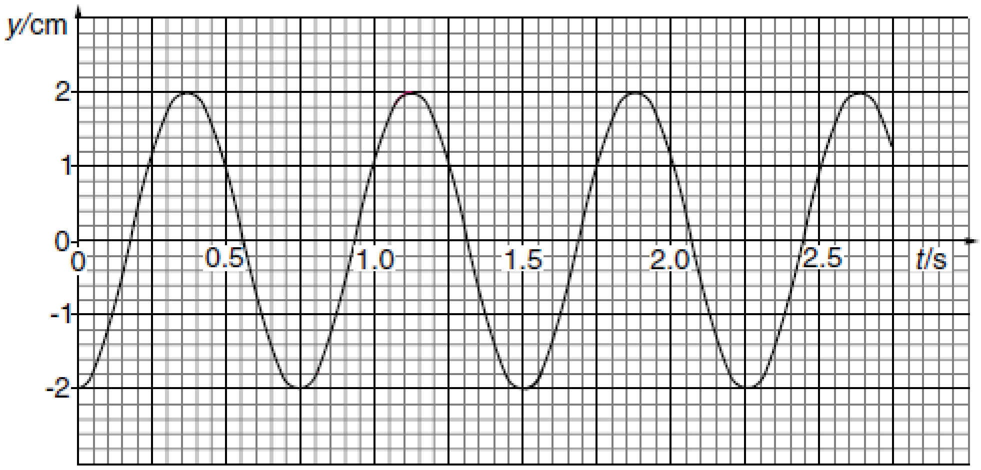

Fig. 8.2

The mass of the magnet is 130 g.

Use Fig. 8.2 to

1. explain why the graph suggests that the oscillations are undamped,

....

.... [1]

2. calculate the angular frequency ω, and

ω = ... rad s^{-1} [2]

3. determine the displacement of the magnet at which its kinetic energy is equal to its potential energy.

displacement = ... m [3]

For Examiner's Use

(b) An induced e.m.f. is measured across the terminals of the coil during the oscillations of the magnet.

(i) On Fig. 8.3, sketch a graph to show the variation with time of the e.m.f. E induced in the coil.

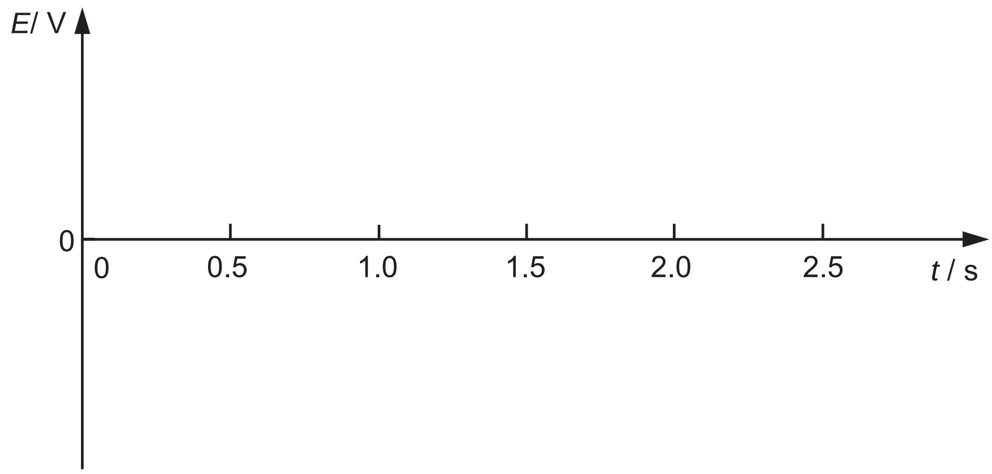

Fig. 8.3 [2]

(ii) Using the principles of electromagnetic induction, explain the shape of the graph sketched in Fig. 8.3.

....

....

....

....

....

....

....

.... [3]

For Examiner's Use

(c) The switch is now closed. During 10 complete oscillations of the magnet, the amplitude of the vibration is seen to decrease where the magnet loses 20% of its energy.

(i) Use Faraday's law of electromagnetic induction to explain why the amplitude of the oscillation decreases.

....

....

....

....

....

.... [3]

(ii) Determine the new amplitude of oscillation after 10 complete oscillations.

amplitude = ... m [2]

(iii) Explain why the amplitude in **(c)(ii)** reduces when the resistance of the resistor is reduced.

....

....

....

.... [2]

For Examiner's Use

9 **(a)** Einstein's interpretation of the photoelectric effect on a metal surface led him to the formulation of the photoelectric equation given by $hf = \Phi + E_k$

(i) State what the following terms represent.

hf : ....

Φ : ....

E_k : .... [2]

(ii) State the conservation law that the photoelectric equation follows.

.... [1]

(iii) In a photoelectric experiment, a metal surface is illuminated with a beam of monochromatic radiation, of wavelength 300 nm and intensity 0.500 W m^{-2}, over an area of 4.50×10^{-5} m^2. Φ has a value of 2.03 eV.

1. Calculate the stopping potential.

stopping potential = ... V [2]

2. The photoelectric quantum yield is defined as the ratio

$$\frac{\textit{no. of photoelectrons emitted per}\ \text{sec}}{\textit{no.of photons incident per}\ \text{sec}}.$$

Given that the photoelectric quantum yield of the metal surface is 5.70×10^{-7}, determine the maximum photoelectric current.

maximum photoelectric current = ... A [3]

For Examiner's Use

(b) An electron beam, capable of firing individual electrons, is directed at a wall made of a gold-coated silicon membrane. The wall had two 62 nm wide slits in it with a centre-to-centre separation of 272 nm.

The electrons were created at a tungsten filament and accelerated across 600 V. After passing through the double slit, they were detected using a suitable screen placed 240 mm behind. A resulting pattern formed after several hours is shown in Fig. 9.1. *d* is the separation between the centres of adjacent bright spots.

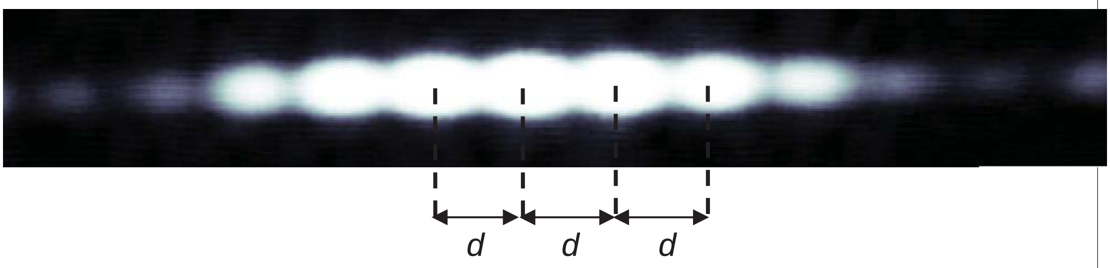

Fig. 9.1

(i) Suggest the significance of this experiment.

.... [1]

(ii) Show that the momentum of the electron when it is at the double slit wall is 1.32×10^{-23} N s.

[2]

(iii) Hence determine the separation *d*.

d = ... m [3]

For Examiner's Use

(c) Fig. 9.2 below shows some of the energy levels (in electron-volts) of an atom X.

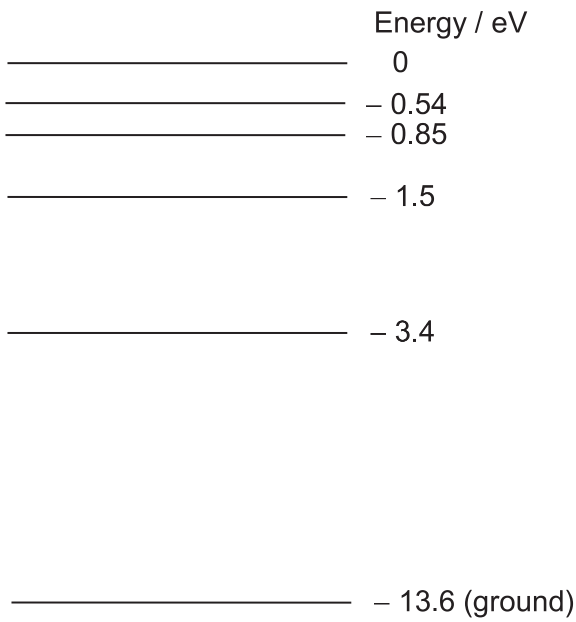

Fig. 9.2

Cool vapour of X at low pressure is bombarded with electrons that are accelerated from rest through an accelerating potential of 12.8 V.

(i) Determine the number of different wavelengths of radiation that will be emitted.

number of wavelengths = ………………… [2]

(ii) Draw the spectral lines in the axis given below. Label the line corresponding to the highest energy radiation.

[2]

(iii) Determine the wavelength of the highest energy radiation.

For Examiner's Use

wavelength = ………………… m [2]

END OF PAPER

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INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/04

Paper 4 Practical

17 August 2017

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Shift
Laboratory

IMPORTANT

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 if you do not use appropriate units.

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

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

For Examiner's Use	
1	14
2	9
3	20
4	12
Penalty	
Total	**55**
Percentage	

This document consists of **19** printed pages and **1** blank page.

You may not need to use all of the materials provided.

1 In this experiment, you will investigate how the motion of a thin card shape depends on its size.

You have been provided with two sets of card strips of different lengths. Spare strips are available if necessary.

(a) (i) Measure and record the length L of the **longer** strip of card as shown in Fig. 1.1.

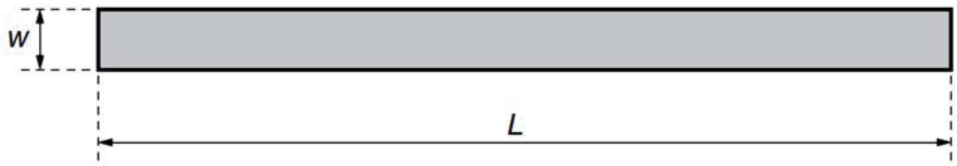

Fig. 1.1

L = ………………………….. [1]

(ii) Estimate the percentage uncertainty in your value of L.

percentage uncertainty = ... [1]

(b) (i) Using a vernier caliper, measure and record the width w of the **same** strip of card as shown in Fig. 1.1.

w = ……………………………. [1]

(ii) Determine the surface area A of the strip, using the equation

$$A = L\,w$$

A = ... [1]

(c) **(i)** Use tape to stick the two **longer** strips together, so that they do not overlap, to make the shape shown in Fig. 1.2.

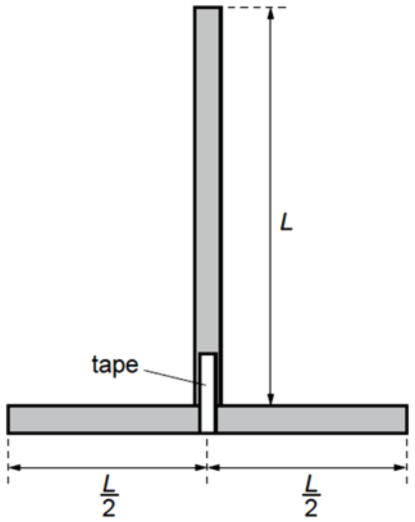

Fig. 1.2

(ii) Use the pin to make a hole at the top of the vertical strip as shown in Fig. 1.3.

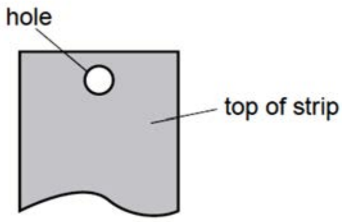

Fig. 1.3

The hole should be central and as near to the top as possible and be large enough for the card to swing freely on the pin.

(iii) Use the cork and pin, suspend the card shape as shown in Fig. 1.4.

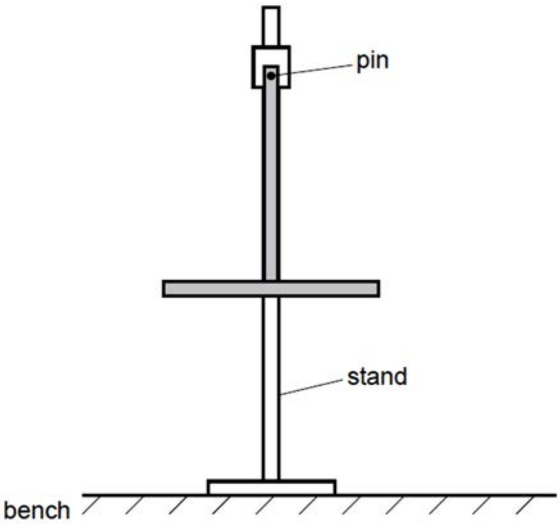

Fig. 1.4

(d) Move the card shape to the left. Release the shape and observe its movement. The card will move to the right and then to the left again, completing a swing as shown in Fig. 1.5.

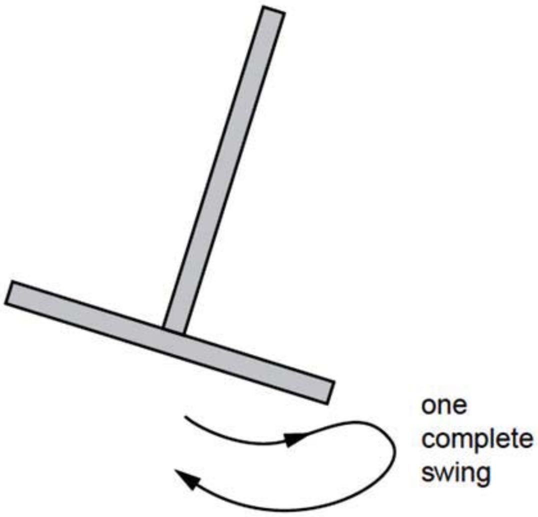

Fig. 1.5

The time taken for one complete swing is *T*.
By timing several of these complete swings, determine an accurate value for *T*.

T = ... [3]

(e) It is suggested that T^2 is directly proportional to L for this shape.

Use the two card strips that are **shorter** to take further measurements to investigate this suggestion.
State and explain whether or not you agree with this suggestion.

Present your measurements and calculated results clearly.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………….. [5]

(f) **(i)** Describe a significant source of uncertainty or limitation of the procedure for this experiment.

………………………………………………………………………………………

………………………………………………………………………………………

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

(ii) Describe an improvement that could be made to this experiment to address the source of error identified in **(f)(i)**. You may suggest the use of other apparatus or different procedures.

………………………………………………………………………………………

………………………………………………………………………………………

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

2 In this experiment you will investigate how the rate of heat energy transferred from a heater depends on the voltage across its resistance.

(a) **(i)** Pour water into the measuring cylinder to the 50 ml mark.

(ii) Pour the water from the measuring cylinder into the empty beaker.
Determine and record the mass *m* of water in the beaker.
(1 ml of water has a mass of 1 g)

m = ... [1]

(b) **(i)** Set up the circuit shown in Fig. 2.1.

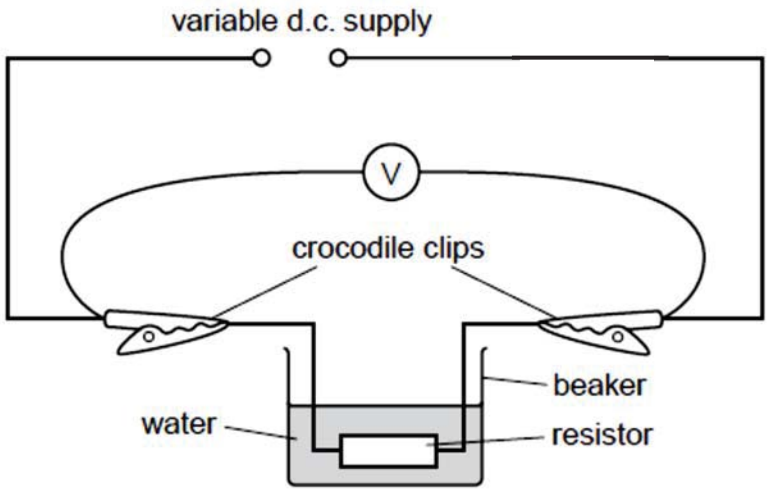

Fig. 2.1

(ii) Adjust the output of the power supply to 6 V.

(iii) Switch on the power supply. Measure and record the voltmeter reading *V*. Switch off the power supply.

V = ... [1]

(c) Measure and record the temperature θ_1 of the water in the beaker.

θ_1 = ...

(d) **(i)** Switch on the power supply and start the stopwatch.

(ii) After four minutes, measure and record the temperature θ_2 of the water. Switch off the power supply.

θ_2 = ... [1]

(iii) Calculate and record the temperature rise (θ_2 - θ_1).

(θ_2 - θ_1) = ... [1]

(e) It is suggested that the relationship between V, θ_1 and θ_2 is

$$V^2 = \frac{mcR}{t}\left(\theta_2 - \theta_1\right)$$

where, c is the specific heat capacity of water,
R is the resistance of the resistor (10 Ω) in Fig. 2.1 and,
t is the heating duration**.**

Use your data in **a(ii)**, **b(iii)** and **(d)(iii)** to calculate c.

c = ... [2]

(f) The design of the resistance heater used in this experiment has limitations in providing a high rate of heat transfer to water.

Suggest changes that could be made to the design of the heater to improve the rate of heat transfer to water for large volume heating in industrial applications. Explain your answer.

……………………………………………………………………………………………

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……………………………………………………………………………………………

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

3 In this experiment you will determine the resistivity of a metal in the form of a wire.

(a) **(i)** Measure and record the diameter *d* of the short sample of the wire placed in the clear container.

d = ………………………….. [1]

(ii) Calculate the cross-sectional area *A* of the wire using the formula

$$A = \frac{\pi d^2}{4}.$$

A = ………………………….. [1]

(b) **(i)** Using the wire attached to the meter rule, set up the circuit shown in Fig. 3.1.

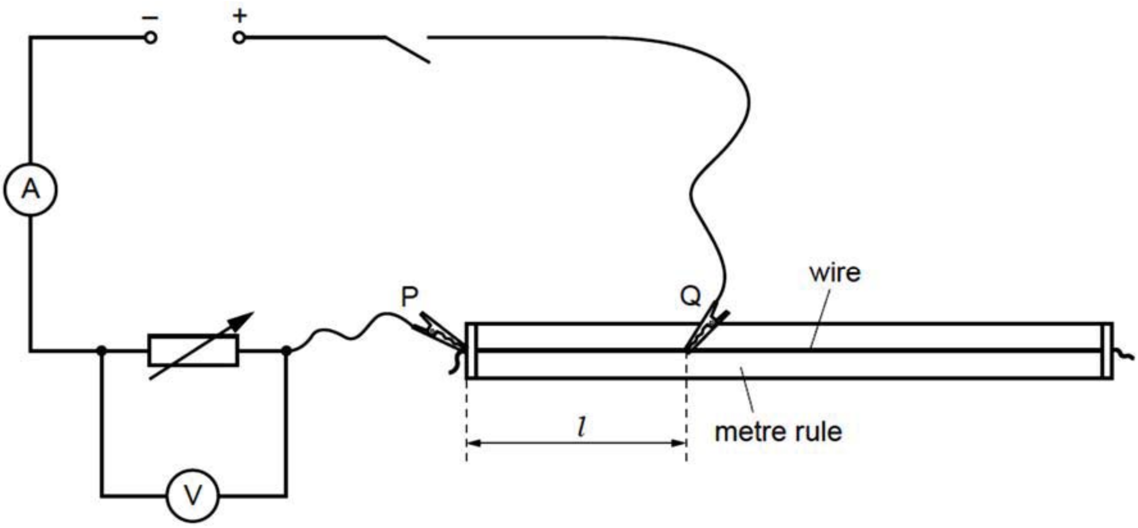

Fig. 3.1

There are two crocodile clips P and Q.

P will remain in the same position throughout the experiment.

Q can be moved to different positions along the wire.

(ii) Position the slider approximately three quarter-way along the rheostat (variable resistor).

(iii) Attach Q approximately 30 cm along the wire away from P.

(iv) Close the switch.

(v) Measure and record the length l, of the wire between P and Q.

Record the voltmeter reading V.

l = ……………………………….

V = ………………………….. [1]

(vi) Record the ammeter reading I.

I = ………………………….. [1]

(vii) Open the switch.

(c) **(i)** Reposition Q at a new distance l from P.

(ii) Close the switch.

(iii) Adjust the slider of the rheostat until the ammeter reading is the same value as in **(b)(vi)**.

(iv) Measure and record the length l, of the wire between P and Q.

Record the voltmeter reading V.

l = ………………………………

V = ………………………………

(v) Open the switch.

(d) Repeat **(c)** until you have six sets of readings for l and V.

For each value of l, adjust the slider on the rheostat so that the ammeter reading I remains constant at the value in (b)(vi).

You may find it helpful to copy your value from **(b)(vi)** here.

I = …………………………..

[7]

(e) It is suggested that the quantities of V and l are related by the equation

$$\frac{V}{l} = \frac{M}{l} - N$$

where M and N are constants.

Plot a suitable graph to determine M and N.

M = ……………………………..

N = ………………………….. [4]

[3]

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

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(g) The resistivity ρ of the material of the wire, in Ω m, can be found using the relationship

$$\rho = \frac{NA}{I}$$

when N is expressed in V m^{-1}, A in m^2 and I in A.

Using your answers in **(a)(ii)**, **(b)(vi)** and **(e)**, calculate a value for ρ.

ρ = ………………………….. Ω m [1]

Please turn over for Question 4.

4 A student investigates the power dissipated by a lamp connected to a model wind turbine as shown in Fig. 4.1.

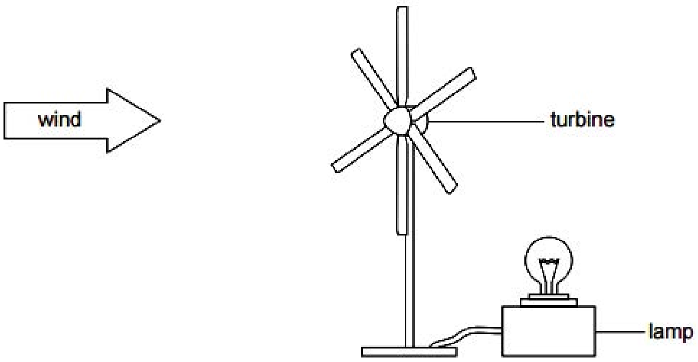

Fig. 4.1

The power P dissipated in the lamp depends on the angle θ between the axis of the turbine and the direction of the wind, as shown by the top view in Fig. 4.2.

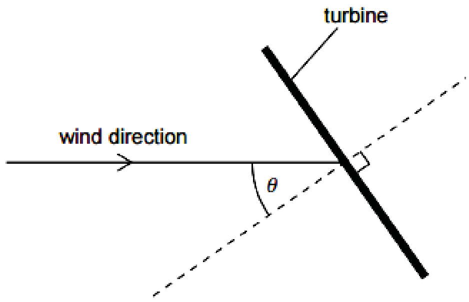

Fig. 4.2

It is suggested that

$$P = k \cos \theta$$

where k is a constant.

Design a laboratory experiment to test the relationship between P and θ and determine a value for k. You should draw a labelled diagram to show the arrangement of your apparatus. In your account you should pay particular attention to

(a) the identification and control of variables,
(b) the equipment you would use,
(c) the procedure to be followed,
(d) how the constant k is determined,
(e) any precautions that would be taken to improve the accuracy and safety of the experiment.

[12]

Diagram

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END OF PAPER

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2017 JC2 H2 Physics 9749 Prelim Exam Solution (Paper 1)

Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans	Qn	Ans
1	**A**	7	**D**	13	**A**	19	**C**	25	**D**
2	**B**	8	**D**	14	**A**	20	**D**	26	**A**
3	**B**	9	**D**	15	**D**	21	**A**	27	**C**
4	**D**	10	**A**	16	**C**	22	**B**	28	**C**
5	**D**	11	**B**	17	**B**	23	**D**	29	**B**
6	**C**	12	**D**	18	**C**	24	**B**	30	**C**

1 Ans: **A**

Comments

Let the top mark be a and the lower mark be b. Let the time the ball passes the top mark be t_a and when it passes the lower mark, t_b.

Hence the speed v of the ball is $\frac{b-a}{t_b-t_a} = \frac{270}{2.00}$

$$\frac{\Delta v}{v} = \frac{(\Delta b + \Delta a)}{b-a} + \frac{(\Delta t_b + \Delta t_a)}{t_b - t_a}$$

$$\frac{\Delta v}{v} = \frac{2 \text{ mm}}{270 \text{ mm}} + \frac{0.04 \text{ s}}{2.00 \text{ s}}$$

$$\frac{\Delta v}{v} = \frac{2}{270} + \frac{0.04}{2.00}$$

2 Ans: **B**

Comments

$$s = ut + \frac{1}{2}gt^2$$

$$L = 0 + \frac{1}{2}gt^2 \text{ ---------(1)}$$

$$s = \frac{1}{2}gt^2(\frac{1}{4})$$

$$s = 0.25\,L$$

3 Ans: **B**

Comments

Statement A: False
This is a violation of Newton's Third Law.

Statement B: True
In compliance with Newton's Third Law.

Statement C: False
If forces acting on the trolley were to be in equilibrium, then the trolley would not accelerate.

Statement D: False
If this statement were true, then according to Newton's Second Law of motion, the trolley's acceleration would be zero and it will be moving at constant speed.

4 Ans: **D**

Comments

Let the volume of the ice block be *V*.

When fully submerged, volume of fluid displaced = volume of ice block = *V*

Upthrust = weight of fluid displaced = density of fluid x volume of fluid displaced x *g*

= 1.0 x *V* x *g* = *V g*

When floating, block is in equilibrium, so:

Upthrust = weight of ice block = density of ice block x volume of ice block x *g*

= 0.9 x *V* x *g* = 0.9 *V g*

Hence, ratio of (upthrust when fully submerged) / (upthrust when floating) = *V g* / 0.9*V g* = 1.1

5 *Ans:* ***D*** Comments

Statement A: False
There must be a force at the pivot for the arm to be in equilibrium.

Statement B: False
When the load is moved nearer to the pivot the clockwise moment due to the load about the pivot will decrease. Hence, the anticlockwise moment by the force from the biceps about the same pivot to maintain equilibrium of the arm will also decrease. Therefore, the force from the biceps will be smaller.

Statement C: False
We must consider the vector sum of the weights rather than scalar addition

Statement D: True
This statement is correct, otherwise the biceps itself will not be in equilibrium as shown.

6 *Ans:* ***C*** Comments

Rate of change of GPE = (m/t)gh = 1.77×10^8
Efficiency = (Useful power output/Power input) × 100%
= $(100 \times 10^6/1.77 \times 10^8) \times 100\%$
= 57%

7 *Ans:* ***D*** Comments

Minimum tension occurs at the top:
T_1 + W = mv2/r = 12.5 N
T_1 = 9.6 N

Minimum tension occurs at the bottom:
$T_2 - W = mv^2/r$ = 12.5 N

T2 = 15.4 N

8 *Ans:* ***D***

Comments

Centripetal force is always perpendicular to the motion,
Thus work done by centripetal force = F × d cos90 = 0

9 *Ans:* ***D***

Comments

(A) The acceleration is always directed towards the central point.
(B) The acceleration and velocity are always 90° out of phase.
(C) The velocity and displacements may be in the same direction or opposite direction.

10 *Ans:* ***A***

Comments

Maximum energy = $\frac{1}{2} m\omega^2 x_0^2 = 50$ J
$\frac{1}{2} m\omega^2 = 50/((100\times 10^{-3})^2 = 5000$
At 40 mm, $v^2 = \omega^2(x_0^2 - x^2)$
Kinetic energy = $\frac{1}{2} m\omega^2[(100 \times 10^{-3})^2 - (40 \times 10^{-3})^2]$
$= 5000[(100 \times 10^{-3})^2 - (40 \times 10^{-3})^2] = 42$ J

11 *Ans:* ***B***

Comments

$XY = \sqrt{(R^2 + (2R)^2} = (\sqrt{3})R$
$F = GMm/XY2 = GMm/3R^2$
$GMm/R^2 = 3F$

When the planets are nearest to each other, distance = R
$F_1 = GMm/R^2 = 3F$

12 *Ans:* ***D***

Comments

Gravitational field at surface, g

$$= \frac{GM}{R^2}$$

$$= \frac{G(\rho V)}{R^2}$$

$$= \frac{G(\rho \frac{4}{3}\pi R^3)}{R^2}$$

$$= \frac{4}{3} G\rho\pi R$$

For planets of the same mean density, $g \propto R$

$$\frac{\text{gravitational field at the surface of planet X}}{\text{gravitational field at the surface of planet Y}} = \frac{R_X}{R_Y} = \frac{1}{2}$$

13 *Ans:* ***A***

Comments

T / K = t / °C + 273.15
t / °C = T / K - 273.15 [a t / °C against T / K graph would have a y-intercept of 273.15]

14 *Ans:* ***A***

Comments

Internal energy can also be changed by the wrok done on the system (expansion or compression)

15 *Ans:* **D**

Comments

Option A is incorrect S should be of higher speed since it is at the equilibrium position.
Option B is incorrect because both should be moving in opposite directions.
Option C is incorrect because kinetic energy of P (being at the amplitude) is 0.
Option D is the answer because acceleration is proportional to displacement from the equilibrium position.

16 *Ans:* **C**

Comments

Upon reflection, the phase should change by π.
Thus, waves that reach the surface would undergoes a pi phase change and proceed towards the left.

17 *Ans:* **B**

Comments

A node to antinode = ¼ wavelength

18 *Ans:* **C**

Comments

For the diffraction grating,
nλ = dsinθ
(1)λ = dsin30° => d= λ/ sin30°
For the double slit experiment,
λ = ax/D
λ = (500d)x/(1)
λ = (500)(λ/ sin30°)x/(1)
1 = 500x/sin30°
X = 0.001 m

19 *Ans:* **C**

Comments

$KE_i + EPE_i = KE_f + EPE_f$

$0 + qV_i = \frac{1}{2} mv^2 + qV_f$

$$v = \sqrt{\frac{2q\Delta V}{m}}$$

Since each nuclei is accelerated through the same p.d.

$$v \propto \sqrt{\frac{q}{m}}$$

For the lowest speed, the nuclei has the smallest $\sqrt{\frac{q}{m}}$.

$$\left(\sqrt{\frac{q}{m}}\right)_H = \sqrt{\frac{1}{1}} = 1$$

$$\left(\sqrt{\frac{q}{m}}\right)_{He} = \sqrt{\frac{2}{4}} = 0.707$$

$$\left(\sqrt{\frac{q}{m}}\right)_{Li} = \sqrt{\frac{3}{7}} = 0.655$$

$$\left(\sqrt{\frac{q}{m}}\right)_{Be} = \sqrt{\frac{4}{9}} = 0.667$$

20 *Ans:* **D**

Comments

$E = IR_{total}$

6.0 = I × (10 + 10)
I = 0.30 A
Q = It
= 0.30 × 60
= 18 C

<u>21</u> Ans: **A**

Comments

Using potential divider rule,

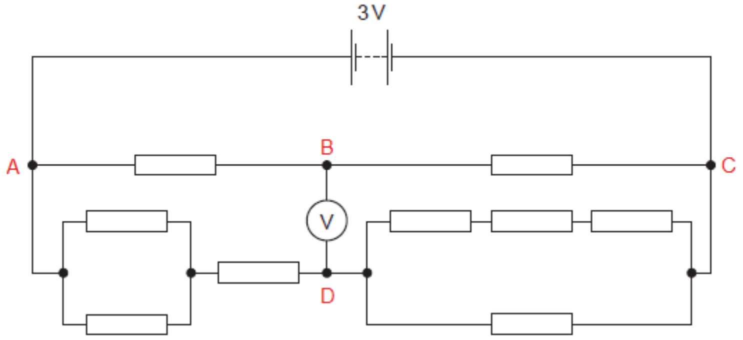
$$V = \frac{R}{R+r} \times E$$

Since r increases with E and R being constant, V decreases.

Thus, since $P_R = \frac{V^2}{R}$*, output power also decreases.*

<u>22</u> Ans: **B**

Comments



$$R_{AD} = \left(\frac{1}{1000} + \frac{1}{1000}\right)^{-1} + 1000$$
$= 1500\ \Omega$

$$R_{DC} = \left(\frac{1}{1000+1000+1000} + \frac{1}{1000}\right)^{-1}$$
$= 750\ \Omega$

$$V_{BC} = \frac{R_{BC}}{R_{AB} + R_{BC}} \times E$$

$$V_{BC} = \frac{1000}{1000+1000} \times 3 = 1.5\ \text{V}$$

$$V_{DC} = \frac{R_{DC}}{R_{AD} + R_{DC}} \times E$$

$$V_{BC} = \frac{750}{1500+750} \times 3 = 1.0\ \text{V}$$

Voltage across the voltmeter
$V_{BD} = V_{BC} - V_{DC}$
$= 1.5 - 1.0 = 0.5\ V$

<u>23</u> Ans: **D**

Comments

$$R = \frac{V}{I}$$

Since R_Q is fixed, the ratio of its voltage and current is constant, i.e. the graph of its voltage and current is an upwards sloping straight line passing from the origin.

With resistors P and Q connected in series,
$E = I\,(R_P + R_Q)$
$\quad = V_P + V_Q$
$V_P = E - V_Q$
Thus the variation with current of the voltmeter reading of P is a downwards sloping straight line.

<u>24</u> Ans: **B** <u>Comments</u>

Using the Right Hand Grip rule,

- *the direction of resultant magnetic field caused by conductor P and R at the center is south west.*
- *the direction of magnetic field caused by conductor Q at the center is north west.*
- *Hence, (vectorially) adding the two magnetic field of equal magnitude, the direction of resultant magnetic field by all the conductors at the center is west of conductor S.*

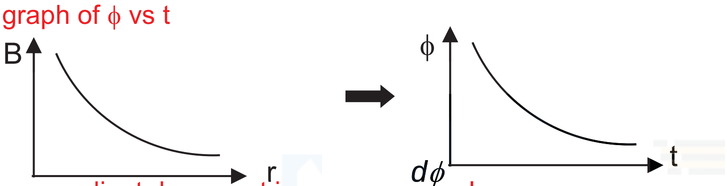
Using the Fleming's Left Hand rule, the direction of magnetic force acting on conductor S is south.

<u>25</u> Ans: **D** <u>Comments</u>

According to Fleming's left hand rule, the positively-charged particle experiences a magnetic force that is perpendicular to its velocity and the magnetic field that it experiences. With magnetic field directed into the paper and current directed downwards, the magnetic force acting on the electrons is rightwards.

<u>26</u> Ans: ***A*** <u>Comments</u>

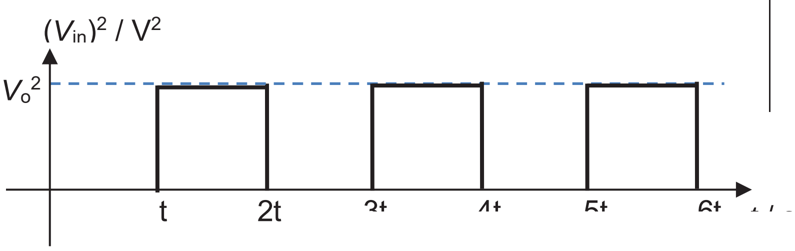
Since rod is moving at constant v, graph of B vs r will be similar to graph of ϕ vs t



Since gradient drops as t increases, $\frac{d\phi}{dt}$ decreases as conductor PQ moves away →magnitude of induced emf decreases.
Using FRHR, induced current is from Q to P, therefore P is at higher potential

<u>27</u> Ans: ***C*** <u>Comments</u>

Half-wave rectification with the diode



$$V_{rms} = \sqrt{\frac{{V_0}^2}{2}}$$

28 *Ans:* ***C***

The work function of a metal corresponds to the minimum photon energy required to eject photoelectrons from the metal surface. Hence since the work function of calcium is half that for platinum, the minimum photon energy to emit photoelectrons for calcium will be half that for platinum.

Comments

29 *Ans:* ***B***

Statement (i) is wrong. Most of the energy goes towards heating the metal target. Statement (ii) is wrong. "hc/E" is the minimum wavelength. Only statement (iii) is correct. The wavelengths of the characteristic X-ray spectral lines depend on the material used to make the target (and not the potential difference applied to accelerate the electrons).

Comments

30 *Ans:* ***C***

background count, B + radioactive source count, R = 120 – eqn (1)

After one half-life, R would be halved. ⇒ B + ½R = 64 – eqn (2)

(1) – (2): ½R = 56 ⇒ R = 112 counts

B + 112 = 120 ⇒ B = 8 counts

When a 5 mm thick lead is inserted between the α-source and the detector, R = 0 (alpha radiation blocked by lead), therefore only the background count can be detected.

Comments

1 (a)

An equation is homogeneous if every term in the equation has the same base units.

LHS: [Q] = kg s^{-1}

RHS: $\frac{[k][r^3][p_1 - p_2]}{[l]} = \frac{m^{-1}\ s \times m^3 \times \frac{kg\ m\ s^{-2}}{m^2}}{m}$ [C1]

= kg s^{-1}

Since the LHS and RHS of the equation has the same base units, the equation is homogeneous. [A1]

Comments

Many students did not explain the criteria when an equation would be homogeneous (When every term in the equation has the same base units). Many merely showed that LHS and RHS had the same units and stopped there, with no further explanation. Students must realize the importance of providing clear explanation for their conclusion.

Many students also did not use the [ ] correctly, failing to recognize that it means 'the unit of'.

1 (b)(i)

$v_y = u_y + a_y t$

$0 = 15.0 \sin 60° + (-9.81)t$ [M1]

$t = 1.33$ s [A1]

Comments

Quite well done

1 (b)(ii)

Since the ball travels through the same vertical height as it moves from the wall back to the ground, the time taken to travel from P to F = 1.33 s [B1]

$s_x = u_x t + ½ a_x t^2$

$6.15 = u_x \times 1.33 + ½ \times 0 \times 1.33^2$ [M1]

$u_x = 4.62 \approx 4.6$ m s^{-1} [A0]

Comments

Many students did not explain why the time taken for the ball to travel from ground to maximum height is the same as that taken to travel from the point of rebound back to the ground.

1 (b)(iii)

Change in momentum = Δmv

$= m(v_{rebound} - v_{incident})$

$= (60 \times 10^{-3})[4.6 - (-15\cos 60°)]$ [M1]

= 0.73 N s OR – 0.73 N s [A1]

Comments

Many students failed to recognize that momentum is a vector quantity and hence since the incident velocity and rebound velocity are in opposite directions, the change would involve a vector subtraction rather than vector addition.

1 (b)(iii)

Since the rebound velocity (4.6 m s^{-1}) is less than the incident velocity (15 cos60° =7.5 ms^{-1}) OR relative speed of separation is less than relative speed of approach [M1]

Hence, collision is inelastic [A1]

Comments

A handful of students argued that the collision was inelastic because the momentum of the ball was not conserved. They were not given credit because conservation of momentum was not a necessary condition to determine if a collision is considered elastic or not. They must explain that the kinetic energy of the ball was not conserved instead.

2 (a)(i)

Since the gas is ideal, potential energy of the gas molecules is zero. Hence the internal energy is the sum of the random kinetic energies of the molecules.

Comments

Poorly done. While most students know that area under p-V graph gives the work done by gas and $\Delta U \propto \Delta T$, most equated ΔU = area under

$\Delta U = \frac{3}{2}nR\Delta T$

For the process A → B, since the ideal gas undergoes expansion under constant pressure,

$p\Delta V = nR\Delta T$ [M1]

$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}p\Delta V$

$= \frac{3}{2} \times 10.0 \times 10^5 \times 2.0 \times 10^{-4}$ [M1]

= 300 J [A0]

graph from V=0 to V = 3.0×10^{-4}. This suggests a lack of understanding of the link between the area under the graph and ΔU.

2 (a)(ii)

Work done on the gas

= area under the graph = – p (V_f – V_i)

= – (10.0×10^5)(3.0 – 1.0) × 10^{-4}

= – 200 J [M1]

By first law of thermodynamics,

W + Q = ΔU

(- 200) + Q = 300 [M1]

Q = 500 J [A1]

Comments

Most students are able to get this right. For those who did not, many did not take into account the sign of W for expansion (which should be negative instead of positive).

2 (b)(i)

Since this is a cyclic process, the initial and final state of the cycle is the same [M1]. Hence the change in internal energy is zero [A1].

OR Since this is a cyclic process, the initial and final temperature of the ideal gas is the same [M1]. Hence the change in internal energy is zero [A1].

Comments

Only a handful managed to get the full credit. While most are able to recognise that ΔU = 0 for a cyclic process, they fall short of providing the correct explanation with the correct terms. Many only stated that the cycle goes back to the same "point" without elaborating the effect this has on the parameters (p, V and hence T) of the **initial** and **final states** of the gas.

2 (b)(ii)

	Q	W	ΔU
A → B	+	-	+
B → C	0	-	-
C → D	-	0	-
D → A	0	+	+

[1m for all correct W.D]
[1m for all correct Q]
[1m for all correct change in U]

A to B: Since it is an expansion, W is negative. By first law of thermodynamics, given ΔU is positive and W is negative, Q needs to be positive.

B to C: Since it is an expansion, W is negative. Since it is an adiabatic process (according to the question), Q needs to be zero.

Comments

Poorly done. Many did not know the effect on **Q** when expansion or compression is done "within a very short time". A handful were confused about the sign for W.

C to D: Since there is no change in volume, W is zero. Since the pressure decrease at constant volume, temperature decrease, which means ΔU is negative. Thus Q also needs to be negative.
D to A: Since it is an compression, W is postive. Since it is an adiabatic process (according to the question), Q needs to be zero.

3 (a)

Principle of Superposition states that when two or more waves meet at a point [B1], the resultant displacement at that point is equal to the vector sum of the displacements due to the individual waves at that point [B1].

Comments

Some students who got this incorrect, mistaken the condition as the condition for stationary wave.

3 (b)(i)

Wave travel down the tube and gets reflected by the water [B1]. The incident and the reflected waves, both having the same amplitude, frequency (or wavelength) and speed travelling in opposite directions superpose [B1] to form standing wave.

OR

The incident sound wave travels along the tube and is reflected by the water. [B1]

The superposition of the incident and reflected wave of same amplitude, speed and wavelength(or frequency) but travelling in opposite directions [B1] creates a standing wave in the pipe.

Comments

Most students are able to identify that upon reflection, the reflected wave will have similar property as the incident wave. A handful of students did not apply the law of superposition after that. Also, A handful of students stated the condition for stationary wave to be formed generally without applying it to the question.

3 (b)(ii)

The length of the air column in tube will limit the type of stationary wave which can be formed within the air column as there is the boundary condition that it has to be a node formed at the closed end of the air column and a antinode at the open end of the air column. [B1] In general, the length of the air column L needs to be equal to $\lambda(2n+1)/4$ [B1], where λ is the wavelength of the incident wave and n is is an integer. If this condition is met, the loudness of the sound will be maximum, otherwise the sound will be of lower amplitude. [B1]

Comments

A lot of students failed to notice that the frequency and wavelength (hence the velocity) of the wave did not change and the change of the water level results in different harmonics

3 (b)(iii)

$\frac{1}{2}\lambda = 32.4$ cm $= 0.324$ [M1]

$\lambda = 0.648$ m

$v = f\lambda = 512 \times 0.648$

$= 332$ m s^{-1} [A1]

Comments

A handful of student identify the wrong wavelength

3 (b)(iv)

$\frac{1}{4}\lambda = L_1 + c$

$\frac{1}{4} \times 64.8 = 15.7 + c$

$c = +0.50$ cm

Therefore the antinode is 0.50 cm above the top of the tube [A1] or 16.2 cm above the water surface due to end correction [A1].

Comments

A handful of student failed to use the value that is provided to pin point exactly the position of the antinode

4 (a)

Comments

Electric field strength is the electric force per unit positive charge (on a small test charge) [B1]

Quite many students did not study their definition well, failing to highlight key considerations of "force PER UNIT charge" and "positive" charge.

4 (b)

$E = \frac{V_H - V_L}{d}$

$1.40 \times 10^4 = \frac{V_{btm} - 140}{0.015}$ [C1]

$V_{btm} = 350$ V [A1]

Comments

Quite a handful of students did not realize that the potential of the bottom plate must be higher than the top for the electric field to be pointing upwards.

4 (c)(i)

$F_n = ma$

$qE = ma$

$1.60 \times 10^{-19} \times 1.40 \times 10^4 = 9.11 \times 10^{-31} \times a$ [C1]

$a = 2.46 \times 10^{15}$ m s^{-2} [A1]

the direction of acceleration is towards the plate of higher potential or downwards [B1]

Comments

Quite well done in terms of calculation of the vertical acceleration of the electron within the electric field. However, many did not state the direction of a correctly, failing to recognize that the electron will be attracted downwards towards the plate of higher polarity.

4 (c)(ii)

$s_x = u_x t + ½ a_z t^2$

$0.120 = 5.0 \times 10^7 t + ½ \times 0 \times t^2$ [C1]

$t = 2.40 \times 10^{-9}$ s [A1]

Comments

Quite a handful of students failed to recognize that the horizontal acceleration of the electron was zero, but merely substituted the value of acceleration from 4(c)(i) into the horizontal displacement equation as shown.

4 (d)

Either

$s_y = u_y t + ½ a_y t^2$

$s_y = \left(0 \times 2.4 \times 10^{-9}\right) + \left(½ \times 2.46 \times 10^{15} \times \left(2.4 \times 10^{-9}\right)^2\right)$ [C1]

$= 7.1 \times 10^{-3}$ m [A1]

Since 0.71 cm is less than 0.75 cm (distance away from the top plate), the electron does not hit the plates, thus passing between the plates. [A1]

Or

To hit the plate, the minimum vertical displacement = 0.75 cm

$0.75 \times 10^{-2} = \left(0 \times t\right) + \left(½ \times 2.46 \times 10^{15} \times t^2\right)$ [C1]

$t = 2.47 \times 10^{-9}$ s [A1]

Since 2.47 ns is longer than the 2.4 ns, the electron does not hit the plates, thus passing between the plates. [A1]

Comments

Those students who got this part correct, provided a logical argument why the electron will pass between the plates and were given full credit. There were also a handful who did not use the correct approach in their reasoning.

5 (a)

For a length of wire l,

Total charge in volume V

Comments

Many are clueless how to start the derivation of current using the definition of current. For those who

= number density of charge carrier × Volume × charge of each charge carriers
= $n \times Al \times q$ [M1]

Time taken for total charge to move through any cross section

$$v = \frac{distance}{time} = \frac{l}{t}$$

$$t = \frac{l}{v}$$ [M1]

Since $I = \frac{Q}{t}$

$$I = \frac{nAlq}{\frac{l}{v}} = nAvq$$ [A1]

manage to derive, it is important show clear relationships between the variables, especially identifying the undefined variables.

5 (b)(i)

Since each copper atom contributes roughly one conduction electron, the number density of charge carriers is equal to the number of atoms per cubic metre.

$$No\ of\ mol = \frac{Mass}{Molar\ Mass}$$

Dividing both sides of the equation by volume:

$$No\ of\ mol\ per\ unit\ volume = \frac{density}{Molar\ mass}$$

$$No\ of\ mol\ per\ unit\ volume = \frac{9000}{63.5 \times 10^{-3}} = 1.417 \times 10^{5}$$ [M1]

$No\ of\ atom = No\ of\ mol \times N_A$

$No\ of\ atom\ per\ unit\ volume = No\ of\ mol\ per\ unit\ volume \times N_A$

number density = No of atom per unit volume

$= 1.417 \times 10^{5} \times 6.02 \times 10^{23}$ [M1]

= $8.53 \times 10^{28} \approx 8.5 \times 10^{28}$ m^{-3} [A0]

Comments
Many did not show proper proof how the number density can be determined. There is a need to indicate correct variable, including stating the object of the variable (e.g. volume of 1 mole of atom)

5 (b)(ii)

$I = nAvq$

$$17 \times 10^{-3} = 8.5 \times 10^{28} \times \frac{\pi}{4} \times \left(1.8 \times 10^{-3}\right)^{2} \times v \times 1.6 \times 10^{-19}$$ [C1]

$v = 4.91 \times 10^{-7}$ m s^{-1} [A1]

Comments
Surprisingly, many did not attempt this part, indicating that they either did not read the question or they forget the equation of I = nAvq is provided in the formulae list.

5 (b)(iii)

Current is the same in all segments of the wire, including the thinner wire [B1]. Having a smaller cross-sectional area, the electrons have to move at a higher drift velocity [B1].

Comments
Many wrongly focussed the argument on the resistance of the wire, without understanding that current in a "series" circuit is the same.

5 (c)

Once the switch is closed, electric field is set up almost instantaneously OR all the electrons in the wire and filament to start to move together. [B1]

Comments
Many have the wrong idea that the electrons has very high instantaneous speed despite having small drift velocity.

6 (a)

The decay constant of a radioactive material is the probability of decay of a nucleus per unit time [B1]. [B1]

Comments
Many could not give the correct definition for decay constant.

6 (b)

$$\lambda = \frac{\ln 2}{87.7 \times 365 \times 24 \times 60 \times 60}$$ [M1]

$= 2.51 \times 10^{-10}\ s^{-1}$ [A1]

Comments
Not well done. Many did not convert half-life to the appropriate unit. Some also did not know the conversion of unit of time from years to seconds.

6 (c)(i)

$A_0 = \lambda N_0$

$= 2.51 \times 10^{-10} \times 1.74 \times 10^{25}$ [M1]

$= 4.36 \times 10^{15}$ Bq [A1]

Comments
Fairly well done. Those who did not gain any credit clearly did not revise this topic as they could not give the correct formula for activity and number of nuclei.

6 (c)(ii)

$A = A_0\, e^{-\lambda t}$

$= 4.36 \times 10^{15} \times e^{-2.51 \times 10^{-10} \times 10 \times 365 \times 24 \times 60 \times 60}$ [M1]

$= 4.03 \times 10^{15}$ Bq [A1]

Comments
Fairly well done. Many made conversion errors and some mistook the relation to be a positive rather than a negative exponential one.

7 (a)(i)

1. *The engineer has to calculate to ensure that the beam is strong enough to withstand any forces applied to it.*
2. *He has to ensure that there is not too much sag in the beam for a given load.*

Any of the above reasons [B1]

Comments
Well done. Students need to careful with language, making measurement cannot prevent the beam from collapsing. It is to ensure that beam is strong enough to take the load.

7 (a)(ii)

The reason is to minimise the amount of steel required for a given load. [B1]

Comments
Well done. Only a few students did not read the passage.

7 (a)(iii)

From the equation $x = \frac{WL^3}{kab^3}$, *the amount of depression is inversely proportional to the width a and inversely proportionally to the cube of the depth b, for the same load and length. [M1] The diagram shows the beam B has a greater width a but a much smaller depth b. [M1] Since the effect of the depth has a larger impact on the depression compared to the width, hence beam B will sag more than beam C. [A1]*

Comments
Poorly done. Students did not seem to realise that they are to use the equation to analyse this.

7 (b)

$$x = \frac{WL^3}{kab^3}$$

$$0.010 = \frac{W \times 3.0^3}{3.6 \times 10^{10} \times 0.050 \times 0.10^3}$$ [M1]

$W = 667$ N [A1]

Comments
There were several students who did not cube the length or the depth in their calculations. Students who showed the correct substitution and expression were awarded 1 mark.

7 (c)(i)
When L = 1.750 m, x = 0.20 mm
$\log_{10}$ (L/m) = 0.2430 and $\log_{10}$ (x/mm) = 0.30 [B1]

Comments
Well done. Only a few students indicated the incorrect significant figures.

7 (c)(ii)
Plot the point to half a small square and draw a best-fit line for the graph. [B1]

Comments
There was some error in the plotting. Students should plot to half a small square and draw the best fit line.

7 (c)(iii)
Gradient = (0.980 – 0.180)/(0.470 – 0.200)
= 2.96
reading off to half the small square [B1]
Value within 2.85 – 3.15 [A1]

Comments
Some triangle used to calculate the gradient is too small. Some students incorrectly included 10^{-3} in the calculation.

7 (c)(iv)
$$\lg x = 3\lg L + \lg\left(\frac{W}{kab^3}\right)$$
The data yielded a linear graph for lg x versus lgL [B1 for working + statement]
The gradient of the graph was about 3, which tallies with the power of L in the relationship. [M1]
Hence the relation is true. [A0]

Comments
Students should indicate clearly that a straight line graph is obtained in the plot of log x vs log L.
Some students determined the percentage difference from the expected gradient of 3 and was awarded the mark in lieu of the straight line. Students should show the linearization clearly in their working.

7 (d)
Total moment
= (0.50)(10) + (1.3)(6.0) + (2.3)(22) + (3.1)(7.0) [M1]
= 8.51×10^4 N m [A1]

Comments
Generally well done.

7 (e)(i)
$$B = \frac{WL}{8}$$
$$= \frac{33000 \times 4.20}{8} = 1.73 \times 10^4 \text{ N m}$$ [B1]

Comments
Students are able to work out the value of B. There were several errors in the significant figures for this part.

7 (e)(ii)
$$x = \frac{BL^3}{c}$$
$$= \frac{1.7325 \times 10^4 \times 4.20^3}{3.35 \times 10^8}$$
= 0.00383 m [B1]

Comments
Generally well done.

7 (f)(i)
By interpolation,
$$\text{Stress} = \frac{83 - 93}{25 - 20} \times (21 - 20) + 93$$ [M1]
= 91 MPa [A1]

Comments
Students need to show their working clearly – in how they arrive at the value of the stress by interpolation. Students should observe that the value decreases with increasing *P*.

7 (f)(ii)

$$\frac{\text{bending moment}}{\text{allowable bending stress}}$$

$= \dfrac{17325}{91 \times 10^{6}}$ = *1.90 × 10^{-4} m^3* *[M1]*

Since the ratio is less than 2.0 × 10^{-4} m^3, the beam is safe [A1]

Comments

Most students who attempted this part were able to come to the correct conclusion.

1 (a)(i)

By the principle of conservation of energy,

$$\frac{1}{2}Mv^2 = Mgh$$

$$v^2 = 2(9.81)(25) \quad \text{[M1]}$$

$$v = 22 \text{ or } 22.1 \text{ m s}^{-1} \quad \text{[A1]}$$

Comments

Quite well done. A handful of students used appropriate kinematics equations to solve which was accepted with full credit.

1 (a)(ii)

By the principle of conservation of momentum,

$$Mv = (M+m)v_{joint}$$

$$v_{joint} = \frac{(100)(22.15)}{(100+300)} \quad \text{[M1]}$$

$$v_{joint} = 5.54 \text{ m s}^{-1} \quad \text{[A1]}$$

Comments

Quite well done. However, quite a handful of students who got this wrong were careless in their substitution of mass of the pile and pile driver which were switched.

1 (b)(i)1.

Change in momentum $= p_f - p_i$

$$= \left[0 - (100+300)(5.54)\right] \quad \text{[M1]}$$

$= -2220$ kg ms^{-1} [A1]

Comments

Many students failed to recognize that momentum is a vector quantity and hence, since the final momentum of the pile and pile driver (as a joint body) was zero, the change of momentum would be a negative quantity.

1 (b)(i)2.

Area under the *F-t* graph = change in momentum

$$F_{ave}\Delta t = 2215 \quad \text{[M1]}$$

$$F_{ave} = \frac{2215}{0.18}$$

$$F_{ave} = 1.23 \text{ x } 10^4 \text{ N} \quad \text{[A1]}$$

Comments

Many students did not have the required concept of a 'constant' average force F_{ave} that will give an impulse equivalent to the 'area under the graph' provided in Fig. 1.2 or the change of momentum calculated in 1(b)(i)1. Hence, they had the impression that the F_{ave} asked for in this question is the maximum Force in Fig. 1.2 which is incorrect.

1 (b)(ii)

By the principle of conservation of energy,

KE Loss + GPE Loss = Work done against external resistive forces

$$\frac{1}{2}(M+m)v_{joint}^{\ 2} + (M+m)gd = F_{ave}(d)$$

$$\frac{1}{2}(400)(5.54)^2 + (400)(9.81)(d) = (1.23 \text{ x } 10^4)(d) \quad \text{[M1]}$$

$d = 0.73$ m [A1]

Comments

This part proved too difficult for most students. Many did not manage to get the correct answer and a majority of students did not consider the GPE lost of the pile and driver as it is lowered to a stop due the external resistive force.

2 (a)(i)

Radial lines (symmetrical) and pointing inwards *[B1]*

Comments

Students should draw straight lines with the use of ruler, else they will be penalised. Mostly well done, except for a few who drew concentric circles, likely because of confusion of magnetic field lines.

2 (a)(ii)

No difference in the pattern of the field lines for distance more than the radius of the initial sphere [B1] and the field lines are closer near the surface of smaller sphere. [B1]

Comments

Students should note that the number of field lines remain the same as the field strength for distance more than the radius of the initial sphere remains the same.

Many students went about explaining why the field strength is stronger. Students should look at the question stem. "Suggest" means students are to state the variation of the field lines they observe.

2 (b)(i)

$F_G = GMm/R^2$

$= (6.67 \times 10^{-11} \times 5.98 \times 10^{24})/(6380 \times 10^3)^2$

$= 9.80$ N [A1]

Comments

Mostly well done. Students should pay attention to the conversion of units and the square in the separation.

2 (b)(ii)

$F_C = mR\omega^2$

$= (6380 \times 10^3)(2\pi/8.64 \times 10^3)^2$

$= 0.0337$ N [A1]

Comments

Mostly well done. Students should note that the quantities given are all to 3 s.f. and the final answer should be left to 3 s.f.

2 (b)(iii)

Difference in magnitude of the force = 9.77 N [A1]

Comments

Students who showed clearly the working are awarded the credit.

2 (c)

because acceleration (of free fall) is (resultant) force per unit mass, [B1]

Acceleration = 9.77 m s^{-2} [B1]

Note: An object, when falling, will also have the same angular velocity as an object on the surface of the Earth. Otherwise, the object will not fall vertically in a straight line. Thus the net force acting on the object is $F_g - F_c$.

Comments

Poorly done. Students need to show the explanation clearly. There were several students who simply use F = ma without explaining clearly that F refers to the net force which is equal to Fg – Fc. Students who indicated the unit of acceleration wrongly are penalised.

3 (a)

Total volume of molecules negligible compared to the volume of containing vessel

No intermolecular forces between the molecules

Molecules in random motion

Time of collision small compared with the time between collisions

Larger number of molecules

Any two

Comments

Mostly well-done. Students should realise the importance of comparison when they use the term "negligible". Also, there are some confusion between volume of gas, volume of gas molecules and volume of container. Some confusion also arises in the terms "time during collision" and "time between collisions"

3 (b)

In a real gas, there is a range of velocities or

Comments

Must take the average of v^2 [B1]
Particles move in random direction and can move in x, y and z-direction. Since the proability is the same
$<v_x^2> = <v_y^2> = <v_z^2>$
$<c^2> = 1/3<v_x^2>$ [B1]

Most students did not mention clearly that there is a range of speeds in the x-direction. Students should read the question carefully and recognised that the question states that "all molecules move with speed v_x" which is physically inappropriate.
Most students recognise that that 1/3 factor is due to the random direction. However, students should note the difference in the terms "v_x^2" is different from $< v_x^2>$

3 (c)(i)
Nm = mass of gas
Therefore, density $\rho = M/V = Nm/V = nm$
Hence, $p = 1/3\, nm<c^2> = 1/3\, \rho<c^2>$ [C1]
$1.0 \times 105 = 1/3 \times 1.2 \times <c^2>$
$<c^2> = 2.5 \times 10^5$ [C1]
$C_{rms} = 500\ m\ s^{-1}$ [A1]

Comments
This part is poorly done. Students need to understand the terms in the equation and made reference to the original relationship.

3 (c)(ii)
$T \propto <c^2>$ [C1]
$<c^2> = 2.5 \times 10^5 \times 480/300$
$= 4.0 \times 10^5\ m^2\ s^{-2}$ [A1]

Comments
This part is poorly done. Most students do not know the relationship to apply to the question.

4 (a)
In a polarised wave, the vibrations of wave particles are limited to only one axis; whereas in an unpolarised wave there is no specific axis of vibrations or many different axis of vibrations.

Comments
The writing was not well done with many students mentioned that "waves travelled in multiple direction" and failed to identify that it is the vibrations that can take place in multiple or single axis.

4 (b)(i)
0 as no light will be able to pass through the polariser given it is perpendicular.

Comments
Well done.

4 (b)(ii)1.
$A_3 = A_2 \cos(62° - 23°)$ [M1]
$A_2 = A_1 \cos(23°)$ [M1]
thus
$A_3 = A_1 \cos(27°) \cos(62° - 27°)$
$= 0.715\, A_1$ [A0]

Comments
Well done with a handful of students not able to identify that when using **Malu's Law**, the angle required is the angle between the axis of vibration and polariser.

4 (b)(ii)2.
let the initial amplitude (unpolarised light) = A_0

$\frac{1}{2} = (\frac{A_1}{A_0})^2$
$A_0 = \sqrt{2}A_1 = 1.41\, A_1$ [C1]
$\frac{I_3}{I_0} = (\frac{A_3}{A_0})^2 = (\frac{0.715A_1}{\sqrt{2}A_1})^2 = 0.256$ [M1]

Comments
Common mistake was that students were confused with the different amplitude and intensity

Percentage of intensity reduced = (1 - 0.256) x 100% = 74.4% [A1]

5 (a)(i)

The waves generated by the sources have a phase difference that remains constant with time.
This can be achieved by connecting the two loudspeakers to the same sound source/ signal generator, producing waves that are in phase.
OR
two constant sound sources of the same frequencies.

Comments

Well done with a few students using the word same phase or in phase when explaining coherent.

5 (a)(ii)

The sound waves from the two sources undergo interference.
The path difference ($S_1P - S_2P$) and the phase difference at P is altering as S_1 moves.
Since the two sources are in phase, the waves meet in phase at P when the path difference between the sources is an integral multiple of wavelengths; constructive interference at P results in maximum intensity.
The waves meet in anti-phase at P when the path difference is an odd integral multiple of half wavelengths; destructive interference at P results in minimum intensity.

Comments

Generally, students showed an understanding of why there is interference but the reasoning may not be strong enough to get all the 3 marks

5 (a)(iii)

path difference = $S_1X = \frac{\lambda}{2}$;

λ = 0.164 m;

Comments

Well done with many students able to get the mark

5 (a)(iv)

S_1X = one wavelength = 0.082 m;
$v = f\lambda$ = 4100 x 0.082 = 336 m s^{-1} OR 340 m s^{-1};

Comments

Some students failed to identify the quantity of wavelength

5 (b)

During maxima, the resultant amplitude will the maximum vector sum of the amplitude of the 2 waves, while during minima,, the resultant amplitude will be the minimum vector sum of the two amplitude.
Thus in order to have the biggest contrast between these two vector sum, their amplitude have to be approximately the same.

Comments

Most students were able to see that with equal amplitude, there would be a complete destruction of waves during destructive interference but failed to explain the importance of it to be awarded the second mark.

6 (a)

Upward direction [B1]

Comments

A significant majority got it correct.

6 (b)(i)

For the negative particles to be undeviated,
Upward magnetic force = Downward electric force

$Bqv = qE$
$v = E / B$
$= (12 \times 10^3) / (930 \times 10^{-6})$ [M1]
$= 1.3 \times 10^7$ m s^{-1} [A1]

Comments

A significant majority got it correct. Most common error is to use concepts of circular motion which they had to assume that the negatively charged particle is an electron which is not mentioned till part (c).

6 (b)(ii)

Comments

Poorly done. Many are clueless how to attempt the question. Main error is to

When a negative particle enter the magnetic field, the magnetic force on the particle provides for the centripetal force for it to move in a circular arc with radius *r*. [B1]

assume that the negatively charge particle is an electron which is not mentioned till part (c) where students simply divide its charge over mass.

$Bqv = mv^2 / r$
$q / m = v / Br$
$= (1.3 \times 10^7) / (930 \times 10^{-6})(7.9 \times 10^{-2})$ [M1]
$= 1.8 \times 10^{11}$ C kg^{-1} [A1]

6 (c)

The difference between alpha particle (helium nucleus) and electron is that the magnitude of the charge of alpha particle is 2 times that of the electron while the polarity of the charge of alpha particle and electron is positive and negative respectively.

As such, the difference in the magnitude of the charge of alpha particle causes the magnitude of both magnetic force and electric force acting on it to both be increased by 2 times. [B1]

The positive charge of the alpha particle causes the direction of the magnetic force and electric force to be now acting downwards and upwards respectively. [B1]6

Despite the changes, the resultant force remains zero. Hence the alpha particle still remains undeviated in the cross fields. [B1]

Comments

Poorly attempted. Students need to realise that the difference in the charge affects both the magnitude and direction of the magnetic and electric force in the cross fields. Many focus either on the effect on one force or one aspect (magnitude or direction) of the forces. It is insufficient to justify the undeviated path by stating the velocity remained the same with the same cross fields. It is also important to note that while it is true that there is a difference in mass between the two charges, the effect of gravitational force is negligible in this scenario.

$F_G = 6.55 \times 10^{-26}$ N
$F_E = F_B = 3.84 \times 10^{-15}$ N.

7 (a)(i)

Energy released in a reaction

$= (4(1.007825) - (4.002603 + 2(0.000549))u\, c^2$

$= 0.027599uc^2$ [M1]

$= 0.028697(1.66\times10^{-27})(3 \times 10^8)^2$

$= 4.1233 \times 10^{-12}$ J

= 25.8 MeV [A1]

Comments

Not well done. While many could compute the mass defect correctly, care was not taken in the conversion of units from u to kg. Many also overlooked the conversion of mass to energy when they omitted the product of c^2 in the computation of energy released. A handful was also unable to distinguish the conversion of J to eV and MeV.

7 (a)(ii)

Let the energy emitted out by the sun per unit time be E,

$$1.35\times10^3 = \frac{E}{4\pi(1.5\times10^{11})^2}$$ [M1]

$E = 3.817 \times 10^{26}$

Rate at which a hydrogen is converted
$= 4\,[3.817 \times 10^{26} / 4.1233 \times 10^{-12}]$ [M1]
$= 3.70 \times 10^{38}$ [A1]

Comments

Poorly done. Many could not compute the rate of energy emission by the sun through the given intensity and distance from the source of emission. For those who were able to compute the rate of emission, many could not proceed to find the rate of hydrogen converted as they have failed to see the link in (i) and that for every reaction, 4 hydrogen nuclei are needed, hence the need to multiply 4 to the rate of reaction.

7 (b)

Energy released in a nuclear reaction is equal to the difference in binding energies between the products and the original reactants. [B1] From graph, the steeper slope of the binding energy curve for lighter nuclei indicates that the change in binding energy in fusion is larger , compared to that for fission reactions. [B1] **larger change in B.E per nucleon for the same change in nucleon number.**

Comments

Poorly attempted. Many tried to explain the difference in energy released for fusion and fission reactions without referring to the graph even though it was explicitly stated in the question. Some could correctly identify that the difference in energy released is due to the difference in the steepness of the gradient, but most stopped short of elaborating how that leads to the conclusion that larger amount of energy is released for fusion than fission.

8 (a)(i)

The expression of restoring force in the form of y = kx suggests that with constant mass and spring shows that acceleration of the block is directly proportional to its displacement from its equilibrium position with constant gradient and no y-intercept [B1]

The negative gradient shows that its acceleration is always in the opposite direction to the displacement of the block. [B1]

Hence the features of the equation shows that the conditions of simple harmonic motion is satisfied.

Comments

Many simply state the 2 conditions needed for SHM. They failed to explain how the expression provide evidence for the two required conditions. In addition, the expression is in terms of resultant force, thus there is a need to relate how the resultant force is directly proportional to acceleration in the case of a constant mass.

8 (a)(ii)1.

The constant amplitude of the oscillations suggests that the oscillations are undamped. [B1]

Comments

Mostly correct. Main error is stating constant displacement instead of amplitude.

8 (a)(ii)2.

$$\omega = \frac{2\pi}{T}$$

$$\omega = \frac{2\pi}{0.75} \qquad [C1]$$

$= 8.38$ rad s^{-1} [A1]

Comments

Significant majority got it correct. Some have difficulty reading off the correct period from the graph.

7 (a)(ii)3.

When KE = PE,

$$½m\omega^2\left(x_0{}^2 - x^2\right) = ½m\omega^2 x^2 \qquad [C1]$$

$$x_0{}^2 - x^2 = x^2$$

$$2x^2 = x_0{}^2$$

$$2x^2 = 0.020^2 \qquad [C1]$$

$x = 0.0141$ m [A1]

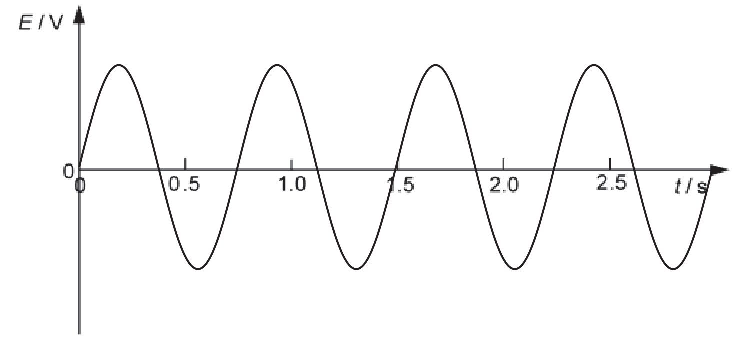
Comments

Poorly attempted. Many did not know how to link KE and PE together with displacement as part of the expression. Many wrongly thought that PE only consists of GPE in a vertical oscillating spring-mass system, without considering EPE.

7 (b)(i)

Comments

Poorly attempted. Many failed to draw link between the displacement-time



graph of the oscillation to the e.m.f.-time graph. This is clearly seen from b(ii). For those who manage to draw a sin or – sin graph, care is need to show constant period and amplitude. Some are poorly drawn.

Shape of e.m.f. graph: sin or – sin function *[B1]*
Period of e.m.f. graph remains as 0.75 s *[B1]*

7 (b)(ii)

When the magnet is placed near to the coil, its magnetic field is experienced by the coil. When it oscillates, the coil experienced a change of flux linkage, leading to an e.m.f. to be induced in it. According to Faraday's Law, this induced e.m.f. is proportional to the rate of change of magnetic flux linkage.
The velocity/speed of the magnet determines the rate of change of flux linkage [B1]. Since the motion of the magnet is simple harmonic, its velocity has a sinusoidal variation, the variation of the induced e.m.f. is also sinusoidal [B1]. Hence the induced e.m.f. is minimum when the magnet is at the amplitude positions (where velocity is zero) and maximum when the magnet is at the equilibrium positions (where velocity is at maximum) [B1].

Comments
Poorly attempted. Explanations for the shape of the curve were usually poor. Many did little more than give a statement of the laws of electromagnetic induction.
It is important to understand the shape of the graph requires the students to use Faraday's law to account for the **variation in the magnitude** of the e.m.f. Rarely was it made clear that the speed of the magnet determined the rate of change of flux linkage and hence the magnitude of the induced e.m.f. It is insufficient to either state that e.m.f. is induced (using Faraday's law) or account for the two polarities of the e.m.f. (using Lenz's law).

7 (c)(i)

As the magnet moves, flux Is cut by the coil, giving rise to induced e.m.f. in the coil [B1]. The induced e.m.f. gives rise to currents and heating of the coil [B1]. The thermal energy is derived from the oscillations of the magnet [B1]. Thus amplitude of the oscillation decreases. ***OR***
As the magnet moves, flux Is cut by the coil, giving rise to induced e.m.f. in the coil [B1]. The induced e.m.f. gives rise to currents which generate a magnetic field [B1]. The magnetic field opposes the motion of the magnet [B1]. Thus the amplitude of the oscillation decreases.

Comments
Poorly attempted. Similar to b(ii), many did little more than give a statement of the laws of electromagnetic induction. Another concern is that a significant no wrongly explain why the loss in the energy (instead of the oscillations of magnet in a solenoid connected to a **closed** circuit) lead to a decrease in amplitude in the first 10 oscillations.

7 (c)(ii)

$$TE = \tfrac{1}{2}m\omega^2 x_0^{\,2}$$

$$\frac{TE}{0.80TE} = \frac{\tfrac{1}{2}m\omega^2 x_0^{\,2}}{\tfrac{1}{2}m\omega^2 x_0^{\,\prime 2}} \quad [C1]$$

$$\frac{1}{0.80} = \frac{0.020^2}{x_0^{\,\prime 2}}$$

x_0 = 0.0179 m [A1]

Comments
Surprisingly, many do not know how to do this. Many wrongly thought that energy is directly proportional to amplitude instead of the correct relationship where the total energy is directly proportional to the square of the amplitude.

7 (c)(iii)

When the resistance of the resistor is reduced, the induced current flowing in the resistor increases with the same e.m.f. induced [B1], leading to a higher rate of heat dissipated in the resistor [B1]. The amplitude of oscillation after 10 complete oscillations is reduced.

Comments

Many understand that the reduction in resistance would lead to an increase in current. However, it is important to highlight that the e.m.f. remain unchanged. The link between the increase in current to the decrease in amplitude of oscillation is often not clearly explained.

8 (a)(i)

hf : Energy of a (one) photon of frequency f incident on the metal surface

Φ : Work function of the metal surface

E_k :Maximum kinetic energy of a (one) photoelectron emitted from the metal surface

[B2]: All three correct

[B1]: Two of three correct

Comments

Majority were able to get one mark. Many did not recognise that the kinetic energy of the photoelectron is the maximum possible.

A handful also wrongly identified the kinetic energy as that of the photon and work function energy is the minimum energy required to emit a photon from the metal surface.

8 (a)(ii)

Conservation of Energy

By conservation of energy, the maximum kinetic energy of a photoelectron is equal to the energy gained by absorbing a photon, less the work done for it to escape from the metal surface. [B1]

Comments

Majority got it right.

A small handful however quoted the photoelectric effect equation which implied a lack of understanding of the objective of the question.

8 (a)(iii)1.

$$\frac{hc}{\lambda} = \phi + eV_s$$

$$\frac{(6.63\times10^{-34})(3.0\times10^{8})}{(300\times10^{-9})(1.6\times10^{-19})} = 2.03 + V_s \text{ [M1]}$$

$$V_s = 2.11 \text{ V}$$

[A1]

Comments

Not very well done. Many could not convert the energy term from eV to J and vice versa which led to many computational errors. A small handful also did not realise that in the computation of energy of photon using the wavelength, the corresponding unit is Joules and not eV.

8 (a)(iii)2.

Power of beam, *P* = (0.500)(4.5 x 10^{-5}) = 2.25 x 10^{-5} W

Number of incident photons per unit time, n_p

$$n_p = \frac{P\lambda}{hc} \qquad \text{[M1]}$$

$$n_p = 3.39\times10^{13}\ \text{s}^{-1}$$

$$\text{Photoelectic Current I} = \frac{N_e e}{t}$$

$$= (5.70\times10^{-7} n_p)e \qquad \text{[M1]}$$

$$= (5.70\times10^{-7})(3.39\times10^{13})(1.6\times10^{-19})$$

$$= \qquad \text{A}$$

[A1]

Comments

A good number of students were able to get this right.

A handful of students mistook the rate of emission of photoelectrons as the current, failing to realise that current is the rate of flow of charges and not rate of emission of photoelectrons (charges).

8 (b)(i)

Comments

Electrons have a wave-like nature. [B1]

Majority got this right.

8 (b)(ii)

Kinetic energy of electron at wall, E_k = 600 eV = 9.6 x 10^{-17} J [M1]

Momentum of electron at wall, p

$$p^2 = 2mE_k$$

$$p = \sqrt{2(9.11\times10^{-31})(9.6\times10^{-17})} \text{ [M1]}$$

$$= 1.32\times10^{-23} \text{ N s}$$

[A0]

Comments

Majority got this right.

8 (b)(iii)

de Broglie wavelength λ of electron at wall

$$= \frac{h}{p}$$

$$= \frac{6.63\times10^{-34}}{1.32\times10^{-23}} \quad \text{[M1]}$$

$$= 5.01\times10^{-11} \text{ m}$$

$$d = \frac{\lambda D}{a}$$

$$= \frac{(5.01\times10^{-11})(0.240)}{272\times10^{-9}} \text{ [M1]}$$

$$= 4.42\times10^{-5} \text{ m}$$

[A1]

Comments

A significant number of students while being able to compute the de Broglie wavelength, were unable to obtain the correct answer as they substituted the wrong value of slit separation, *a* which suggests the lack of understanding of what each term in the equation represents.

8 (c)(i)

Energy levels X can attain ≤ 12.8 – 13.6 = – 0.80 eV

Hence highest energy level that can be attained is – 0.85 eV [M1]

Number of wavelengths = number of discrete transitions

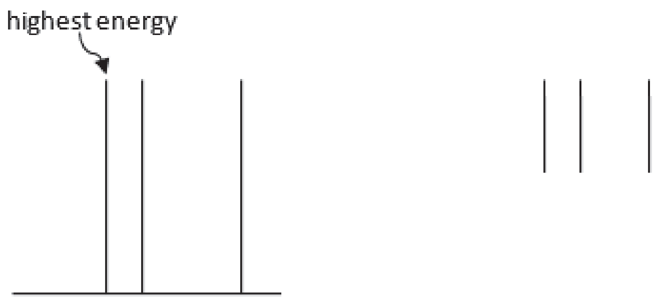
$= {}^4C_2$

= 6 [A1]

Comments

Very poorly attempted. Many did not know how to approach this question and did not recognise that the highest energy level must first be identified but the number of possible wavelengths could be computed.

8 (c)(ii)



- Correctly labels the highest energy line as the leftmost line
- 3 lowest and 3 highest wavelengths clustered as shown.
- Correct relative spacing between wavelengths within each cluster.

[B2] – All three shown

[B1] – Two of three shown

Note': ecf from (ii) can only be given if answer in (ii) is 10, corresponding to highest energy level attained is – 0.54 eV

Comments

Very poor attempted. Many did not label the "highest energy" even though it was stated in the question. Many displayed a lack of understanding of the concept behind transposing the energy level diagram to the spectral line diagram.

8 (c)(iii)

Energy of highest energy photon
= – 0.85 – (–13.6)
= 12.75 eV = 2.04 x 10^{-18} J [M1]

$$E = \frac{hc}{\lambda}$$

$$2.04 \times 10^{-18} = \frac{(6.63 \times 10^{-34})(3.0 \times 10^{8})}{\lambda}$$ [M0]

$\lambda = 97.5$ nm
[A1]

Comments

A good handful was able to get this right. Many did not recognise that the energy of the most energetic photon is 12.75 eV instead of 13.6 eV since the highest energy level is capped at -0.85 eV and not zero.

INNOVA JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATION
in preparation for General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/04

Paper 4 Practical

17 August 2017

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Shift
Laboratory

IMPORTANT

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

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

For Examiner's Use	
1	14
2	9
3	20
4	12
Penalty	
Total	**55**
Percentage	

This document consists of **18** printed pages and **1** blank page.

Suggested solution

Question 1 (14 marks)

1 (a) (i) L_1 = 28.0 cm, L_2 = 27.5 cm

L = 27.8 cm **A1**: (check for L stated to the **nearest mm with unit**.)
(check for L stated in the range of **26.0 cm ≤ L ≤ 30.0 cm**)

(ii) % uncertainty $= \frac{\Delta L}{L}$ x 100%

= (0.1 / 27.8) x 100%

= 0.36 %

A1: (check that **ΔL is 0.1 cm or 0.2 cm**)(**Not more than 0.2 cm)**
(check for **percentage uncertainty stated to 1 or 2 s.f.**)

(b) (i) w = 2.00 cm **A1**: (check for w stated to the **nearest 0.1 mm with unit**.)
(repeated reading required)
(check for w stated in the range of **15.0 mm ≤ w ≤ 25.0 mm**)

(ii)

$A = L\,w$

= (27.8)(2.00)

= 55.6 cm^2

A1: (check for A stated to the **least s.f. of raw values with unit**.)(**allow ecf**)

(d) No. of oscillations: 15

t_1 / s	t_2 / s	T / s
15.64	15.76	1.047

T = 1.047 s

A1 - (check for raw values of t stated to **2 d.p. and more than 10 s**)
A2 - (check for **repeated readings** of t)
A3 – (check for T **correctly calculated** and stated to **correct 4 s.f. with unit**)

(e) New L measurement

L_3 = 18.0 cm, L_4 = 18.0 cm
L = 18.0 cm

(**A1**: check for measurement for L stated to the **nearest mm with unit**, **smaller value from L in (b)**)

New corresponding value of T

No. of oscillations: 15

t_1 / s	t_2 / s	T / s	T^2 / s^2
12.94	12.66	0.8533	0.7282

(**A2**: value of **second T <** value of **first T**). (Repeated readings for t not assessed here)
(**A3**: check for **T^2 correctly calculated** and **stated to correct s.f. with unit**)

Using the first data set, L = 27.8 cm and T^2 = 1.096 s^2,
$k = T^2 / L$ = 1.096 / 27.8 = 0.0394 $s^2\ cm^{-1}$

Using the second data set, L = 18.0 cm and T^2 = 0.7282 s^2,
$k = T^2 / L$ = 0.7282 / 18.0 = 0.0405 s^2 cm^{-1}

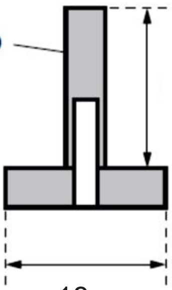
(**A4**: Correct **determination of constant of proportionality**)

Percentage difference = $\frac{0.0405-0.0394}{0.0394} \times 100\% = 2.8\ \%$

Since the percentage difference between the 2 proportionality constants is less than 10%, the suggestion of T^2 being proportional to L could be true.

(**A5**: **Drawing appropriate conclusion based on stated criterion of percentage difference** between the 2 constants of proportionality)

** Figure for second value of *L* (for reference only)



(f)

	1. Sources of error **(A1)**	**2.** Improvement **(A1)**	Do not credit
1	Two readings are not enough (to draw a conclusion)	Take more readings and plot a graph/calculate more *k* values (and compare)	
2	Card does not swing freely/ friction between pivot and card	Idea of using bushing or bearing.	
3	Difficult to judge end/start/a complete swing	Use of fiducial marker/pointer	Reaction time error/human reaction/difficult to know when to start/stop timer
4	Irregular/uneven/unusual swings/not in same vertical plane	Method of keeping shape aligned vertically in the same plane (elaborate)	
5	Oscillations die out quickly/ heavy damping	Use increased thickness of card / card that is more rigid	
6	Card is bent and will affect length measured	Use a more rigid card	

Question 2 (9 marks)

2(a)(ii) $m = 50$ g **[M1 = 1]** (check for m stated to **g or kg with unit**.)
(Accept to the nearest 0.5 g)
(check for value of m in **range 45 g ≤ m ≤ 55 g**)

2(b)(iii) $V = 5.270$ V **[M2 = 1]** (check for V stated to **nearest mV with unit**)

2(c) $\theta_1 = 28.0\ ^0$C (check for θ_1 stated to the **nearest 0.5 ^{0}C with unit**.)

2(d)(ii) $\theta_2 = 31.0\ ^0$C **[M3 = 1]** (check for θ_2 stated to the **nearest 0.5 ^{0}C with unit**.)
(2(c) and 2(d)(ii) to be correct before awarding M3 mark)
($\theta_2 > \theta_1$)

2(d)(iii) $(\theta_2 - \theta_1) = 3.0\ ^0$C **[M4 = 1]** (follow precision for θ_1 and θ_2 measurement)

2(e)
$$V^2 = \frac{mcR}{t}(\theta_2 - \theta_1)$$
$$c = \frac{V^2 t}{mR(\theta_2 - \theta_1)}$$
$$c = \frac{(5.270)^2(4 \times 60)}{(0.050)(10)(3.0)}$$
$c = 4400$ J kg^{-1} K^{-1} **[M5 = 1]** (check for c stated correctly calculated to **4200 +/- 1000** with correct sf (**accept 1 more**)
[M6 = 1] (correct unit)

2(f) possible modifications are:

- Use heater with fins. This will increase the surface area of the heater in contact with water and hence improve the rate of heat transfer. **[M7 = 1]**
- Use a coiled heater with high number of turns. Similarly, there will be a larger surface area of the heater in contact with water. **[M8 = 1]**
- Increase the number of heater connected in parallel with the same power supply. This will decrease the effective resistance and increase the output power which in turn increase the rate of heat transfer. **[M9 = 1]**
- **Or any other acceptable method eg. (change material to one of lower specific heat capacity, colour the material black, using a cylindrical or spherical shaped heater)**

Note: Changes made to cover the beaker/ position of the heater are not acceptable as it does not change the design of the heater.

Question 3 (20 marks)

3(a)(i) d_1 = 0.25 mm, d_2 = 0.25 mm
d = 0.25 mm **[M1 = 1]** (check for d stated to the **nearest 0.01 mm with unit**.)
(repeated readings needed)
(check for value of d in **range 0.15 mm ≤ d ≤ 0.44 mm**)

3(a)(ii) $A = \frac{\pi d^2}{4}$

$A = \frac{\pi (0.25 \text{ x } 10^{-3})^2}{4}$

$= 4.9 \text{ x } 10^{-8} \text{ m}^2$ **[A1 = 1]** (check for A stated to the **correct sf of d with unit**)

3(b)(v) l = 0.300 m **[M2 = 1]** (check for l stated to the **nearest mm with unit**.)
(check for value of l in **range 0.100 m ≤ l ≤ 1.000 m**)
V = 0.804 V (check for V stated to the **nearest mV with unit**.)
(check for value of V in **range 0.500 V ≤ V ≤ 1.500 V**)

3(b)(vi) I = 48.6 mA **[M3 = 1]** (check for I stated to the **nearest 0.1 mA with unit**.)

3(c)(iv) l = 0.400 m **[no marks]**

V = 0.727 V

3(d)

l / m	V / V	$\frac{V}{l}$ / V m^{-1}	$\frac{1}{l}$ / m^{-1}
0.300	0.804	2.68	3.33
0.400	0.727	1.82	2.50
0.500	0.653	1.31	2.00
0.600	0.576	0.960	1.67
0.800	0.433	0.541	1.25
0.900	0.363	0.403	1.11

Table: (7 marks)

P1 - (Check for **correct column headers**)

M4 [2] - (Check for **minimum 6 sets** of data)

- Award **2 marks** if student has successfully collected **6 or more sets** of data (l, V) without assistance/intervention.
- Award **1 mark** if student has successfully collected **5 sets** of data (l, V) without assistance/intervention.
- Award **zero marks** if student has successfully collected **4 or fewer sets** of data (l, V) without assistance/intervention.
- **Deduct 1 mark** if student requires **some assistance/intervention** but has been able to do most of the work independently. Indicate the nature of any assistance.

• **Deduct 2 marks** if student has been unable to collect data without **substantial assistance/intervention.**

Minimum mark for M4 = 0

P2 - (Check for correct precision for raw data *l* and *V*) – **nearest mm and nearest mV respectively**

P3 - (Check for range of *l*: **$\Delta l \geq 60$ cm**)

P4 - (Check for correct precision for calculated values of $\frac{V}{l}$ and $\frac{1}{l}$ (**least sf between *V* & *l*** and **sf of *l* respectively or one more**).

A2 - (Check for correctly calculated values of all calculated quantities. **Allow one slip**)

3(e) Linearize into - [$\frac{V}{l} = M\left(\frac{1}{l}\right) - N$]

Plot a graph of $\frac{V}{l}$ against $\left(\frac{1}{l}\right)$ with an expected gradient of *M* and a vertical intercept of - *N*.

A3 - (Check for **correct linearizing statement**)

3(e) Using points (1.00, 0.275) and (3.50, 2.850)

gradient = $(y_2 – y_1) / (x_2 – x_1)$
= [(2.850) – (0.275)] / [(3.50) – (1.00)]
= 1.03

M = 1.03 V (3 sf)

Substitute gradient and point (1.00, 0.275) into equation,

0.275 = 1.03(1.00) + *vertical intercept*
Vertical intercept = - 0.755

- *N* = - 0.755
N = 0.755 V m^{-1} (3 sf)

A4 - (Check for **gradient triangle size greater than half the line drawn**. **Read-offs** must be **accurate to half a small square**. Gradient correctly calculated, **$\Delta y / \Delta x$ and not $\Delta x / \Delta y$**)

A5 - (Check for **vertical intercept correctly read off to the nearest half small square OR calculated with a point on the line**)

A6 - (*M* = gradient calculated to **3 sf with correct units**)
(*N* = - intercept calculated to **3 sf with correct units**)

Graph: (3 marks)

P5 - (Check for **correct choice of scale and correct axis labels. Awkward scales not allowed**)(Only allow 1:1, 1:2, 1:2.5, 1:4, 1:5 and 1:10)

P6 - (**All observations** must be **plotted**. Check for **plotting accuracy to half a small square**. Check **points 2, 4 and 6** with increasing x-axis values)

P7 - (Check for good choice of **best fit line**)

3(f) Most data points fall close to the best fit line and are randomly and equally distributed about the best fit line drawn. Hence, there are no anomalous points.
M4 - (Check for **correct comment**)(**Closeness to BFL** and **scatter** commented)
(Comment **must commensurate with the students plotted graph**)

3(g) $\rho = \frac{NA}{I}$

$$\rho = \frac{(0.755)(4.9 \times 10^{-8})}{48.6 \times 10^{-3}}$$

$\rho = 7.6 \times 10^{-7}\ \Omega\ \text{m}$

A7 - (Check for value of **ρ correctly calculated to the correct least sf of N, A and I**)
(Check for **ρ: $2.0 \times 10^{-7} <= \rho <= 20.0 \times 10^{-7}\ \Omega$ m consistent with units**)

(Total: 20 marks)

Question 4 (12 marks)

4

Diagram (1 × D1)

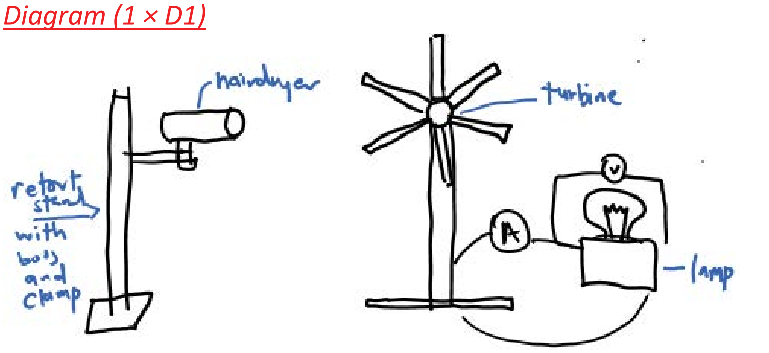


Diagram should show:

1. the method to produce the air flow (e.g. fan, hair dryer, etc)
2. the method to determine the power of the lamp connected to turbine in closed circuit (e.g. ammeter and voltmeter)

Comments

In general, students need to be specific in their statements. More elaboration is given in the comments below.

Many are penalized when they did not show how the turbine is connected to lamp in series. There should not be any other electrical devices such as e.m.f. or resistor as these would affect the power of the lamp.

Procedure

(a) Set up the apparatus as shown above.

(b) Switch on the fan or hairdryer and close the switch of the circuit with the lamp.

Procedure and Measurement marks (1 × P1, 2 × M1)

(c) Measure the angle ϑ between the direction of the wind from the fan or hairdryer and the normal of the turbine using a protractor. [M1]

(d) Measure the current I through the lamp and the potential difference V across the lamp using an ammeter and voltmeter respectively. [M1]

(e) Repeat step (c) & (d) to obtain additional 6 sets of current and potential difference with different angles by rotating the turbine. [P1]

Students should identify the variable, the object and the instrument needed.

The power of the lamp should be measured directly rather than using LDR.

Students need to be specific in stating how the angle between the wind and the normal of the turbine can be varied.

Analysis marks (3 × A1)

(f) The power of the lamp is determined by $P = IV$ [A1]

(g) Plot a graph of P against $\cos\vartheta$ where k is the gradient of the best fitted line. [A1]

(h) The relationship is valid if the plotted points follows a straight line trend through the origin (y-intercept = 0) [A1]

Students should identify the symbol used in the determination of power of lamp.

The validity of the relationship is often missing. For those who try to answer this, they need to understand that this relationship is unique where the linearized trend is expected to pass through the origin since the y-intercept of the linearized equation is zero.

Control marks (2 × C1)

(i) Ensure that the speed of the wind/fan is the same (by applying the power or voltage of the fan the same or by monitoring it with an anemometer)

(j) Ensure that the distance between the fan/hairdryer and the turbine is the same (by measuring it with a metre rule before each reading).

(k) Ensure that the direction of the wind is the same (by using a wind vane)

The control variables identified should be focused on those that can affect the input power provided by the wind and the angle between the wind and normal of the turbine. Changes to the resistance of the lamp does not affect the power of the lamp since the current through lamp would react inversely.

Safety (1 × S1): moving turbine and hot lamp

- Do not touch the turbine blades when it is moving
- Do not touch the hot lamp when it is operating for a period of time.

It is important to highlight that the lamp would be only dangerously hot to touch when it is switched on for a period of time. The brightness of the lamp is usually not harmful to eyes.

Reliability (2 × R1)

To fix control variables

- As stated above

To measure independent variable accurately and precisely

- Measure the direction of the wind accurately using a wind wave.

To measure dependent variable accurately and precisely

- Ensure that there is no other wind sources by doing the experiment in an enclosed room.
- The speed of the wind should be large so that the power of the lamp can be measurable.
- The turbine should have low friction so that there is minimal loss of power during the transfer of power between the turbine and the lamp.
- The readings should be taken only when the wind and/or meter readings have stabilized.

Students need to focus on the key ideas on how to

1. fix the control variables
2. measure independent variable
3. measure dependent variable

in given context.

END OF PAPER