BP~727

Class

Adm No

Candidate Name: ____________________

millennia institute

2022 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749/1**

Paper 1 Multiple Choice **20 September**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and admission number on the Answer Sheet in the spaces provided.

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 OMR 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 working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **15** printed pages and **1** blank page.

Data

speed of light in free space	c	$= 3.00 \cdot 10^{8}$ m s^{-1}
permeability of free space	μ_0	$= 4\pi \cdot 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	$= 8.85 \cdot 10^{-12}$ F m^{-1} $= (1/(36\pi)) \cdot 10^{-9}$ F m^{-1}
elementary charge	e	$= 1.60 \cdot 10^{-19}$ C
the Planck constant	h	$= 6.63 \cdot 10^{-34}$ J s
unified atomic mass constant	u	$= 1.66 \cdot 10^{-27}$ kg
rest mass of electron	m_e	$= 9.11 \cdot 10^{-31}$ kg
rest mass of proton	m_p	$= 1.67 \cdot 10^{-27}$ kg
molar gas constant	R	$= 8.31$ J K^{-1}mol^{-1}
the Avogadro constant	N_A	$= 6.02 \cdot 10^{23}$mol^{-1}
the Boltzmann constant	k	$= 1.38 \cdot 10^{-23}$ J K^{-1}
gravitational constant	G	$= 6.67 \cdot 10^{-11}$ 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	$p = \rho g h$
gravitational potential	$\varphi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$
	$v = \pm\omega\sqrt{(x_0^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$
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,	$\lambda = \frac{\ln 2}{t_{1/2}}$

[Turn over

1 A mass is dropped from rest and falls through a distance of 2.0 m in a vacuum. An observer records the time taken for the mass to fall through this distance using a manually operated stopwatch and repeats the measurements a further two times. The average result of these measured times, displayed in the table below, is used to determine a value for the acceleration of free fall. This is calculated to be 9.8 m s^{-2}.

	first measurement	second measurement	third measurement	average
time / s	0.6	0.73	0.59	0.64

Which of the following statement best relate to the experiment?

A The measurements are precise and accurate with no evidence of random errors.

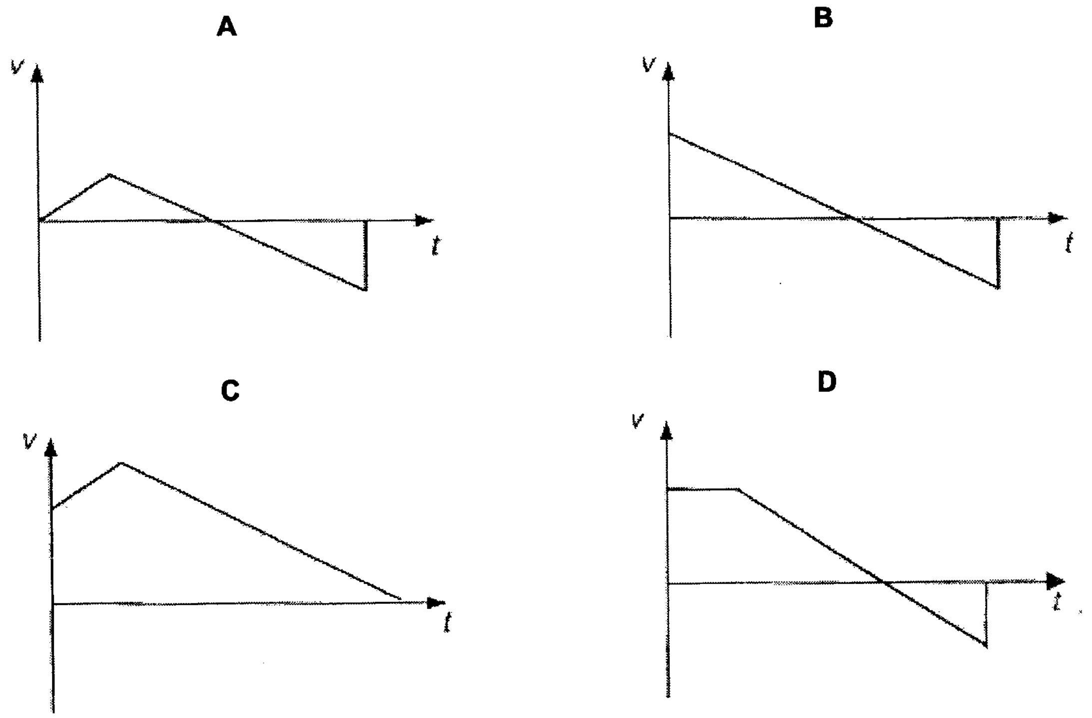
B The range of results shows that there are no random errors made but the calculated value for acceleration of free fall is accurate, so the experiment was successful.

C The measurements are not always recorded to the degree of precision of the measuring device but the calculated value for acceleration of free fall is accurate. Systematic errors may be present.

D The measurements are not always recorded to the degree of precision of the measuring device but the calculated value for acceleration of free fall is accurate. Random errors may be present.

2 A toy rocket, initially at rest, is launched vertically from Earth with constant acceleration. After some time, the fuel is used up and the toy rocket falls freely back to Earth.

Which of the following velocity-time graphs best represents the journey? Neglect air resistance.



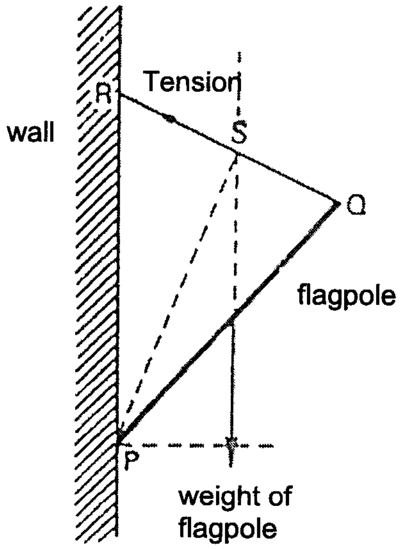
3 A mug slides across a frictionless bar counter with constant velocity u. It tips over the edge and falls to the ground in projectile motion.

Which of the following expressions represents the horizontal distance from the base of the bar counter if the mug hits the ground with vertical velocity component v?

A $\frac{uv}{g}$ **B** $\frac{u^2}{g}$ **C** $\frac{v^2}{g}$ **D** $\frac{uv}{2g}$

4 A flagpole pivoted to a wall at point P, is linked to the wall at point R with an inextensible cable.

What is the direction of the force exerted by the wall on the flagpole?



A from P to Q

B from P to S

C from P to X

D from Q to P

5 Two smooth blocks of masses 0.2 kg and 1.0 kg, are connected by a light, inextensible string running over a smooth pulley. One block is placed on a smooth table and the other hangs over the table via the string and pulley. Two possible cases are shown in Fig. A and Fig. B below.

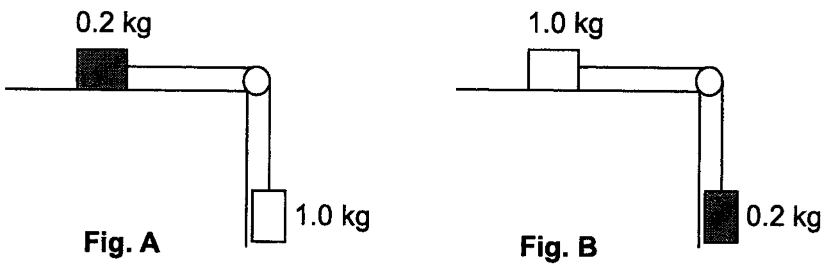


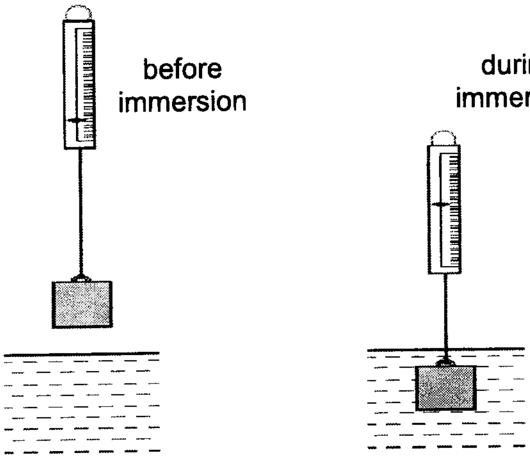
Fig. A **Fig. B**

If the blocks in both Fig. A and Fig. B are released from rest, what is the ratio of the acceleration of the blocks in Fig. A to that in Fig. B?

[Turn over

A 10:1 B 6:1 C 5:1 D 1:1

6 The diagrams show a metal cube suspended from a spring balance before and during immersion in water. A reduction in the balance reading occurs due to the immersion.



Which of the following statements is correct?

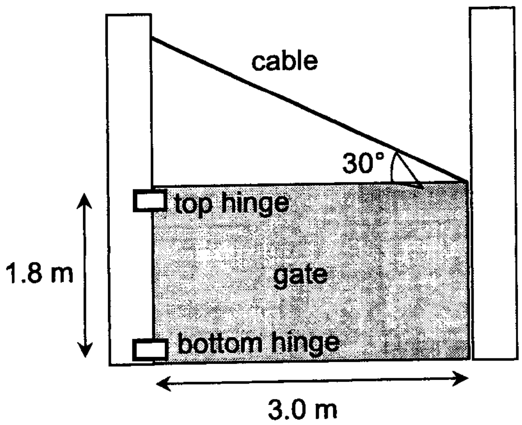
A The gravitational pull on the cube is unchanged by the immersion.

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

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

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

7 A uniform farm gate is 3.0 m wide and 1.8 m high, with hinges attached to the top and bottom of the gate. A cable makes an angle of 30° with the top right corner of the gate and has a tension of 200 N. The mass of the gate is 40 kg.



What is the magnitude and direction of the horizontal force exerted by the top hinge on the gate?

A 13 N to the left

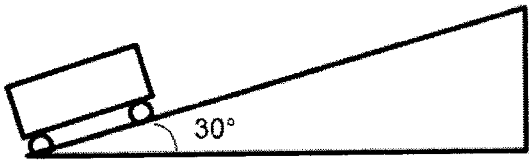
B 13 N to the right

C 160 N to the left

D 160 N to the right

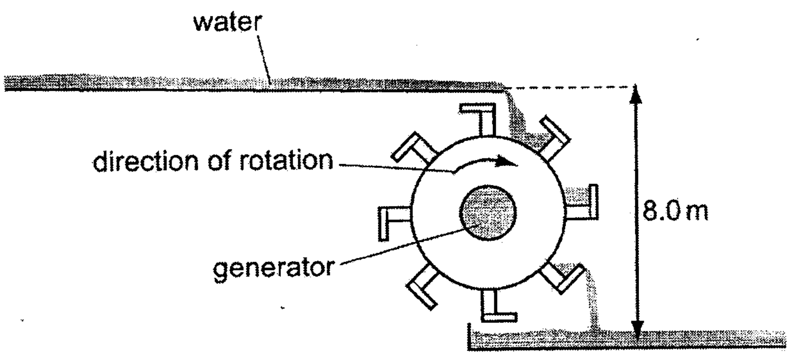
8 For a toy car of mass 500 g to overcome the frictional forces on a horizontal rough surface and move at a constant speed of 0.10 m s^{-1}, it requires an output power of 1.0 W. The resistive forces are assumed to be constant at all speeds.

What is the total output power developed by the car as it moves up the same rough surface, now banked at an angle of 30° with the constant speed 0.20 m s^{-1}?



A 2.0 W **B** 2.5 W **C** 2.8 W **D** 3.0 W

9 The diagram shows the design of a water wheel which drives a generator to produce electrical energy. The flow rate of water is 200 kg s^{-1}. The generator supplies a current of 32 A at a voltage of 230 V.

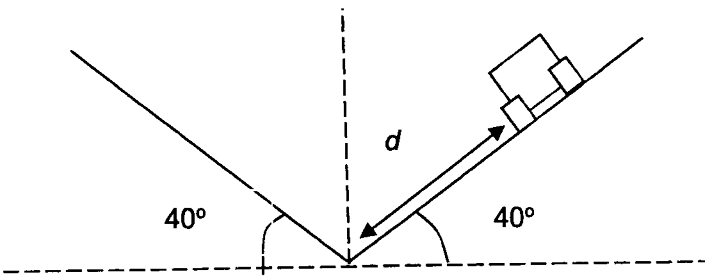


Ignoring any changes in the kinetic energy of the water, what is the efficiency of the system?

A 5 % **B** 14 % **C** 22 % **D** 47 %

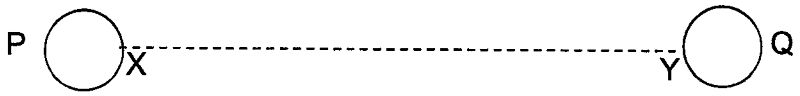
10 The diagram shows the cross-section of a racetrack that has the shape of an inverted cone. On this surface the cars race in circles that are parallel to the ground.

At a speed of 34 m s^{-1}, what should the value of the distance *d* be if the driver wishes to stay on a circular path without depending on friction?

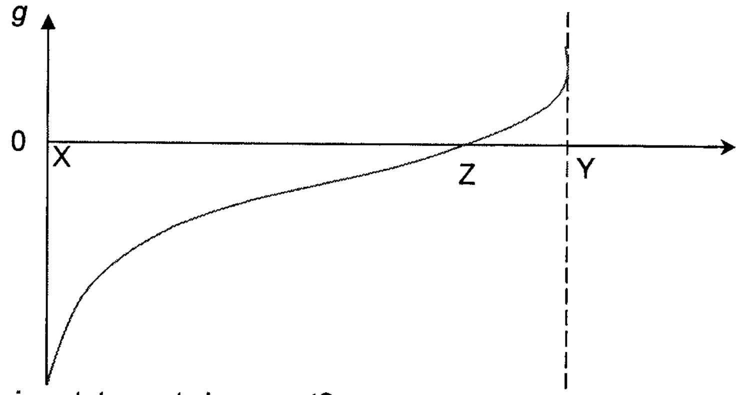


A 95 m **B** 183 m **C** 230 m **D** 304 m

11 The diagram below shows the relative positions of two massive bodies, P and Q. The sizes of P and Q are not drawn to scale.



The line XY joins the surface of P to the surface of Q and the graph below represents the variation of gravitational field strength g along the line XY.



Which of the following statements is correct?

A The gravitational potential is zero at point Z.

B The mass of Q is greater than the mass of P.

C The gravitational field strength due to P is repulsive but that due to Q is attractive.

D The magnitude of gravitational force on a test mass due to P is equal to that due to Q at point Z.

12 A satellite travels just above the Moon's surface in a circular orbit. The acceleration at the Moon's surface due to gravity is $\frac{g}{6}$ and the Moon's radius is $\frac{R}{4}$, where g is the acceleration at the Earth's surface due to gravity and R is the radius of the Earth.

If a satellite, travelling just above the Earth's surface has a period T, what is the period of the Moon's satellite?

A $\frac{2T}{3}$ **B** $\sqrt{\frac{2}{3}}T$ **C** $\left(\frac{2}{3}\right)^2 T$ **D** $\sqrt{\frac{3}{2}}T$

13 A small bubble of air of volume 1.00 cm^3 rises to the surface from the bottom of a lake. The temperature of lake at the bottom of the lake is found to be 15.0 °C.

With the volume of air bubble, atmospheric pressure and temperature at the water surface as 5.00 cm^3, 1.00 x 10^5 Pa and 30.0 °C respectively, what is the change of pressure exerted on the bubble as it rises from the bottom of lake to surface? Assume that air in bubble behave as an ideal gas.

A 250 kPa **B** 375 kPa **C** 475 kPa **D** 526 kPa

[Turn over

14 Iron has a specific heat capacity that is about four times that of gold. A cube of gold and a cube of iron, both of equal mass and at 20 °C, are placed in two different styrofoam cups, each filled with 100 g of water at 40 °C. Assume that the styrofoam cups have negligible heat capacities and that no heat is lost to the environment.

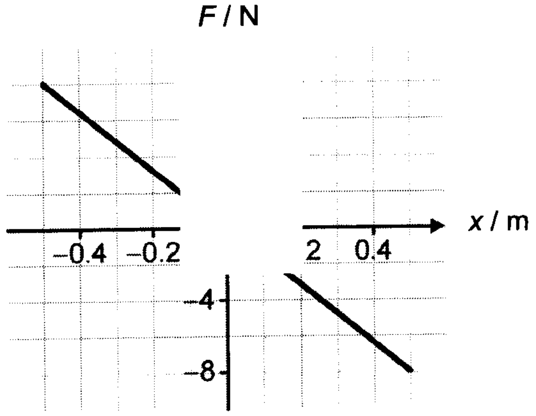
After thermal equilibrium has been attained, which of the following statements is correct?

- **A** The temperature of the gold is lower than that of the iron.
- **B** The temperature of the gold is higher than that of the iron.
- **C** The temperatures of the water in the two cups are the same.
- **D** There is insufficient information provided for comparison of the final temperatures of gold and iron.

15 Which of the following statements is incorrect?

- **A** The internal energy of an ideal gas depends only on its kinetic energy.
- **B** When an ideal gas undergoes an isothermal change, there is no change in internal energy.
- **C** When an ideal gas undergoes an adiabatic compression, there is work done on the system.
- **D** The First Law of Thermodynamics states that the change in internal energy of a system is the sum of heat supplied to the system and the work done on the system.

16 A mass of 2.0 kg is executing simple harmonic motion. The net force F acting on the mass varies with displacement x as shown. What is the maximum speed of the mass?



A 1.0 m s^{-1} **B** 1.3 m s^{-1} **C** 1.4 m s^{-1} **D** 2.0 m s^{-1}

17 A small source of sound transmits energy equally in all directions. The intensity of the sound 3.0 m away from the source is 0.18 W m^{-2}.

If the power of the source is tripled, what is the intensity of the sound at a distance 4.5 m away from the source?

A 0.090 W m^{-2} **B** 0.14 W m^{-2} **C** 0.18 W m^{-2} **D** 0.24 W m^{-2}

18 Which of the following statements is true for a stationary sound wave?

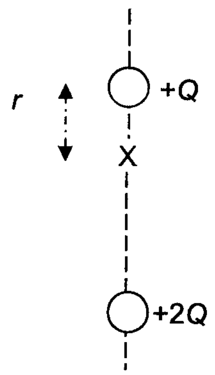
- **A** The pressure at a displacement node is always very high.
- **B** The pressure at a displacement antinode is always very high.
- **C** The pressure at a displacement node fluctuates from high to low.
- **D** A stationary wave can be formed by two waves with the same amplitude and frequency, travelling with the same velocity towards a point.

19 A narrow beam of monochromic light falls at normal incidence on a diffraction grating. Third order diffracted beams are formed at an angle of 45° to the original direction.

What is the highest order of diffracted beam produced by this grating?

A 3rd order **B** 4th order **C** 5th order **D** 6th order

20 Two point charges of +Q and +2Q are lined up along a vertical straight line as shown below. The distance between them is *r*.

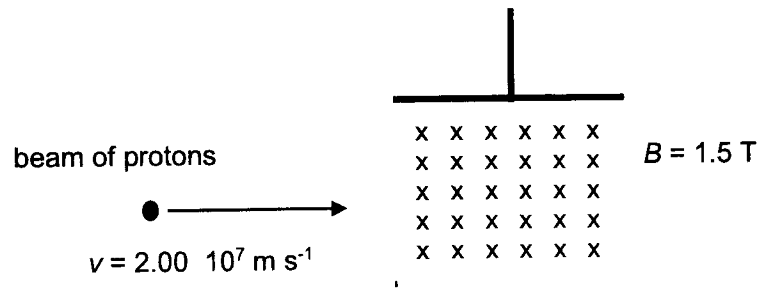


Which set of values correctly gives the electric field strength and the electric potential at point X, a distance $\frac{1}{3}r$ from the +Q charge?

	electric potential	electric field strength
A	$\frac{3Q}{2\pi\varepsilon_0 r}$	$\frac{9Q}{8\pi\varepsilon_0 r^2}$ downwards
B	$\frac{3Q}{2\pi\varepsilon_0 r}$	$\frac{9Q}{8\pi\varepsilon_0 r^2}$ upwards
C	$\frac{3Q}{8\pi\varepsilon_0 r}$	$\frac{9Q}{8\pi\varepsilon_0 r^2}$ upwards
D	$\frac{3Q}{8\pi\varepsilon_0 r}$	$\frac{9Q}{4\pi\varepsilon_0 r^2}$ downwards

[Turn over

21 A beam of protons passes through a velocity selector. The magnetic flux density, B is 1.5 T and directed into the plane of paper.



If protons travelling at 2.00 x 10^7 m s^{-1} pass through the velocity selector undeflected, what is the direction and magnitude of the electric field applied?

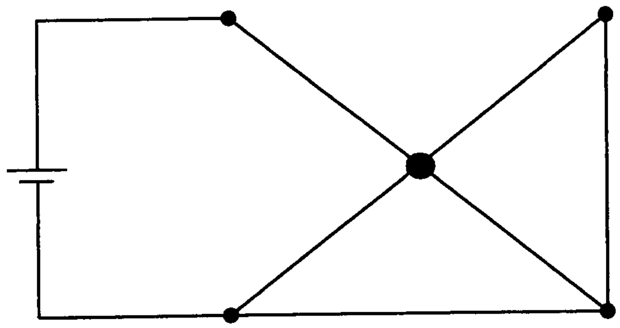
	direction	magnitude
A	Towards upper plate	6.00 x 10^5 N C^{-1}
B	Towards lower plate	6.00 x 10^5 N C^{-1}
C	Towards upper plate	3.00 x 10^7 N C^{-1}
D	Towards lower plate	3.00 x 10^7 N C^{-1}

22 A battery is connected in series with a resistor R. The battery moves 2000 C of charge completely round the circuit. During this process, 2500 J of energy is dissipated in the resistor R and 1500 J of energy is expended in the battery.

What is the e.m.f. of the battery?

A 2.00 V **B** 1.25 V **C** 0.75 V **D** 0.50 V

23 A cell of e.m.f. 12.0 V with negligible internal resistance is connected to 4 resistors.



10.0 Ω
4.0 Ω

6.0 Ω

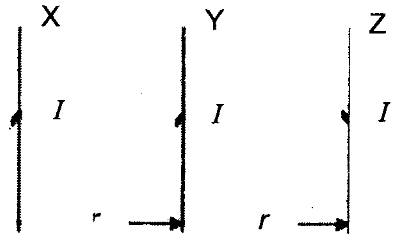
2.0 Ω

12.0 V

What is the current flowing through the 10.0 Ω resistor?

A 0.59 A **B** 1.0 A **C** 5.3 A **D** 11 A

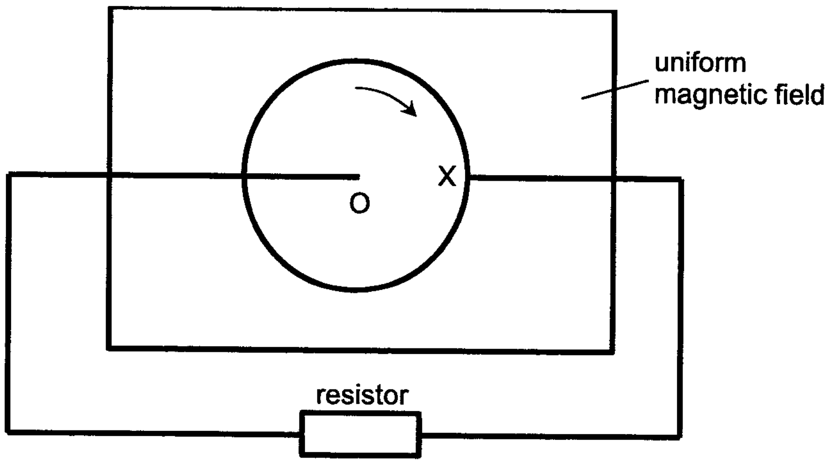
24 The diagram shows three parallel wires X, Y and Z carrying current I of equal magnitudes in the directions shown. The wires are placed at equal distance apart.



Which of the following best descri… force … Y?

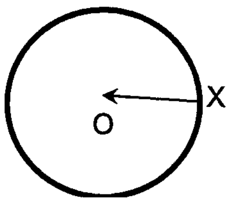
A zero **B** towa… …ɔwarc **D** along Y

25 A copper disc is rotated clockwise … ınstant s… in a region where there is a uniform magnetic field perpendicular to the surface of the disc as shown below. The direction of the magnetic field is into the paper. A circuit consisting of a resistor is connected to the disc at its center O and its rim at X.

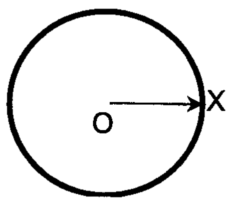


Which of the following diagrams shows a possible direction of the induced current?

A



B

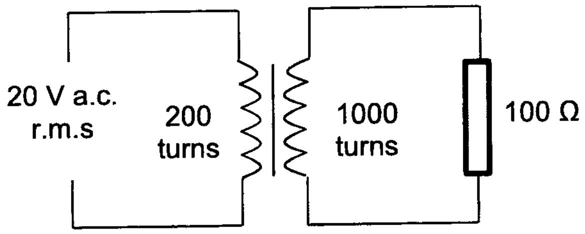


C

D

[Turn over

26 The primary coil of an ideal transformer has 200 turns and is connected to a power supply of 20 V root-mean-square. The secondary coil has 1000 turns and is connected to a resistor of resistance 100 Ω.



What is the peak primary current?

A 1.0 A

B 1.4 A

C 5.0 A

D 7.1 A

27 Which of the following statements is a correct statement of an observation of the photo-electric effect?

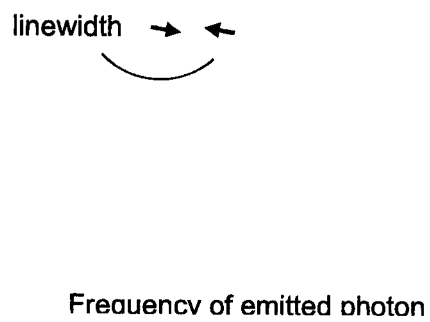
A The higher the work function of the metal, the higher the kinetic energy of an emitted electron.

B The stopping potential is the amount of energy required to stop the most energetic electron.

C It takes place instantaneously as a single photon transfers all its energy to an electron.

D It cannot take place unless the intensity of the radiation is above a threshold value.

28 A laser-spectroscopy obtained an emission spectrum for hydrogen, part of which is shown in the figure below.



The emission lines represent electronic transitions between discrete energy levels. They are not perfectly sharp, but instead display finite linewidths as shown.

Which of the following best accounts for this phenomenon?

A photoelectric effect

B energy-time uncertainty principle

C wave-particle duality of photons

D position-momentum uncertainty principle

29 Which of the following statements is true of both β-particles and X-rays?

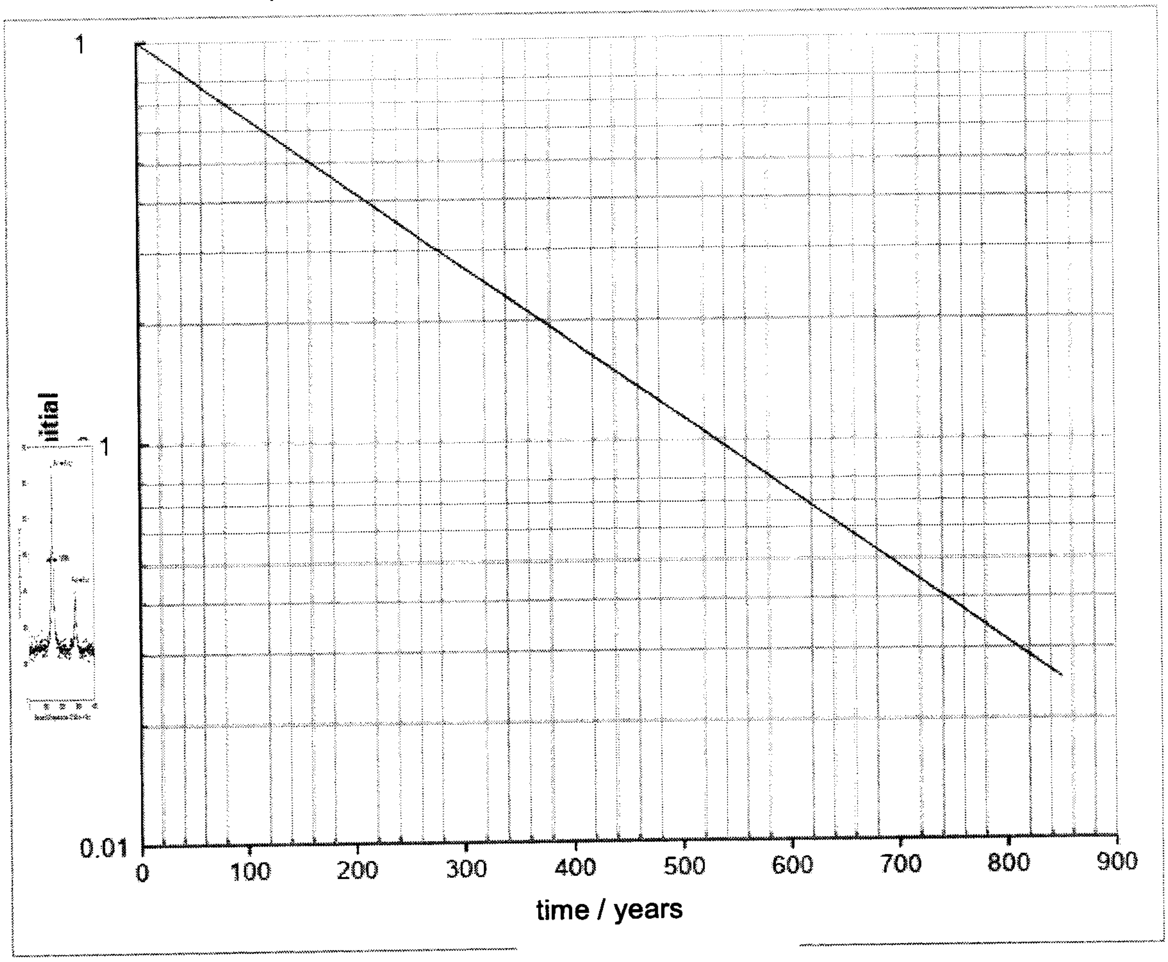
A They can be deflected by electric fields.

B They are used industrially for the scanning of cargo trucks.

C They cause ionisations of the air when they pass through it.

D They can be detected after passing through a few millimeters of aluminum.

30 A radioactive source has activity, A, and initial activity A_o. A graph of $\frac{A}{A_o}$ against time for this radioactive source is plotted on a logarithmic scale as shown below.



What is the half-life of the radioactive sou

A 0.0017 years

B 160 years

C 280 years

D 420 years

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Class	Adm No

Candidate Name: ______________________________

H

millennia institute

2022 Preliminary Examinations
Pre-University 3

H2 PHYSICS **9749/02**

Paper 2 Structured Questions **15 September**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and Adm number in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

Answer **all** questions.

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

For Examiner's Use		
1		**/ 10**
2		**/ 12**
3		**/ 9**
4		**/ 11**
5		**/ 10**
6		**/ 8**
7		**/ 20**
Significant figures		
Total		**/ 80**

This document consists of **24** printed pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^2\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

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

1 **(a)** State the conditions for a rigid body to be in static equilibrium.

....

....

.... [2]

(b) A uniform rigid rod of mass 30 kg is attached to a vertical wall by a hinge as shown in Fig. 1.1. The other end of the rod is held to the ceiling by a cable.

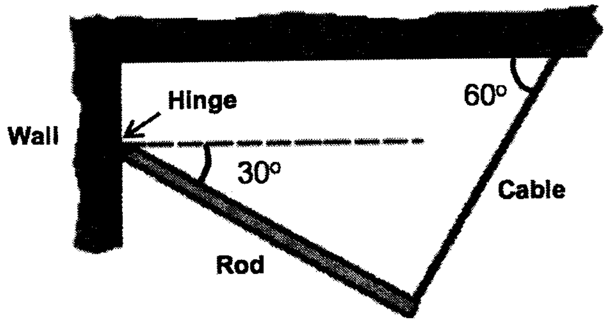


Fig. 1.1

(i) Draw the forces acting on the rod in Fig. 1.1. Label all the forces clearly. [2]

(ii) Show that the tension *T* in the cable is 127 N.

[2]

(iii) Determine the magnitude and direction of the force acting on the rod by the hinge.

force = ... N [2]

direction = ... [2]

[Total: 10]

[Turn over

2 (a) A student clamps one end of a flexible plastic ruler against the laboratory bench and sets it into simple harmonic oscillation. The end of the ruler moves a distance of 8.0 cm as shown in Fig. 2.1 and makes 28 complete oscillations in 10 s.

Fig. 2.1

(i) Calculate the angular frequency ω of the oscillations of the ruler.

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

(ii) Sketch a graph of velocity v against displacement x for the motion at the tip of the ruler on Fig. 2.2.

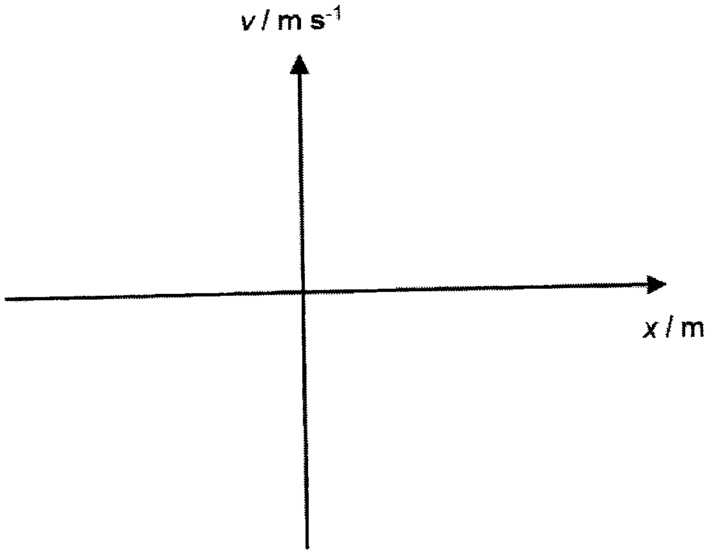


Fig. 2.2

[2]

(iii) Fig. 2.3 shows the variation with time t of the displacement x for the oscillations.

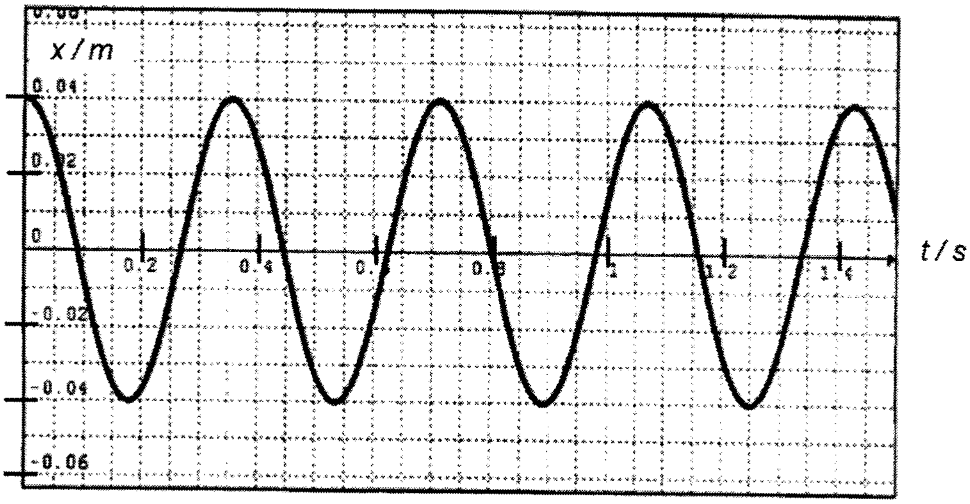


Fig. 2.3

Write down the equation for the displacement x in terms of the time t for these oscillations.

.... [2]

(iv) The end of the ruler is attached with a piece of card of large surface area and the experiment is then repeated. Sketch a graph on Fig. 2.3 to show the effect of this change on the variation with t of the displacement of the ruler. [2]

(b) When a mass m attached to a spring of force constant k is set into oscillation, the period T of oscillations of the mass is given by

$$T=2\pi\sqrt{\frac{m}{k}}.$$

A mass of 0.20 kg is connected to a light, horizontal spring of force constant 6.0 N m^{-1}. The mass, which is free to oscillate on a frictionless surface, is then displaced 5.0 cm from its equilibrium position and released from rest as shown in Fig. 2.4.

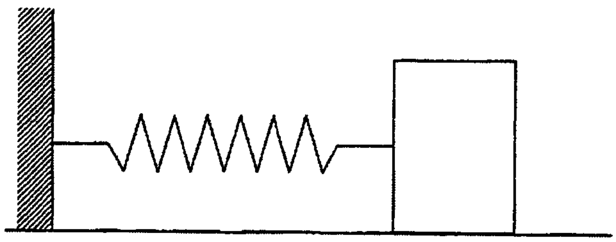


Fig. 2.4

[Turn over

(i) Calculate the period of oscillation of the mass.

period = ... s [1]

(ii) Calculate the maximum speed of the mass.

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

(iii) Determine the total energy of this spring-mass system.

total energy = ... J [2]

[Total: 12]

3 Two charged metal spheres A and B are isolated in space, as shown in Fig. 3.1.

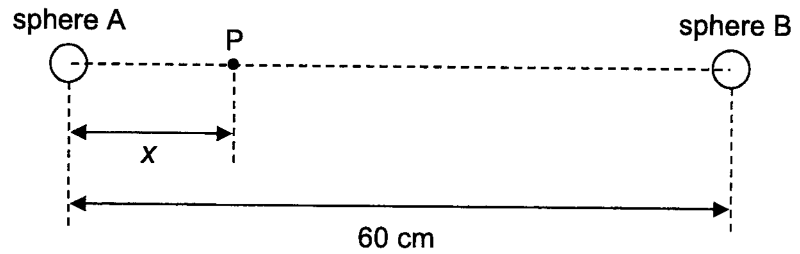


Fig. 3.1

The centres of the spheres are separated by a distance of 60 cm. Point P is at a distance x from the centre of sphere A along the line joining the centres of the two spheres.
The variation with x of the electric potential V at P is shown in Fig. 3.2. The potential at x = 15 cm is zero.

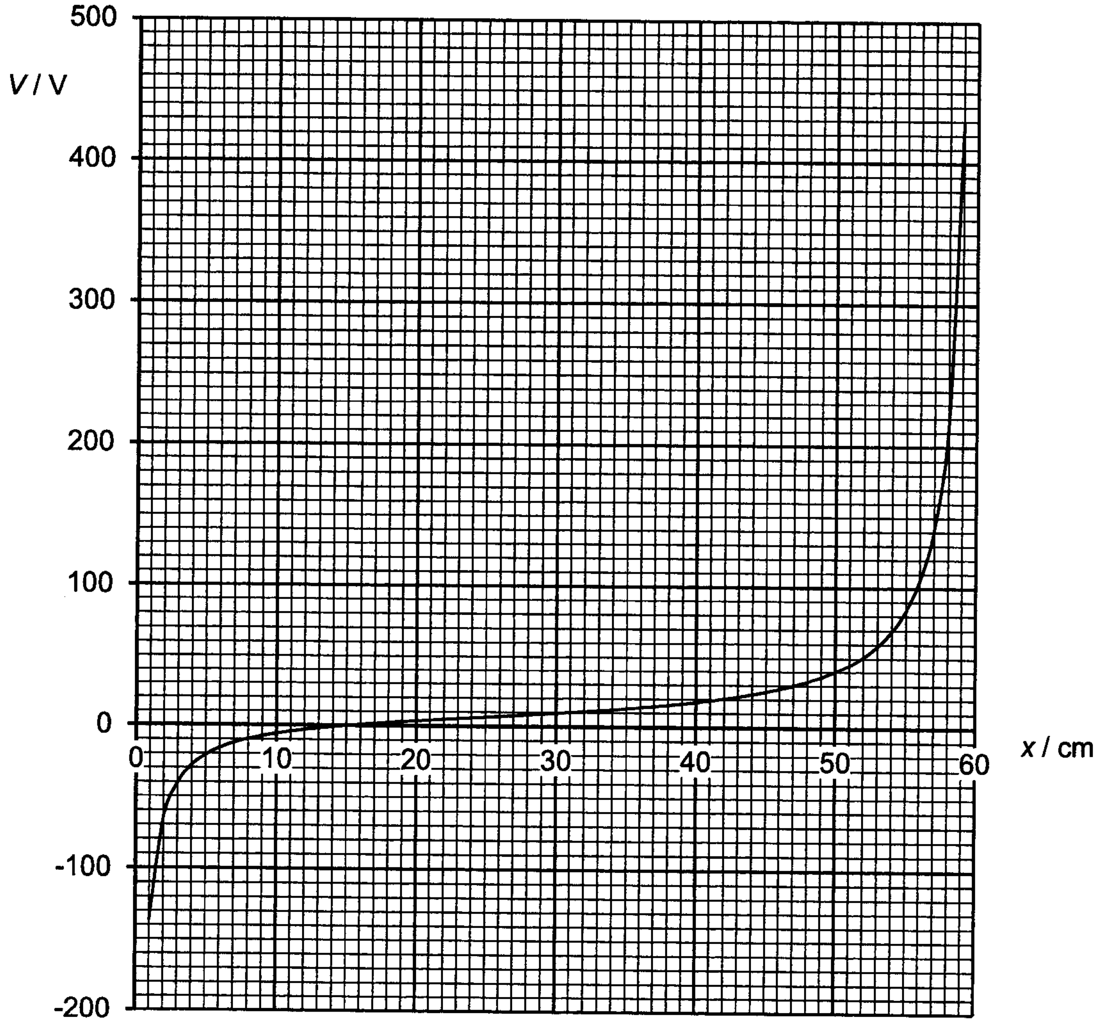


Fig. 3.2

[Turn over

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

....

.... [1]

(ii) State the relation between electric field strength E and potential V.

....

.... [1]

(iii) Hence, explain the direction of the electric field at the point P, where x = 15 cm.

....

.... [1]

(b) Given that the magnitude of the charge of sphere B is 0.48 nC, determine the charge of sphere A.

charge of sphere A = ... C [3]

(c) An electron moves along the line joining the centres of the two spheres towards sphere B and passes x = 15 cm with a speed of 4.0×10^{6} m s^{-1}. Calculate the speed of the electron when it reaches x = 57 cm.

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

[Total: 9]

4 **(a)** Define resistance.

....

.... [1]

(b) The resistivity of copper is 1.7×10^{-8} Ω m. Calculate the resistance of a copper wire of length 1.5 m and cross-sectional area of 3.2×10^{-9} m^2.

resistance = ... Ω [2]

(c) The copper wire in **(b)** is used to connect a circuit as shown in Fig. 4.1. Cell A has an e.m.f of 12.0 V and internal resistance 1.0 Ω. A 2.0 Ω resistance is also connected in series with cell A.

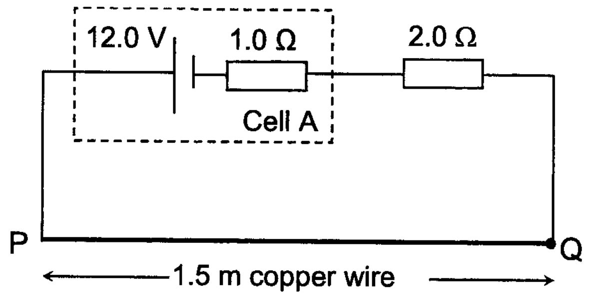


Fig. 4.1

Determine the drift velocity of the electrons flowing in the copper if the number of electrons per unit volume is 8.5×10^{28} m^{-3}.

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

[Turn over

(d) **(i)** Cell B, a galvanometer and resistor of 4.0 Ω are now placed in parallel together with the circuit as shown in Fig. 4.2. The movable contact J can be connected to any point along the wire PQ.

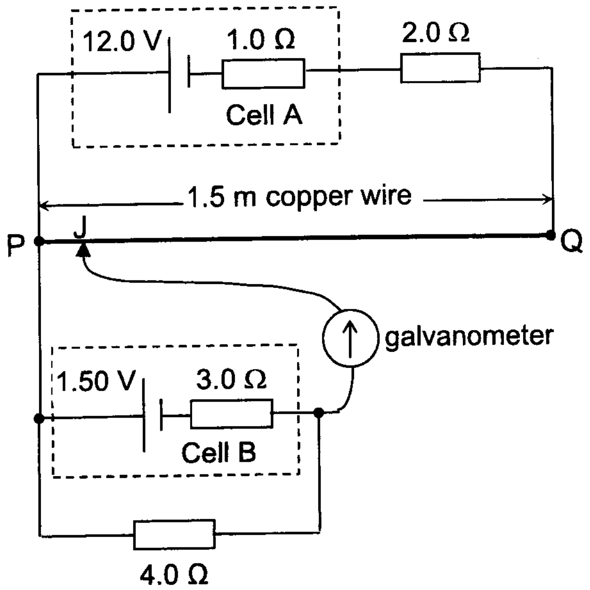


Fig. 4.2

Show that the potential difference across the copper wire PQ is 8.7 V when there is zero current in the galvanometer.

[1]

(ii) Calculate the balance length PJ.

PJ = ... m [3]

(iii) The balance point is found to be too near P.

Suggest and explain how the circuit can be modified, without changing Cell B, to improve the accuracy of the balanced length PJ.

....

....

....

.... [2]

[Total: 11]

5 A chlorine gas consists of two types of atoms: chlorine-35 and chlorine-37, of different masses. A researcher wants to separate these two atoms. He does this by using a device called the mass spectrometer as shown in Fig. 5.1.

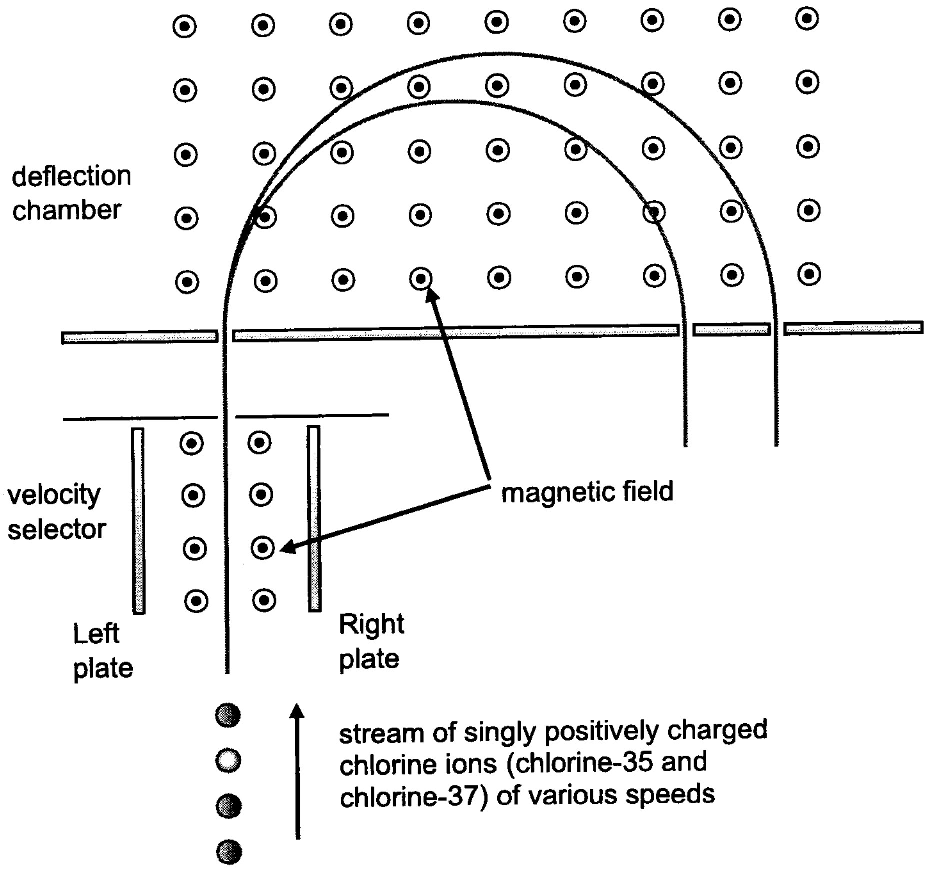


Fig. 5.1

The researcher first ionises all the atoms into singly positively charged ions, and then sends the individual ions of various speeds through the velocity selector. The emerging ions then enter the deflection chamber where they are deflected by a uniform magnetic field.

(a) The first part of the device is the velocity selector where there is a uniform magnetic field, two charged parallel plates, and a slit to allow undeflected ions to emerge through, as shown in Fig. 5.1.

(i) State whether the left plate is at a higher or lower electric potential, explain your answer.

....

....

.... [2]

(ii) The flux density of the magnetic field in the velocity selector is 0.020 T. The field strength of the electric field between the plates is 1.5×10^4 V m^{-1}.
Calculate the speed of the emergent ions as they pass undeflected in the velocity selector.

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

(iii) Describe what happens to those ions that do not have the speed as calculated in **(a)(ii)** and suggest why it is called the velocity selector.

....

....

.... [2]

(b) The second part of the device is the deflection chamber where the flux density of the magnetic field is also 0.020 T. The two different types of ions, chlorine-35 and chlorine-37, are deflected with different radii and hence are separated. Chlorine-35 atom has a mass of 35*u* and chlorine-37 atom has a mass of 37*u*.

(i) Calculate the radius of the semi-circular path of the chlorine-35 ions.

radius = ... m [2]

[Turn over

(ii) Given that the mass of the ions are unchanged, state the effect on your answers to **(a)(ii)** and **(b)(i)** if

1. the ions are singly negatively charged,

effect on **(a)(ii)** : ....

effect on **(b)(i)** : .... [1]

2. the ions are still positively charged but are doubly charged.

effect on **(a)(ii)** : ....

effect on **(b)(i)** : .... [1]

[Total: 10]

6 **(a)** Explain the term root mean square (r.m.s.) value of a current.

....

....

.... [1]

(b) An alternating current generator consists of a rectangular coil of 800 turns with the dimensions 5.0 cm × 8.0 cm in a uniform magnetic field of magnitude 0.50 T. The coil has a resistance of 0.60 Ω and it is connected to an external load of resistance 11 Ω in a complete circuit. The coil is rotating at a constant speed of 240 revolutions per minute.

For the rotating coil, the e.m.f. induced, E is

$$E = NBA\omega \sin(\omega t)$$

where N is the number of turns, B is the magnetic field strength, A is the cross-sectional area of the coil, ω is the angular velocity of the coil, and t is time.

(i) Determine the maximum voltage produced by this generator.

maximum voltage = ... V [2]

(ii) Calculate the r.m.s. current through the external load.

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

[Turn over

(iii) On the axes in Fig. 6.1, sketch a graph of power dissipated, *P* in the external load against time, *t* for 2 cycles of the A.C. current.

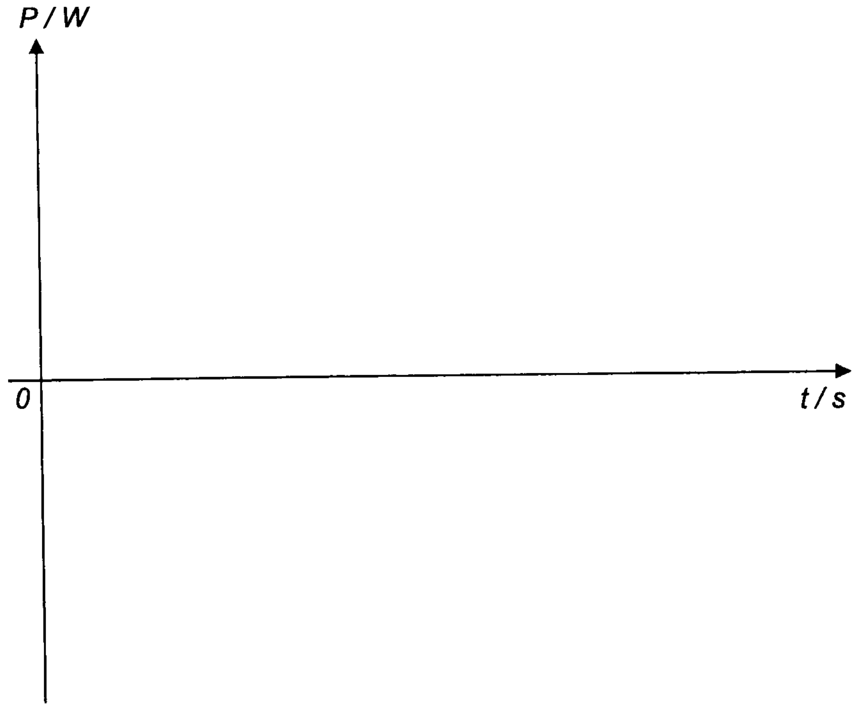


Fig. 6.1

[3]

[Total: 8]

7 In recent years, seismology and an understanding of wave motion have produced many benefits. One consequence has been a much clearer picture of the internal structure of the Earth. Two different types of seismic waves are generated by the sudden movement on a fault: P-waves (primary waves) and S-waves (secondary waves). The speed of the waves depends on wave type and the properties of the rock; the denser the rock, the faster the waves travel.

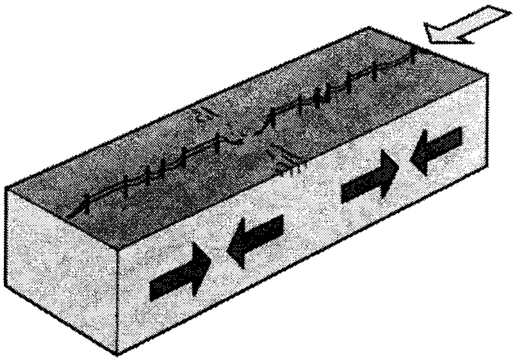


Fig 7.1

P-waves, shown in Fig. 7.1, travel fastest. They consist of successive contractions and rarefactions, just like sound waves in air. The motion of the particles in the rocks that the waves travel through is parallel to the direction of the wave.

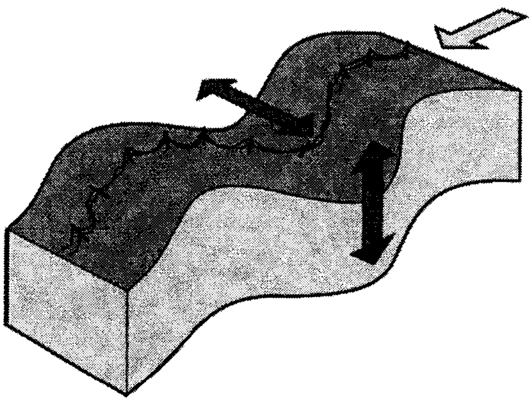


Fig 7.2

S-waves, shown in Fig. 7.2, are slower than P-waves. They are transverse waves, which means that the particle motion is at right angles to the direction of travel. S-waves cannot travel through air or liquids.

By studying the propagation characteristics of seismic waves we have learned much about the detailed nature of Earth's interior. Fig. 7.3 shows the velocity and density variations within Earth (from the surface to the centre) based on seismic observations. The main regions of Earth and important boundaries are labelled.

[Turn over

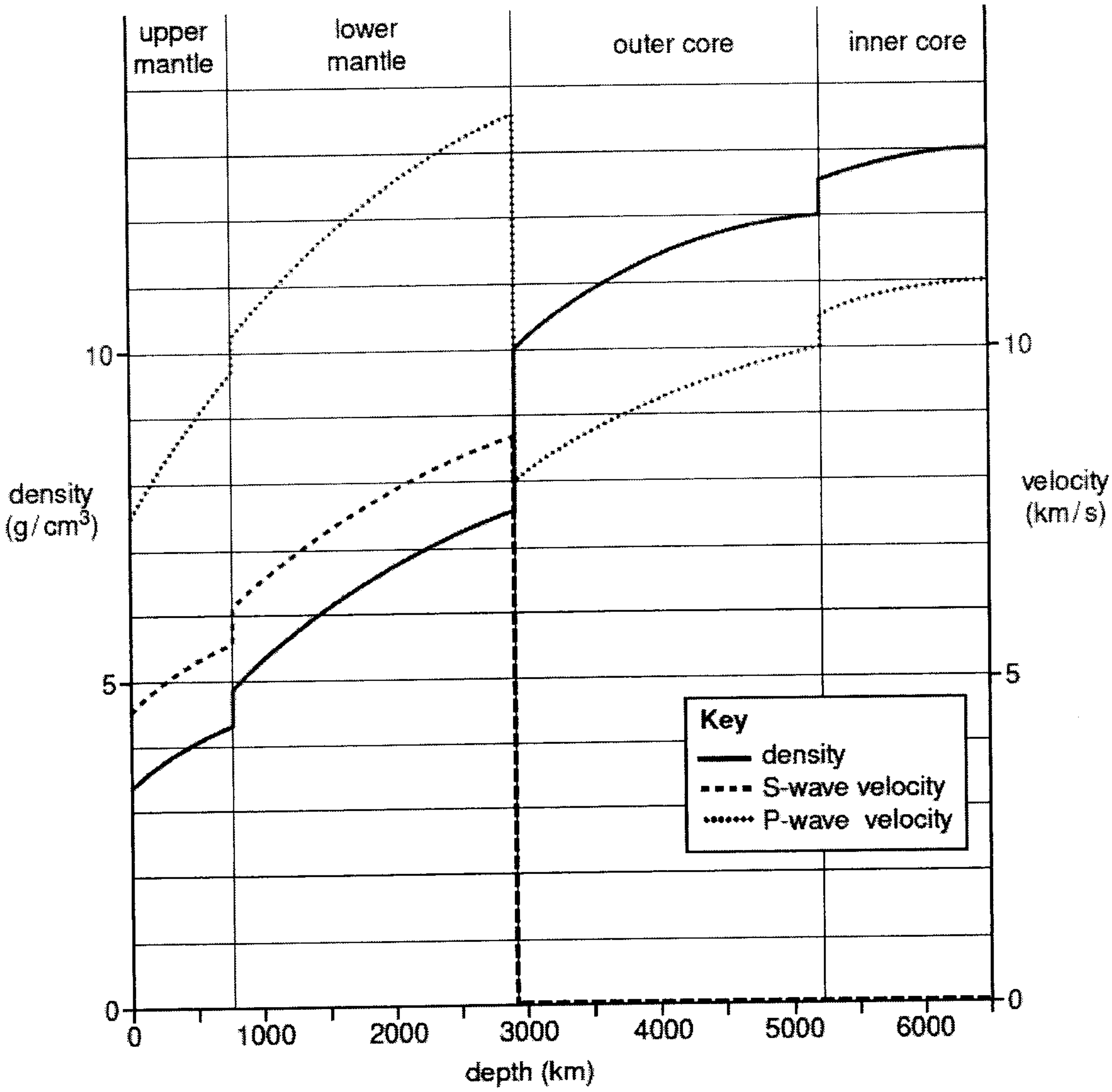


Fig 7.3

Several characteristics of Earth's structure are illustrated in the Fig. 7.3. In several large regions such as in the lower mantle, the outer core, and inner core, the velocity smoothly increases with depth. The increase is a result of the effects of pressure on the seismic wave speed. Although temperature also increases with depth, the pressure increase resulting from the weight of the rocks above has a greater impact and the speed increases smoothly in these regions of uniform composition. The atoms in these rocks rearrange themselves into compact structures that are stable at the high pressures and the result of the rearrangement is an increase in density and elastic moduli, producing an overall increase in wave speed.

As seismic waves pass through the Earth, they are refracted, or bent, like rays of light bend when they pass through a glass prism, as shown in Fig. 7.4.

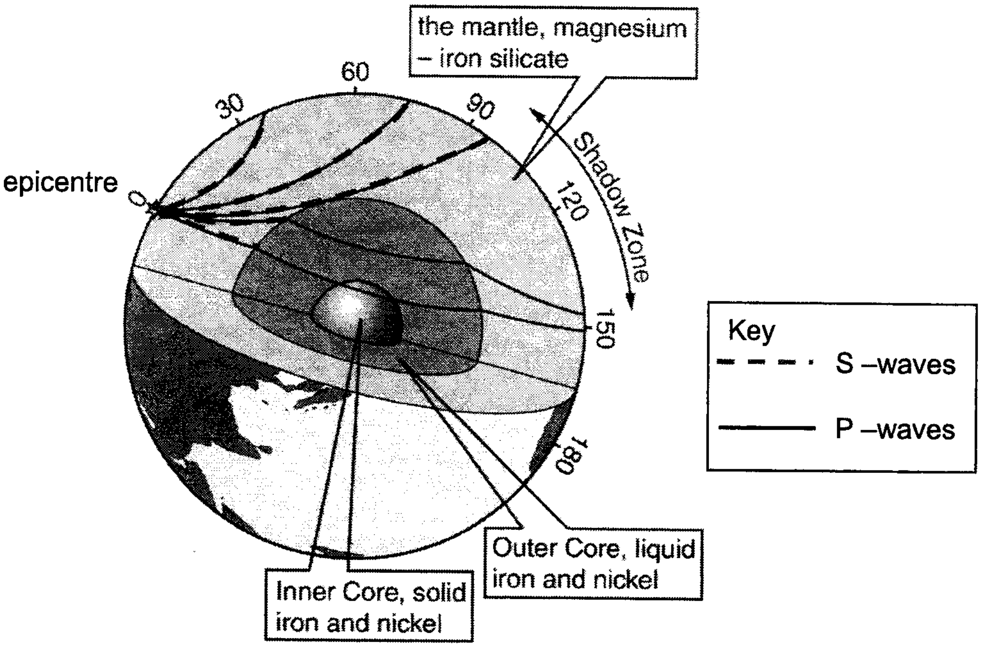


Fig 7.4

Seismology is the analysis of little measurements, which allows us to understand big events – earthquakes, tsunamis, volcanoes, and landslides. Basically, it is all about seismic waves or vibration waves occurring naturally from earthquakes. Sometimes scientists create them by sending energy into the ground to see how it bounces off underground layers. Geophysicists who explore for oil, natural gas, minerals, and groundwater do this. We can also use these techniques in other situations, such as looking for sunken treasures deep below the ocean or finding abandoned oil tanks that can contaminate soil.

(a) Explain what is meant by

1. a *longitudinal wave*,

....

.... [1]

2. a *transverse wave.*

....

.... [1]

[Turn over

(b) A large earthquake occurs near the surface of the Earth at a particular location and both seismic P-waves and S-waves are produced. The P-waves and S-waves travel through the Earth away from the epicentre of the earthquake.

The average speed of the P-waves is 7.98 km s^{-1} and the average speed of the S-waves is 4.75 km s^{-1}. A seismograph at a different location detects the arrival of the S-waves 2 minutes 50 seconds after the arrival of the P-waves.

(i) Calculate the time taken, in minutes, for the S-waves to travel from the epicentre of the earthquake to the seismograph,

time = ... min [2]

(ii) Calculate the distance of the epicentre of the earthquake from the seismograph.

distance = ... km [1]

(c) **(i)** Seismic waves produced by the earthquake are detected by seismographs in many different countries. In certain parts of the world, however, seismographs do not detect any of the S-waves produced by the earthquake.

Using Fig. 7.3 and other information, explain why these seismographs do not detect the S-waves.

....

....

....

....

....

....

.... [3]

(ii) Using Fig. 7.4, state where relative to the epicentre of the earthquake, these seismographs are located.

....

.... [1]

(d) As the S-waves travel through the upper and lower mantle, the speeds of the waves change.

(i) Describe and explain this change in speed.

....

....

....

....

.... [3]

(ii) Describe the effect of this change in speed on the path taken through the mantle by the S-waves.

....

....

....

.... [2]

(e) (i) Explain why there are parts of the Earth's surface, named "Shadow Zone", at distances between 103° and 143° in Fig. 7.4, where it is not possible for seismographs to detect the P-waves produced by the earthquake.

....

....

....

.... [2]

(ii) **1.** Estimate the radius of the Earth from Fig. 7.3,

radius of Earth = ... km [1]

2. Hence provide an estimate of the length of the "Shadow Zone" for P-waves.

length = ... km [2]

(f) The temperatures and pressures within the Earth reach very high values within a few kilometres of the surface. It is difficult, therefore, to imagine that human beings will ever be able to reach regions further than a few kilometres from the surface. Both public and private money are used to support the study of geophysics and seismology.

Suggest why this expenditure is justified. Your answer could take into considerations the social, technological and economic effects of such research.

....

....

.... [1]

[Total: 20]

End of Paper

Class

Candidate Name: ________________

Adm No

H

millennia institute

2022 Preliminary Examination
Pre-University 3

H2 PHYSICS **9749/03**

Paper 3 Longer Structured Questions **16 September**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and Adm number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer **one** question only.

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

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

For Examiner's Use		
Sect A		
1		/ 5
2		/ 10
3		/ 13
4		/ 17
5		/ 15
Sect B		
6		/ 20
7		/ 20
Presentation		
Total		**/80**

This document consists of **24** printed pages.

[Turn over

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn over

Section A

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

1 **(a)** Derive the equation $E_p = mgh$ for the potential energy change, E_p, of a mass m moved through a vertical distance h near the Earth's surface.

[2]

(b) Fig. 1.1 shows the variation with velocity v of the force F applied to an object. F and v are in the same direction.

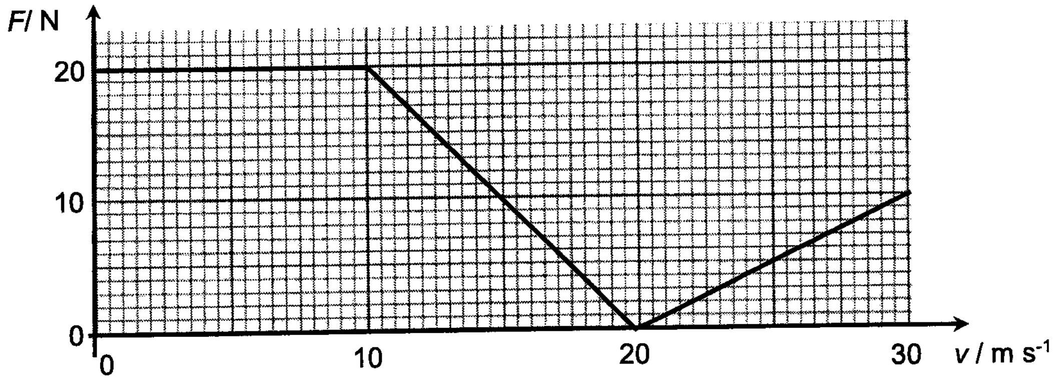


Fig. 1.1

On Fig. 1.2, draw a graph showing the variation with v of the rate of work done.

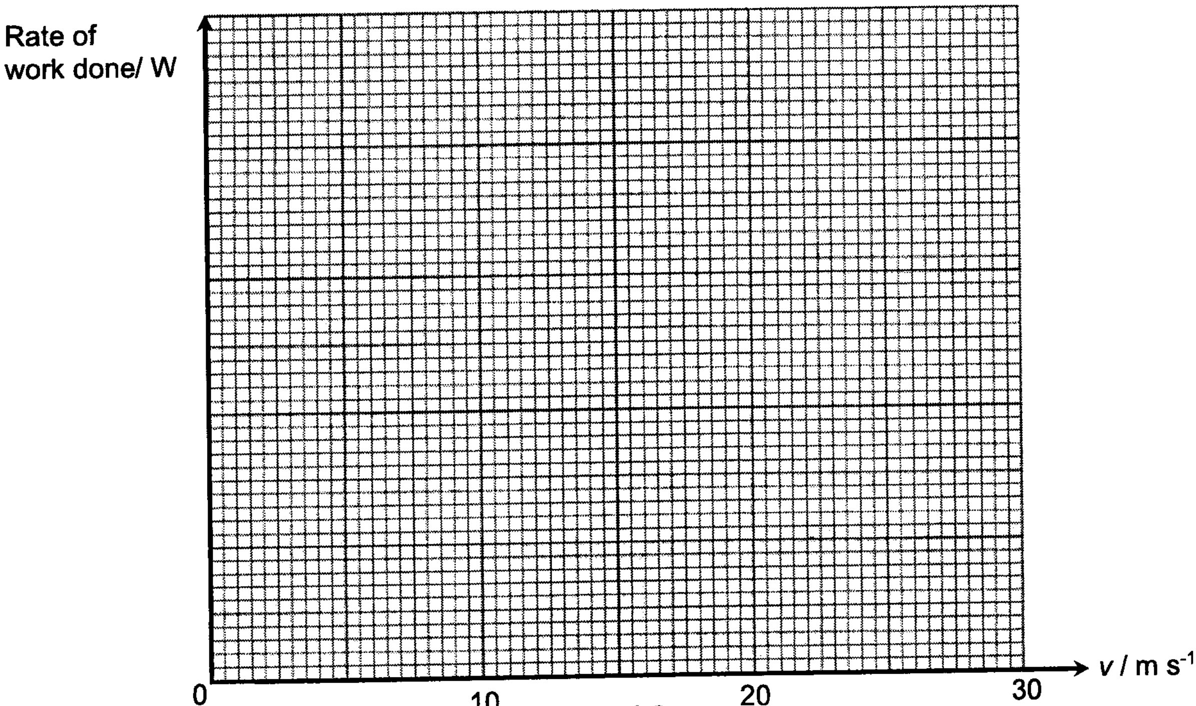


Fig 1.2

[3]

2 (a) On 16 July 1994, a fragment of the comet Shoemaker-Levy 9 entered the gravitational field of the planet Jupiter. The fragment had an estimated mass of 5.5×10^{13} kg.

Fig. 2.1 shows the gravitational field strength around Jupiter as calculated by a keen physics student.

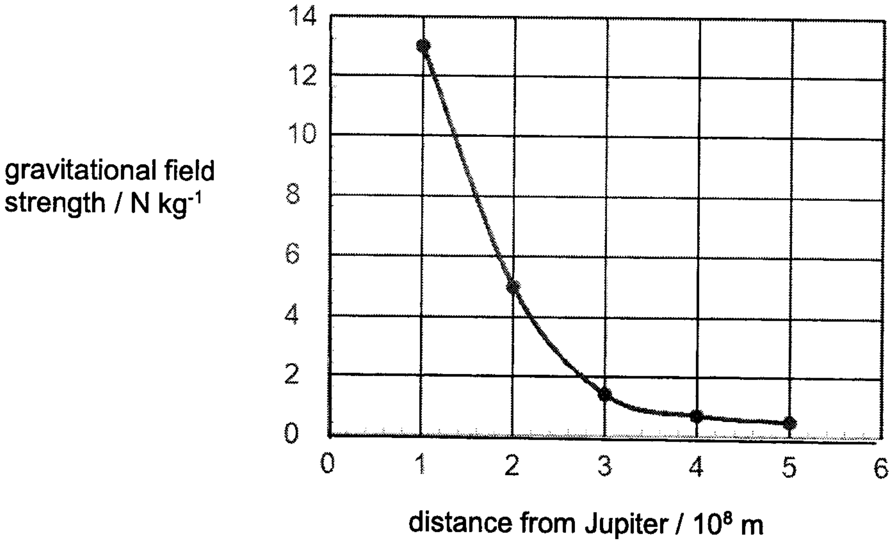


Fig. 2.1

(i) Calculate the gravitational force acting on the fragment of the comet when it is 4.0×10^8 m from Jupiter.

gravitational force = ... N [1]

(ii) Estimate the amount of kinetic energy gained by the comet fragment as it moves from 4.0×10^8 m to 2.0×10^8 m from the Jupiter. Show your working clearly.

kinetic energy gained = ... J [2]

[Turn over

(b) **(i)** A new geostationary satellite called SKY 7 is to be placed in orbit above the Earth's equator. Show that the orbital radius for SKY 7 is 4.23×10^4 km.
Mass of Earth is 6.0×10^{24} kg.

[1]

(ii) Given that the mass of the satellite is 1000 kg, and Earth's radius is 6.39×10^6 m determine the minimum energy required to put the satellite in geostationary orbit from the surface of the earth when it is launched from the equator.

minimum energy = ... J [3]

(iii) As the satellite orbits Earth, it gradually losses energy due to small resistive forces. State and explain the effect of this change on the radius of the orbit and the speed of satellite.

____

____

____

____

____

____ [3]

[Total: 10]

3 Fig. 3.1 below shows a beam of red light from a laser shone normally on a double slit of slit separation 20.0 cm.

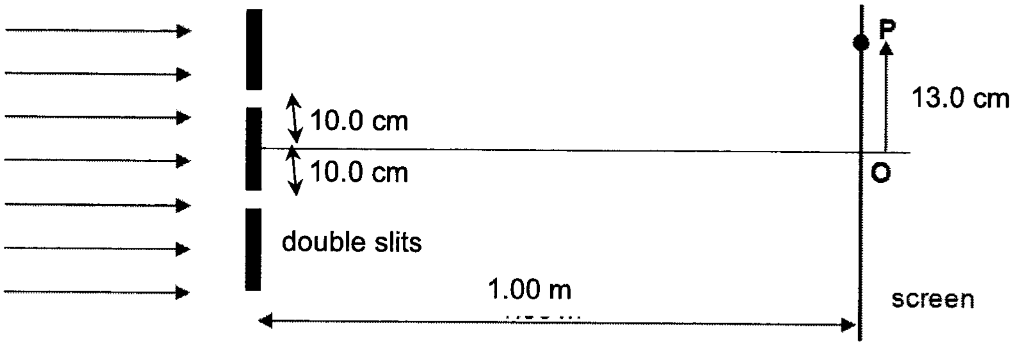


Fig. 3.1

(a) **1.** Draw a sketch of what you will observe on the screen.

[1]

2. Describe the changes you will observe when the screen is placed 2.00 m away from the double slits.

....

....

.... [2]

(b) **(i)** Show that the path difference of the sources at point P is 0.0257 m.

[2]

[Turn over

(ii) 1. The wavelength of the wave is 1.03 cm. Calculate the phase difference of the waves arriving from the sources at point P.

phase difference = ...rad [2]

2. Hence, explain what will be observed at point P.

____

____ [1]

(iii) Determine the number low intensity regions observable between point P and point O, including point P and point O.
Show your working clearly.

number of low intensity regions = ... [2]

(c) If the red light is replaced by white light, state and explain what will be observed on the screen.

____

____

____

____

____

____ [3]

[Total: 13]

4 (a) (i) Incident radiation of wavelength 444 nm is shone on a metal with a work function of 2.2 eV. Calculate the maximum kinetic energy of an ejected photoelectron.

maximum kinetic energy = ...J [2]

(ii) Calculate the stopping potential.

stopping potential = ...V [1]

(iii) The intensity of the incident radiation is doubled but the wavelength is kept constant. State and explain how this will affect your answers in **(a)(i)** and **(a)(ii).**

____

____

____

____ [2]

(b) A beam of electrons traveling the positive x-direction with speed 3.75×10^6 m s^{-1} passes through a slit that is parallel to the y-axis and 5.0 μm wide. The diffraction pattern is recorded on a screen 2.5 m from the slit.

(i) State Heisenberg's Uncertainty Principle.

____

____

____ [1]

[Turn over

(ii) In single-slit diffraction, the first minima of the central diffraction pattern occurs at $\sin\theta = \frac{\lambda}{D}$, where D is the width of the slit. Based on the angle of diffraction of the first minima of the central diffraction pattern, show that the maximum y-component of the momentum of an electron just after it has passed through the slit is 1.32×10^{-28} N s.

[3]

(iii) Hence, estimate the minimum uncertainty in the y-coordinate of an electron's position just after it has passed through the slit.

uncertainty in the y-coordinate of position= ....m [2]

4 (c) A CD-ROM is used in an electron diffraction experiment as shown in Fig. 4.1. The surface of the CD-ROM has tracks of tiny pits with a uniform spacing of 1.60 μm. Assume that you can use the same equation as for optical diffraction, $n\lambda = d \sin \theta$.

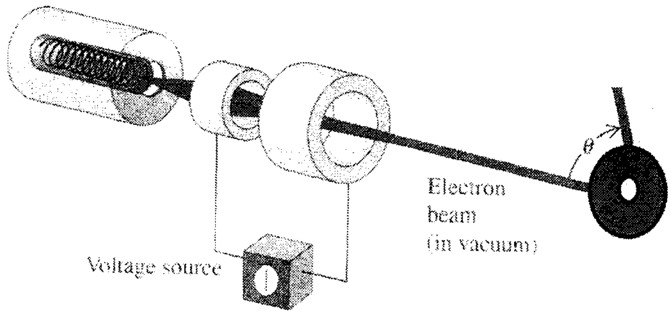


Fig. 4.1

If the speed of the electrons is 1.26×10^4 m s^{-1}, calculate the angle θ, in radians, of the 2nd order maxima.

θ = ...rad [2]

(d) Fig. 4.2 (not drawn to scale) represents part of the emission spectrum of atomic hydrogen.

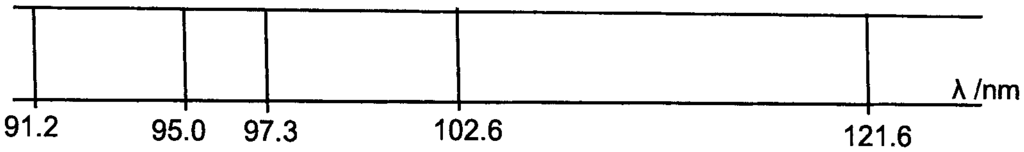


Fig. 4.2

The ionization energy of hydrogen atom is 13.6 eV. The electron transition giving rise to the emission line with wavelength 91.2 nm is indicated in Fig. 4.3.

(i) Calculate the photon energies, in eV, equivalent to all the emission lines marked in Fig. 4.2.

photon energies =..................eV , ...eV , ... eV, ...eV [2]

[Turn over

(ii) Using your answers in **(d)(ii)**, map a partial energy level diagram for hydrogen in Fig.4.3. Show, and label clearly, the electron transitions responsible for the emission lines labelled in Fig. 4.2.

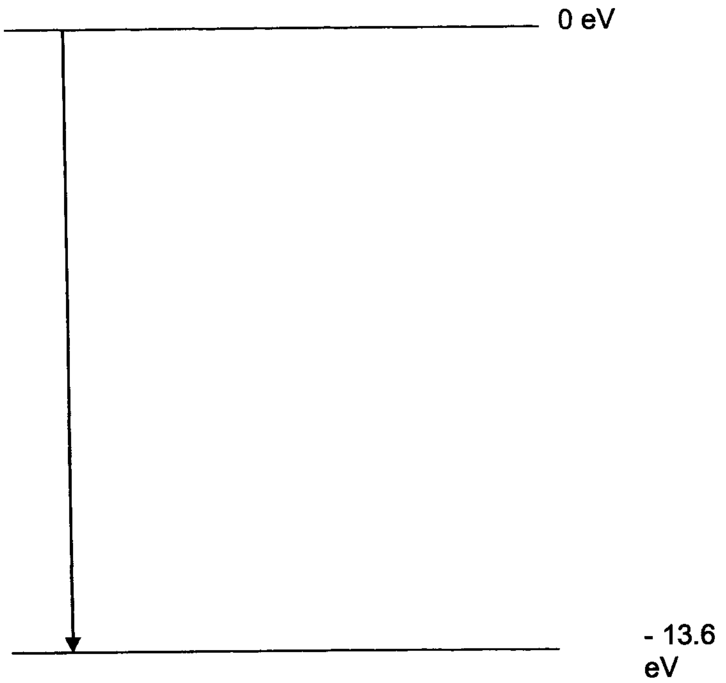


Fig. 4.3

[2]

[Total: 17]

5 (a) Fig. 5.1 shows the path of an alpha particle as it scatters off a gold nucleus from a thin gold foil in the Rutherford's scattering experiment.

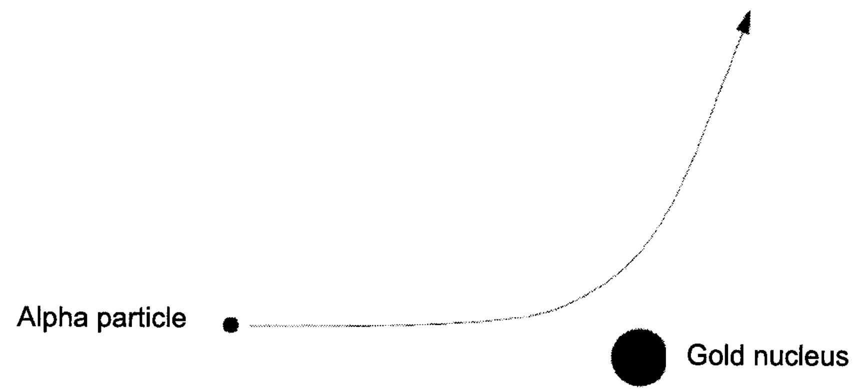


Fig. 5.1

(i) Explain why the alpha particle follows the path as shown in Fig. 5.1.

....

....

.... [1]

(ii) On Fig. 5.1, sketch the path of an alpha particle with the same initial path, but less kinetic energy and label it **(ii)**. [1]

(iii) Explain why a thin gold foil is required for this experiment.

....

....

.... [1]

(iv) On Fig 5.1, sketch the path of an alpha particle if the gold nucleus is now changed to an iron nucleus and label it **(iv)**.
Atomic number of gold is 79 and atomic number of iron is 26. [1]

(b) In **Fig. 5.2**, an alpha particle on path Q has a head-on collision with a lithium nucleus $^{7}_{3}Li$.

Fig. 5.2

The energy of alpha particle changes as it moves towards the centre of the nucleus. This alpha particle gets to within a distance of 4.2 x10^{-15} m from the centre of the nucleus.

[Turn over

(i) Show that the *minimum* energy needed by the alpha particle to get to within 4.2×10^{-15} m from the centre of the nucleus is 3.3×10^{-13} J.

[2]

(ii) When the alpha particle gets to within 4.2×10^{-15} m of the centre of the nucleus, the following nuclear reaction takes place.

$$^{4}_{2}He + ^{7}_{3}Li \rightarrow ^{10}_{5}B + ^{1}_{0}n$$

The masses of the particles involved in the nuclear reaction are as follows:

Particle	mass / u
24 He	4.0015
37 Li	7.0144
$^{10}_{5}B$	10.0011
$^{1}_{0}n$	1.0087

Calculate the maximum possible energy of a neutron ejected from the target when the alpha particles in the beam have energy of 3.3×10^{-13} J.

maximum possible energy = ...J [3]

(c) **(i)** Compare the properties of a photoelectron and a β-particle by making reference to their origin.

....

....

....

....

.... [2]

(ii) Write down the equation which relates the rate of decay $-\mathrm{d}N/\mathrm{d}t$ in a sample of N radioactive nuclei to their decay constant λ.

.... [1]

(iii) State the units of λ.

.... [1]

(iv) A certain medical treatment requires a radioactive source with an activity of 2.8×10^3 Bq at the start of the treatment. The nuclide selected has a half-life of 4.2×10^4 s and happens to be prepared 20 hours before the treatment commences. Determine the activity of the source at the time of preparation.

activity of the source = ...Bq [2]

[Total: 15]

[Turn over

Section B

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

6 (a) (i) Define acceleration.

....

....

.... [1]

(a) (ii) State a scenario in which an object has an acceleration but is at rest.

....

....

.... [1]

(b) The graph in Fig. 6.1 shows the variation of the acceleration of a ball bearing being released into a beaker filled with an unknown fluid.

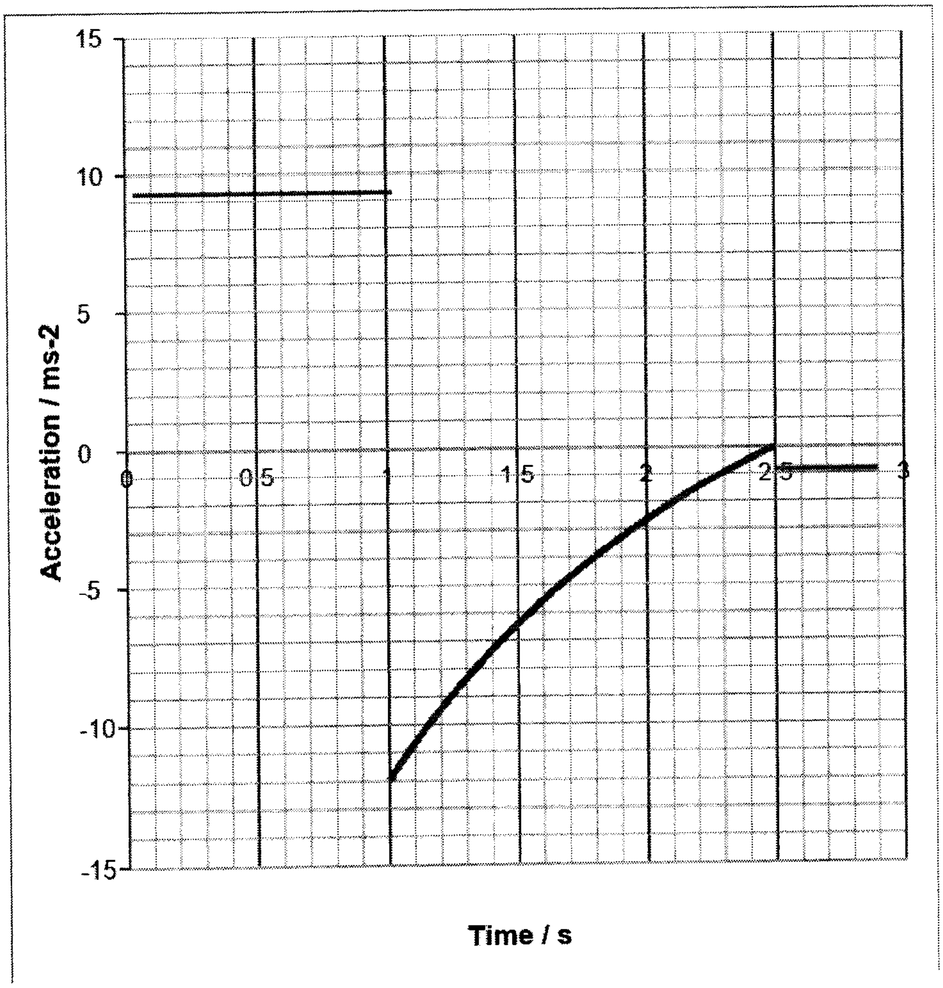


Fig. 6.1

(b) **(i)** Explain whether air resistance is negligible in Fig. 6.1.

....

....

.... [1]

(ii) At the time of 2.5 s, the acceleration of the ball is zero. Explain whether this means that the ball has reached the bottom of the beaker.

....

....

.... [1]

(iii) Draw a free body diagram indicating all forces acting on the ball bearing at the time of 2.5 s.

[1]

(iv) Determine the magnitude of the highest velocity of the ball bearing.

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

[Turn over

(v) Determine the terminal velocity of the ball bearing.

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

(vi) Sketch a velocity time graph for the motion of the ball in Fig. 6.2. Indicate all relevant values on your graph.

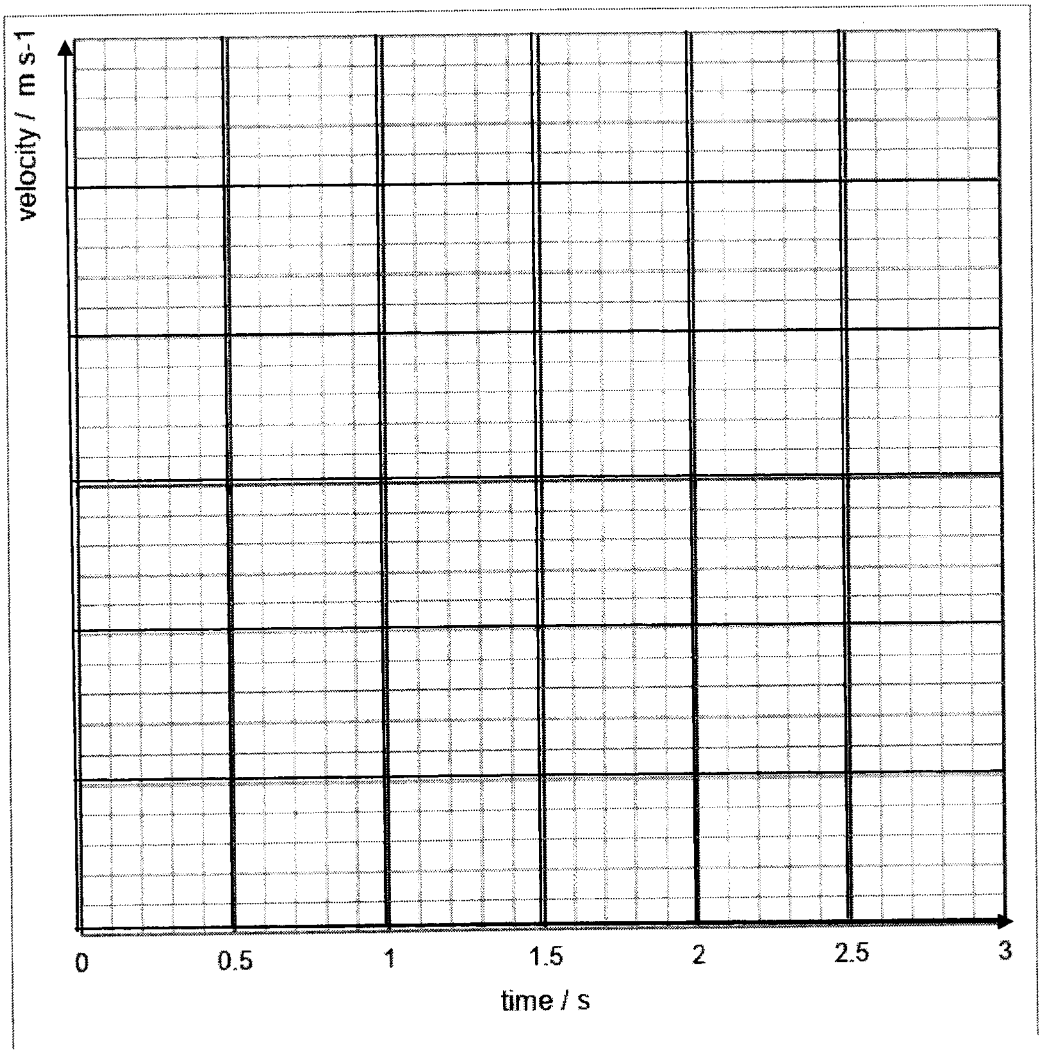


Fig. 6.2

[2]

(c) Fig. 6.3 below shows part of an experiment that is being used to estimate the speed of an air gun pellet.

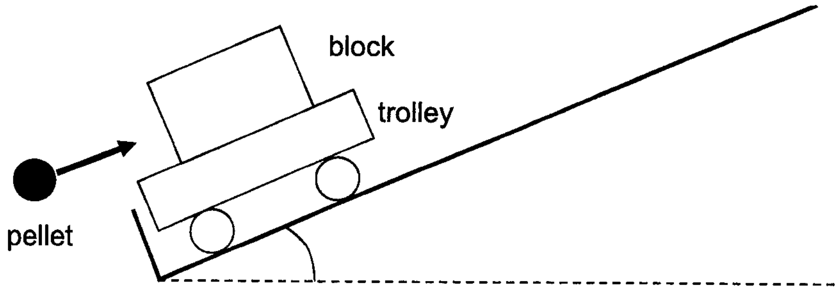


Fig. 6.3

The pellet which is moving parallel to the track, strikes the block with a speed of *u* before it is embedded to the block. The trolley and the block then move along the smooth track, rising a vertical height, *h*.

(i) Explain how the speed of the pellet *u* can be determined from measurements of *h*.

....

....

....

.... [2]

(ii) Explain whether the speed of pellet *u*, is an underestimated or overestimated if frictional forces are not negligible.

....

....

.... [1]

(d) The following data is collected from the experiment:

Mass of trolley and block	0.50 kg
Mass of pellet	0.0020 kg
Speed of trolley and block immediately after impact	0.40 m s^{-1}

(i) State the principle of conservation of linear momentum.

....

....

....

.... [2]

[Turn over

(ii) Calculate the speed of the pellet just before impact.

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

(e) Use your answer from part **(d)** to show that the collision between the pellet and block is inelastic.

[2]

[Total: 20]

7 (a) At the triple point of water, the three states of water (ice, water and water vapour) coexist in stable equilibrium. The triple point of water is 273.16 K.

Compare the average kinetic energy of the molecules in ice and water at the triple point of water.

....

....

....

.... [2]

(b) Fig. 7.1 shows an experiment to determine the latent heat of fusion of ice. For setup A, a 12.0 W heater was turned on while for setup B, a control setup, the heater was not turned on. The heaters used in setup A and setup B are identical heaters.

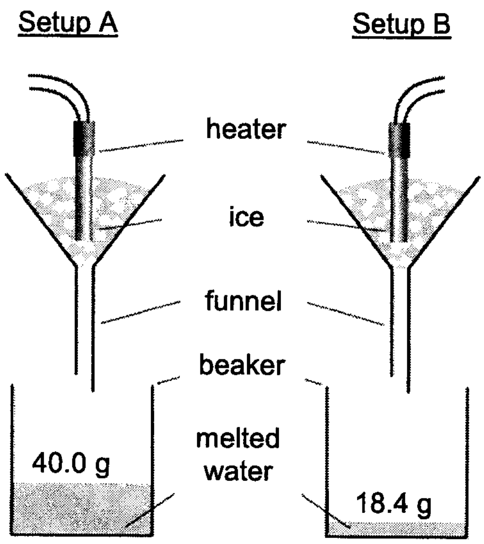


Fig. 7.1

(i) Explain why control setup B is needed.

....

.... [1]

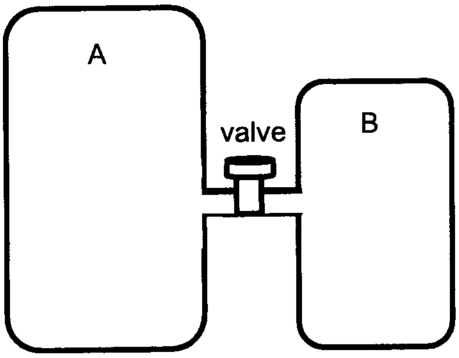
(ii) The ice was allowed to melt for 10 minutes and the mass of the water collected from each funnel is shown in Fig. 7.1. Calculate the specific latent heat of fusion of ice.

specific latent heat of fusion of ice = ... $J\ kg^{-1}$ [2]

[Turn over

(c) Fig 7.2 shows 2 containers, A and B, connected by a tube of negligible volume with a valve installed. Container A is filled with 0.200 mol of ideal gas while there is a vacuum in container B. The valve is closed.

Volume of A =



Volume of B =

Fig. 7.2

(i) Given that both containers are kept at 27 °C, calculate the pressure of the ideal gas in container A.

pressure = ... Pa [1]

(ii) Calculate the pressure and the amount of ideal gas in the container B when the valve is opened assuming that the temperature remains constant and the gas reaches an equilibrium state.

pressure = ... Pa

amount of ideal gas = ... mol [2]

(iii) Container B is now heated to 100 °C while container A is kept at 27 °C. Calculate the pressure in container B with the valve remaining open.

pressure = ... Pa [2]

(d) A fixed mass of ideal gas is made to undergo the following processes as shown in Fig. 7.3 below:

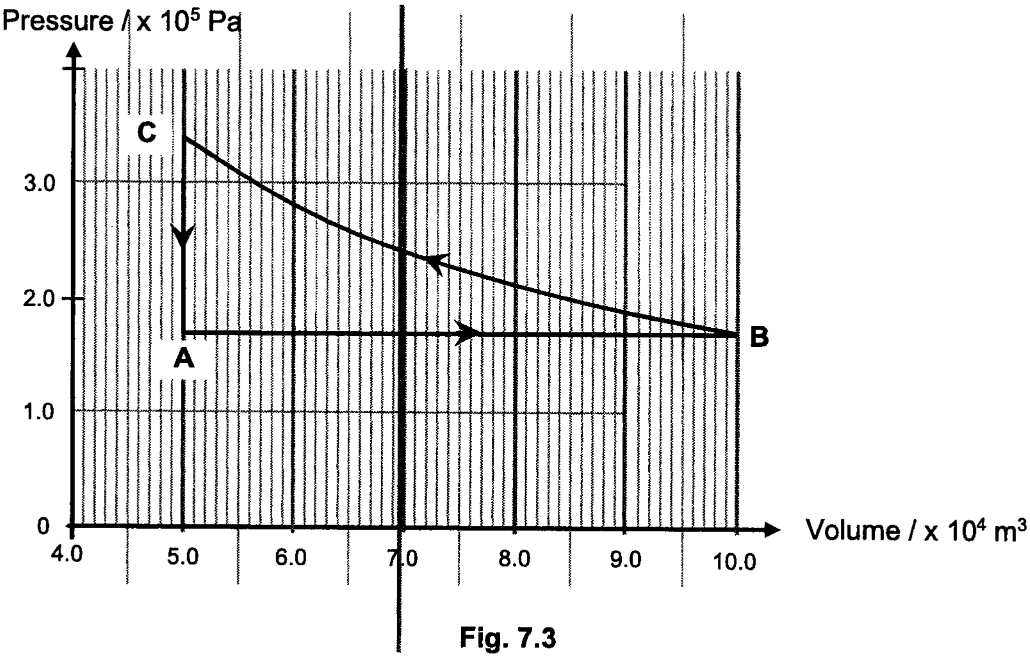


Fig. 7.3

(i) Use the data from Fig. 7.3 to confirm that process BC is isothermal. Show your working clearly.

[3]

[Turn over

(ii) State and explain how you would attempt to ensure experimentally that the process BC is isothermal.

....

....

....

....

.... [2]

(iii) The temperature of the gas at C is 385 K. Calculate the temperature of the gas at A.

temperature at A = ... K [2]

(iv) During the process A to B, 213 J of energy is supplied by heating the gas. Use the First Law of Thermodynamics to calculate the increase in internal energy of the gas for process A to B.

increase in internal energy = ... J [3]

[Total: 20]

BP~793

Class	Adm No

Candidate Name: ____________________

H

millennia institute

2022 Preliminary Exams
Pre-University 3

H2 PHYSICS **9749 / 04**

Paper 4 Practical **30 August**

Candidates answer on the Question Paper. **2 hours 30 minutes**

READ THESE INSTRUCTIONS FIRST

Shift
Laboratory

Write your name, class and admission number in the spaces provided at the top of this page.
Write in dark blue or black pen on both sides of the papers.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided in this 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.

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

For Examiner's Use	
1	/ 12
2	/ 11
3	/ 20
4	/ 12
TOTAL	55

This document consists of **14** printed pages and **0** blank pages.

1 In this experiment, you will investigate the oscillations of a triangular-shaped object.

(a) You have been provided with a wire. Bend the wire to form a triangle shape so that the length of each side *a* is approximately 10 cm, as shown in Fig. 1.1.

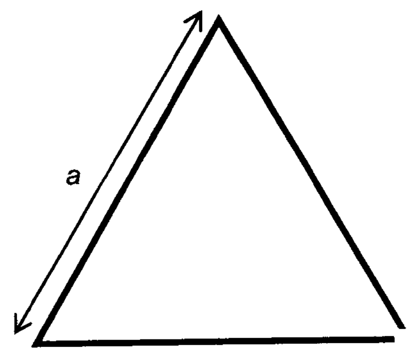


Fig. 1.1

Use the wire cutter to remove any excess wire.

(i) Measure and record *a*.

a = ... [1]

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

percentage uncertainty in *a* = ... [1]

(b) Suspend the triangular-shaped wire as shown in Fig. 1.2. The pin should be held firmly in the clamp and the wire should be able to pivot about the pin freely.

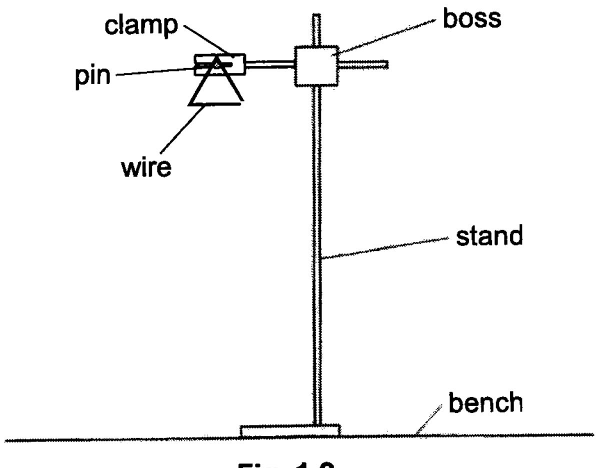


Fig. 1.2

Gently displace the wire and release it so that it oscillates about the pin.

Take suitable measurements to determine *T*, the period of the oscillation.

T = ... [2]

(c) Remove the triangular-shaped wire from the pin. Form a new triangle shape from the wire so that *a* is approximately 8 cm.

Use the wire cutter to remove any excess wire.

Repeat **(a)(i)** and **(b)**.

a = ...

T = ... [2]

(d) It is suggested that

$$T^2 = \frac{a}{k}$$

where *k* is a constant.

Use your values from **(a)(i)**, **(b)** and **(c)** to determine two values of *k*.

first value of *k* = ...

second value of *k* = ... [2]

(e) Justify the number of significant figures given in your values of *k*.

....

....

.... [1]

(f) State whether the results of your experiment support the relationship suggested in **(d)**.

Justify your conclusion by referring to your answer in **(a)(ii)**.

....

....

....

....

.... [2]

(g) The acceleration of free fall g near the surface of the Earth is given by

$$g = \frac{4}{\sqrt{3}}\pi^2 k$$

Use your first value of k to calculate a value for g.

g = ... [1]

[Total: 12]

2 In this experiment, you will investigate the forces acting on an object.

(a) Place a cylinder on top of a wooden block. Place some blue-tac at the base of the cylinder to ensure that it does not roll off the wooden block. Place a metre rule on the cylinder.

Hang the rubber bung on the metre rule 15.0 cm away from the pivot. Ensure that the metre rule is balanced by placing a 20 g mass on the other side of the pivot, as shown in Fig. 2.1.

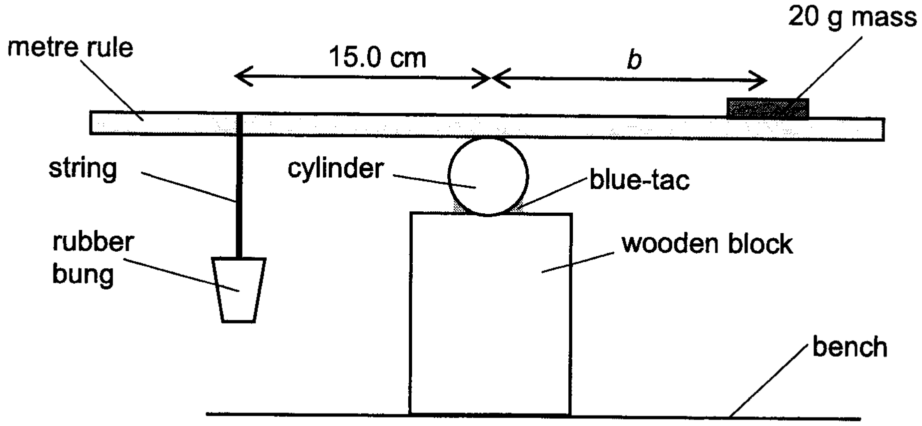


Fig. 2.1

b is the distance between the pivot and the centre of the 20 g mass.

Measure and record *b*.

b = ... [1]

(b) Place a beaker under the rubber bung and pour approximately 250 cm^3 of liquid X into the beaker until it is completely submerged. Adjust the position of the 20 g mass so that the metre rule remains balanced, as shown in Fig. 2.2.

c is the distance between the pivot and the centre of the 20 g mass when the rubber bung is completely immersed in liquid X.

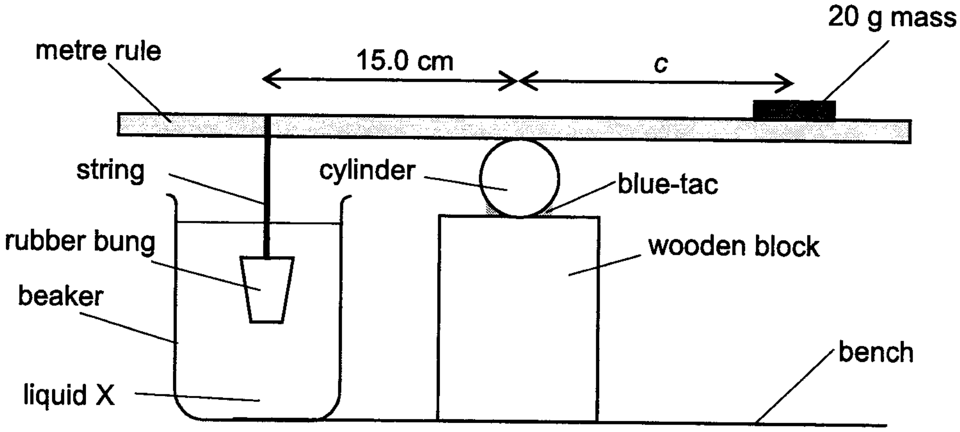


Fig. 2.2

(i) Measure and record c.

c = ... [1]

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

percentage uncertainty in c = ... [1]

(iii) The density of liquid X, ρ_X, b and c are related by the expression

$$\rho_X = Z\,(b - c)$$

where $Z = 0.0296\ \text{g cm}^{-4}$.

Calculate ρ_X.

ρ_X = ... [2]

(iv) Suggest one significant source of uncertainty in this experiment.

....

....

....

.... [1]

(v) Suggest an improvement that could be made to the experiment to reduce the uncertainty identified in **(b)(iv)**.

You may suggest the use of other apparatus or a different procedure.

....

....

....

.... [1]

(c) The expression given in **(b)(iii)** suggests that the density of the liquid in the beaker in Fig. 2.2 has a linear relationship with *c*.

Explain how you would investigate this relationship.

You would be provided with liquids of different densities.

Your account should include:

- your experimental procedure
- control of variables
- how you would measure the densities of the liquids
- how you would use your results to show that the two variables are linearly related

....

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....

....

.... [4]

[Total: 11]

3 In this experiment, you will investigate an electrical circuit.

(a) You have been provided with metre rule Y, with a resistance wire attached.

(i) Record the resistance per unit length of the wire attached to rule Y, r.

r = ...

(ii) Take measurements to determine the cross-sectional area of the wire attached to rule Y, a_Y.

a_Y = ... [2]

(iii) Calculate the resistivity of the wire attached to rule Y, ρ_Y

ρ_Y = ... [1]

(b) Set up the circuit shown in Fig. 3.1

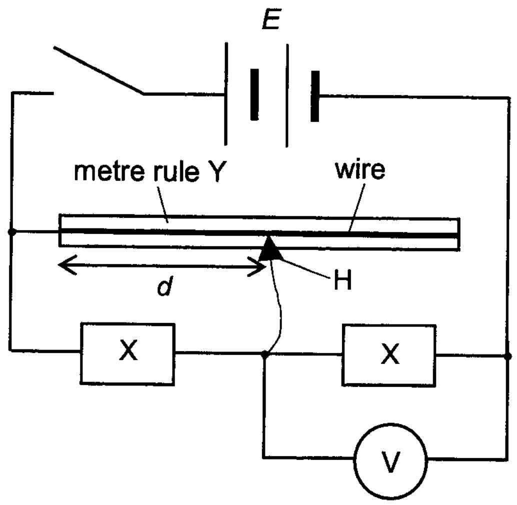

Fig. 3.1

H is a crocodile clip that is free to move along the wire.

The e.m.f. of the cell is E. The value of the resistance of X is R_X.

d is the distance between the end of the rule and H, as shown in Fig. 3.1.

(i) Measure and record E.

E = ... [1]

(ii) Record R_X.

R_X = ...

(iii) Close the switch. Adjust the position of H until d is 50.0 cm.

Record the voltmeter reading that measures the potential difference across X, V_X.

V_X = ... [1]

(iv) Calculate the resistance of the length d of the resistance wire R_Y using information from **(a)(i)**, and the following expression

$$R_Y = r\,d$$

R_Y = ... [1]

(v) Vary *d*, obtaining a suitable range of values, and repeat **(b)(iii)** and **(b)(iv)**.

Present your results clearly.

[5]

(vi) V_X, R_X and R_Y are related by the expression

$$V_x (R_X + 2R_Y) = pR_Y + q$$

where *p* and *q* are constants.

Plot a suitable graph to determine values for *p* and *q*.

p = ...

q = ... [6]

(vii) Theory suggests that

$$q = R_X E$$

where E is the e.m.f. of the cell.

State and explain whether the results of your experiment support the suggested relationship. Justify your answer by comparing your experimental results with the value of R_X recorded in **(b)(ii)**.

....

....

....

....

.... [2]

(viii) It is also known that p decreases when E decreases.

Assuming that the relationship stated in **(b)(vii)** is true, sketch a new line on your graph grid to show the results you would expect if the experiment is repeated with a smaller E.

Label this line as T. [1]

[Total: 20]

4 A typical dragon boat requires 20 paddlers, 1 drummer and 1 steerer. Every time a crew member steps onto the dragon boat, it experiences vertical oscillations in water.

The frequency f of the oscillations of an object (such as the dragon boat) with mass m in solution of density ρ is given by the equation

$$f = k\, m^x \rho^y$$

where k, x and y are constants.

Design an experiment to determine the values of x and y.

You are provided with a bucket, a small empty plastic box, sugar and some small pebbles.

Draw a diagram to show the arrangement of your apparatus. Pay particular attention to:

- the equipment you would use
- the procedure to be followed
- how the frequency of oscillations and density of solution is measured
- the control of variables
- any precautions that should be taken to improve the accuracy of the experiment

Diagram

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....

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[Total: 12]