DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/01

Paper 1 Multiple Choice

September 2019

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.

DO **NOT** WRITE IN ANY BARCODES.

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.

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

Data

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

Formulae

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

1 Which of the following definitions is correct?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

2 A body is thrown vertically upwards in a medium in which the viscous drag cannot be neglected. If the times of flight for the upward motion t_u and the downward motion t_d (to return to the same level) are compared, then

A $t_d > t_u$, because the body moves faster on its downward flight and therefore the viscous force is greater.

B $t_d < t_u$, because the effect of the viscous force is greatest at the moment of projection.

C $t_d = t_u$, because effect of the viscous force is the same whether the body is moving upwards or downwards.

D $t_d > t_u$, because at a given speed the net accelerating force when the body is moving downwards is smaller than the retarding force when it is moving upwards.

3 A good driver is driving a car at 30 m s^{-1} on a lane when another bad driver travelling at a constant speed of 20 m s^{-1} swerves into the lane 20 m ahead. As soon as the good driver sees the car in front of him, he begins to brake.

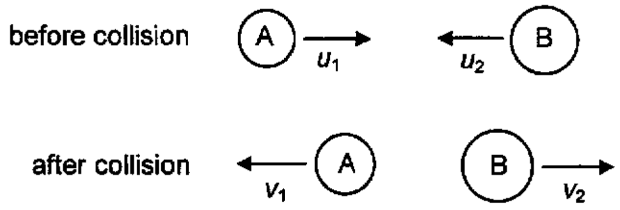
Assume that the deceleration is constant.

Determine the smallest deceleration to avoid hitting the rear of the car.

A 1.5 m s^{-2} **B** 2.5 m s^{-2} **C** 5.0 m s^{-2} **D** 12.5 m s^{-2}

4 Two spheres, A and B, are moving towards each other at speeds u_1 and u_2 respectively and make a head-on elastic collision. After the collision, Aand B move off with speeds v_1 and v_2 respectively, as shown.

u_1 is more than u_2 and v_2 is more than v_1.



What is the correct expression that equates the relative speed of approach to the relative speed of separation?

A $u_1 + u_2 = v_1 + v_2$

B $u_1 + u_2 = v_2 - v_1$

C $u_1 - u_2 = v_1 + v_2$

D $u_1 - u_2 = v_2 - v_1$

5 A 20 g object travelling to the right at 8.0 m s^{-1} collides head-on with a 10 g object travelling to the left at 7.0 m s^{-1}.

Determine the loss in kinetic energy for both the 20 g and 10 g objects during the collision if the collision was perfectly inelastic.

A 3.0 kJ **B** 0.75 kJ **C** 3.0 J **D** 0.75 J

6 A 50 g piece of ice is added to a cup containing 250 cm^3 of water.

Given that the density of water and ice is 1000 kg m^{-3} and 900 kg m^{-3} respectively, after all the ice has melted, the volume of water in the cup will

A remain unchanged.

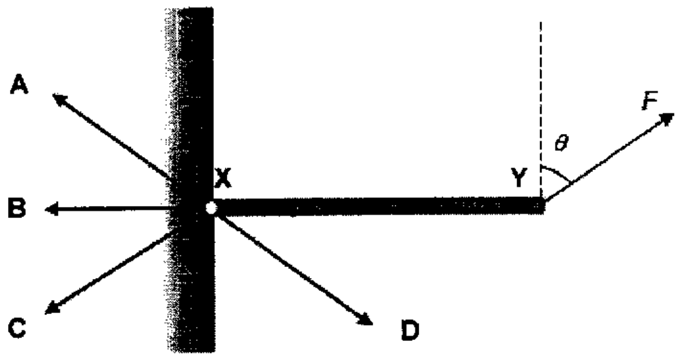
B increase by 17 %.

C increase by 20 %.

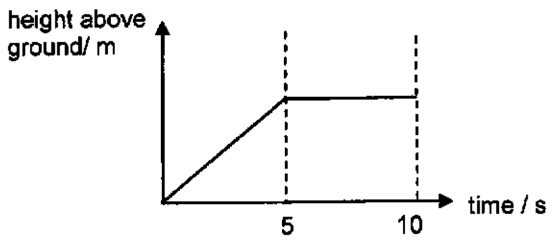
D increase by 22 %.

7 A uniform rod **XY** is freely hinged to the wall at **X**. It is held horizontal by a force F acting from **Y** at an angle θ to the vertical as shown in the diagram.

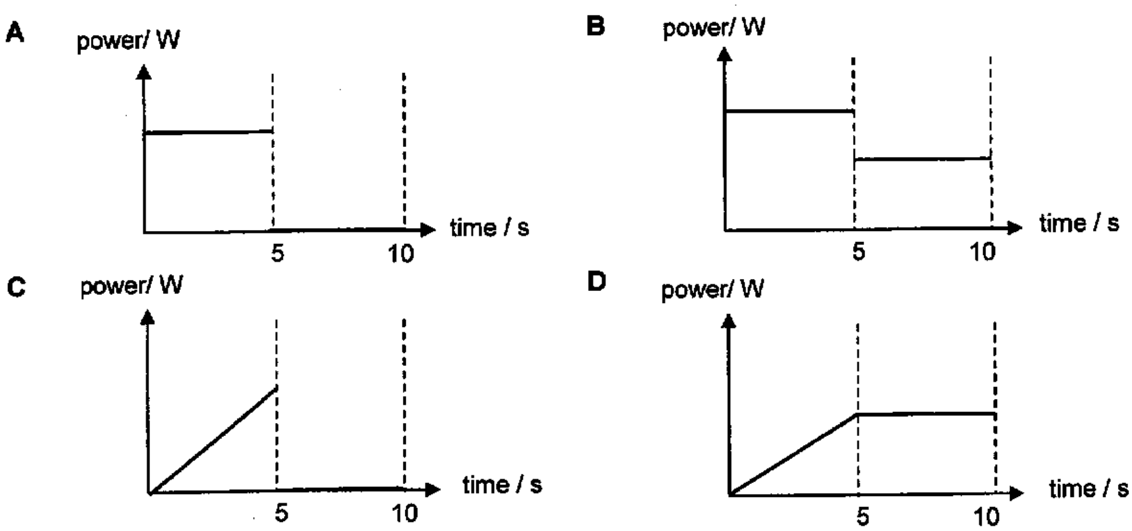
Which of the four options (**A**, **B**, **C** and **D**) best shows the direction of the force exerted by the rod on the wall?



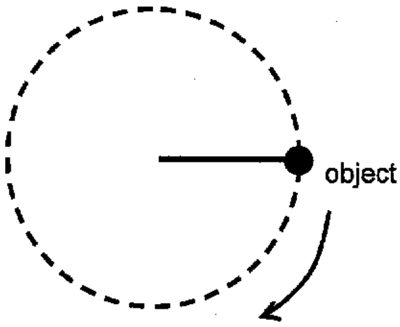
8 A crane lifts a load at constant speed vertically for the first five seconds. It then holds it at a fixed height for another five seconds. The variation of the height of the load above the ground with time is shown in the graph below.



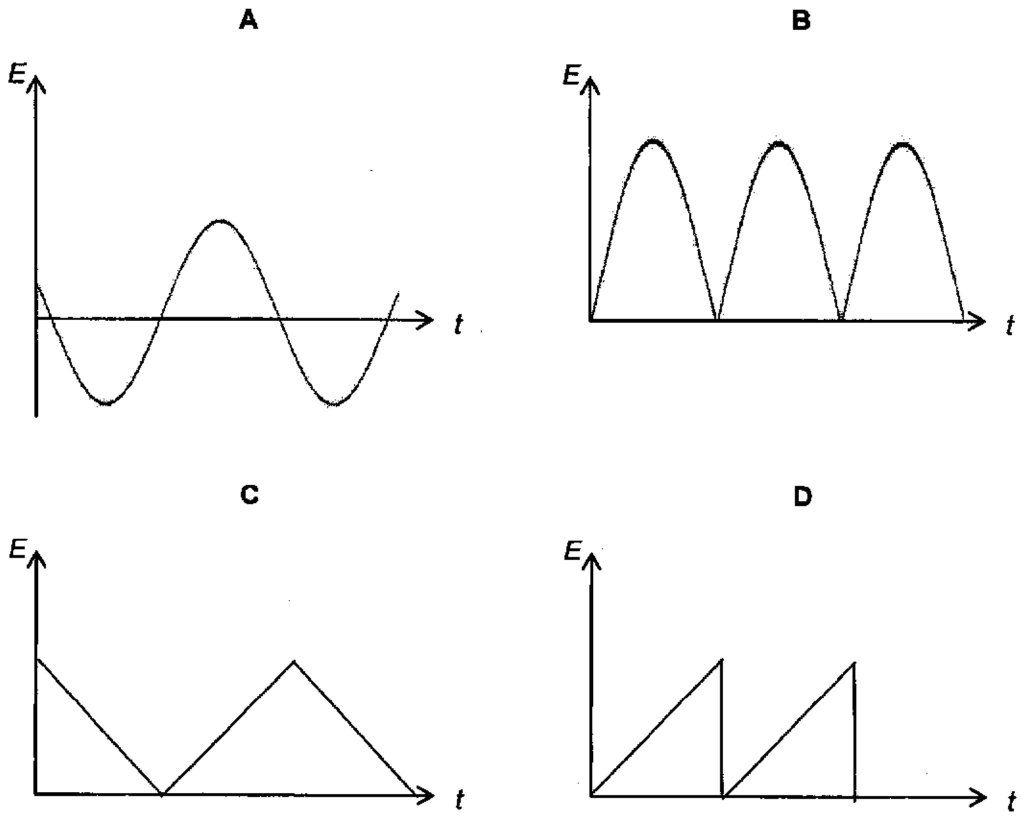
Which of the following graphs shows the variation of power supplied to the load with time?



9 An object attached to a rigid rod moves in a uniform circular motion in a vertical plane as shown.



Which of the following shows the variation with time t of its gravitational potential energy E?



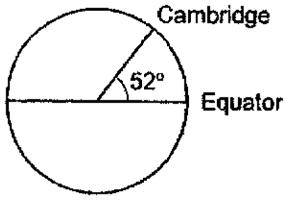
10 The drag force acting on a car moving at a speed v through still air is proportional to v^2.

When the car is travelling at 20 m s^{-1} on a level road, the power required to overcome the drag force is 4800 W.

What power is required when the car travels at 25 m s^{-1}?

A 6000 W **B** 7500 W **C** 8000 W **D** 9400 W

11 Singapore is on the Equator. Cambridge is at a latitude of 52° N, as shown in the diagram.



A student at Singapore has a centripetal acceleration a_s because of the Earth's rotation about its axis. The centripetal acceleration of another student at Cambridge is a_c.

What are the magnitudes of the centripetal accelerations?

(radius of Earth = 6.4×10^6 m; angular velocity of Earth about axis = 7.3×10^{-5} rad s^{-1})

	a_s / ms^{-2}	a_c / ms^{-2}
A	3.4×10^{-2}	2.1×10^{-2}
B	3.4×10^{-2}	2.7×10^{-2}
C	3.4×10^{-2}	3.4×10^{-2}
D	4.7×10^{2}	4.7×10^{2}

12 Which statement about geostationary orbits is **false**?

A A geostationary orbit must be directly above the equator.

B All satellites in a geostationary orbit must have the same mass.

C The period of a geostationary orbit must be 24 hours.

D There is only one possible radius for a geostationary orbit.

13 Four different solids **A**, **B**, **C** and **D** of equal masses at 20 °C are separately heated at the same rate. Their melting points and specific heat capacities are as shown in the table below.

Which of these solids will be the third to start to melt?

Solid	Melting point/ °C	Specific heat capacity/ J kg^{-1} K^{-1}
A	150	600
B	80	1200
C	300	250
D	100	800

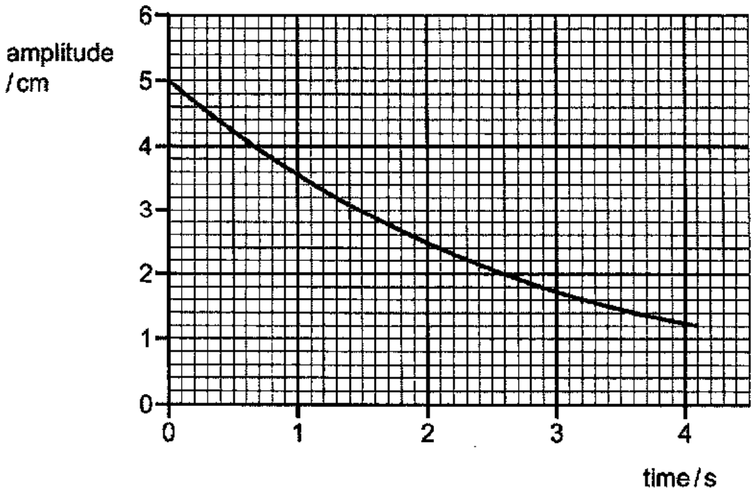
14 Container X contains neon and container Y contains argon. The two containers are identical and the two gases are at the same temperature. The pressure in X is twice that in Y.

What is the ratio of the mean kinetic energy of a neon molecule to the mean kinetic energy of an argon molecule?

[The relative atomic masses of neon and argon are 20 and 40 respectively.]

A 0.5 **B** 1 **C** 2 **D** 4

15 The graph shows how the amplitude of a simple pendulum decays with time from an initial amplitude of 5.0 cm.



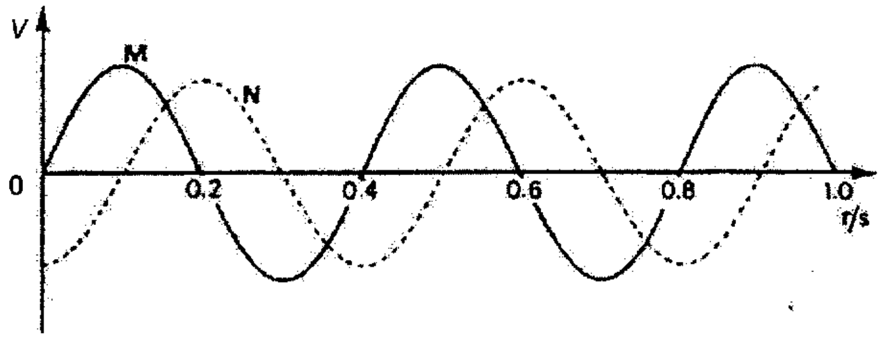
What is the fraction of the initial energy that has been lost in the first 4.0 s?

A $\frac{1}{16}$ **B** $\frac{1}{4}$ **C** $\frac{3}{4}$ **D** $\frac{15}{16}$

16 A small mass executes s.h.m. about a point O with amplitude a and period T. Its displacement from O at time $T/8$ after passing through O is

A $\frac{a}{8}$ **B** $\frac{a}{2\sqrt{2}}$ **C** $\frac{a}{2}$ **D** $\frac{a}{\sqrt{2}}$

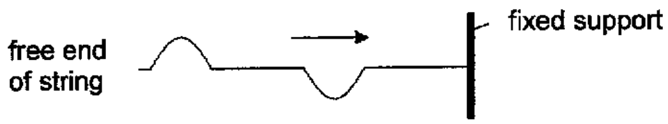
17 Two sinusoidal voltages of the same frequency are shown in the diagram.



What is the phase lead of N over M, in rad, between the voltages?

A $-\frac{\pi}{2}$ **B** $+\frac{\pi}{2}$ **C** $-\frac{\pi}{4}$ **D** $+\frac{\pi}{4}$

18 A string is held horizontally with one end attached to a fixed support. Two pulses are created at the free end of the string. The pulses are moving towards the fixed support as shown in the diagram.



Which one of the following is a possible subsequent picture of the string?

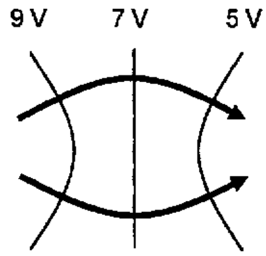
AB

CD

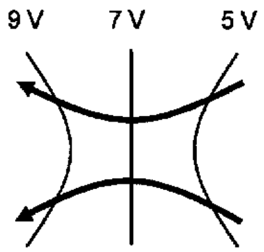
19 In the following diagrams, the thin lines show equipotential lines and the bold arrows show the electric field lines and their directions.

Which set of equipotential lines and field lines is possible?

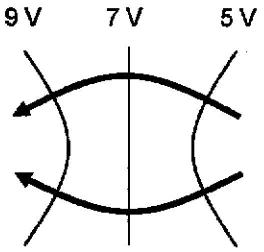
A



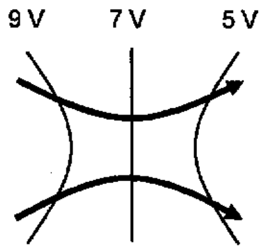
B



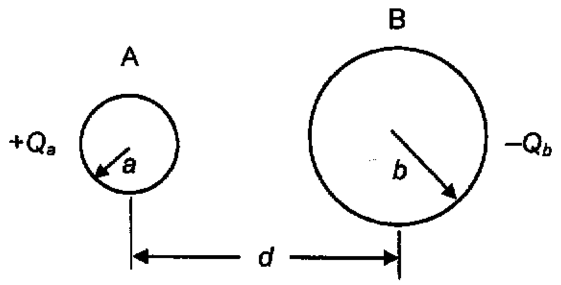
C



D



20 A and B are two large conducting spheres, of radii a and b and carrying charges $+Q_a$ and $-Q_b$ respectively. They are placed a short distance d apart.



Which of the following statements about the magnitude of electrostatic forces F, between the spheres is true?

A $F = \dfrac{Q_a Q_b}{4\pi\varepsilon_o d^2}$

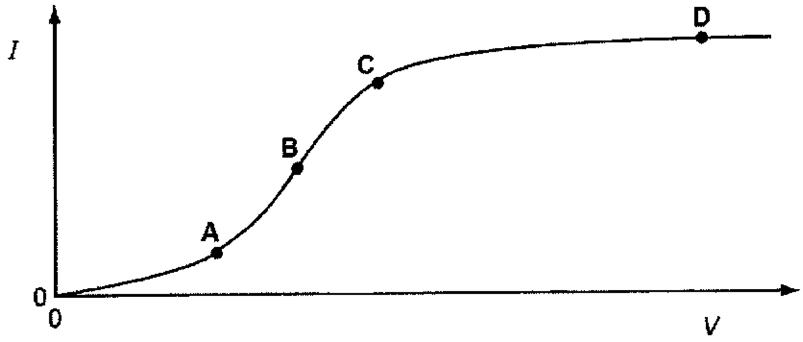
B $F = \dfrac{Q_a Q_b}{4\pi\varepsilon_o (d-a-b)^2}$

C $F > \dfrac{Q_a Q_b}{4\pi\varepsilon_o d^2}$

D $F > \dfrac{Q_a Q_b}{4\pi\varepsilon_o (d-a-b)^2}$

21 The graph shows how the electric current I through a conducting liquid varies with the potential difference V across it.

At which point on the graph does the liquid have the smallest resistance?



22 Which statement about electrical resistivity is correct?

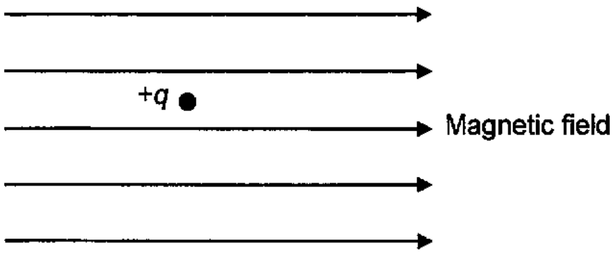
A Theresistivity of a material is numerically equal to the resistance in ohms of a cube of that material, the cube being of side length one metre and the resistance being measured between opposite faces.

B The resistivity of a material is numerically equal to the resistance in ohms of a one metre length of wire of that material, the area of cross-section of the wire being one square millimetre and the resistance being measured between the ends of the wire.

C The resistivity of a material is proportional to the cross-sectional area of the sample of the material used in the measurement.

D The resistivity of a material is proportional to the length of the sample of the material used in the measurement.

23 A positive charge $+q$ is held at rest in a uniform magnetic field, and then released. The effect of gravity on the charge can be ignored.



How does the charge move after it is released?

A The charge moves to the right with constant velocity.

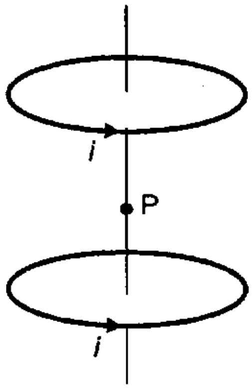
B The charge moves in a circle with constant speed.

C The charge moves in a circle with increasing speed.

D The charge stays at rest.

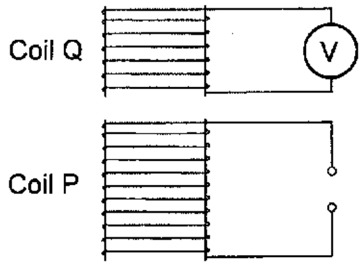
24 Two identical loops of wire carry identical currents i. The loops are located with their centres vertically above each other as shown in the diagram.

Which arrow best represents the direction of the magnetic field at the point P, midway between the loops?

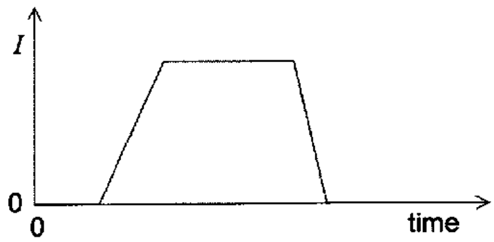


A ↓ **B** → **C** ↑ **D** zero

25 Two coils P and Q are arranged as shown below.

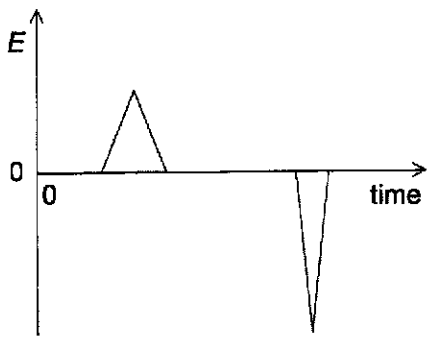


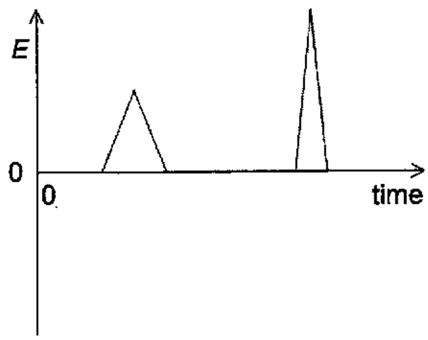
Coil Q is connected to a sensitive voltmeter. The current I in coil P is varied as shown below.



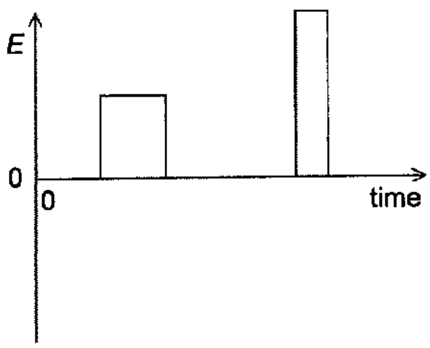
Which of the following graphs best shows the variation with time of the e.m.f. E induced in the coil Q?

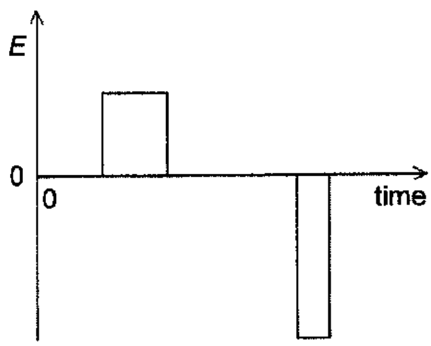
AB



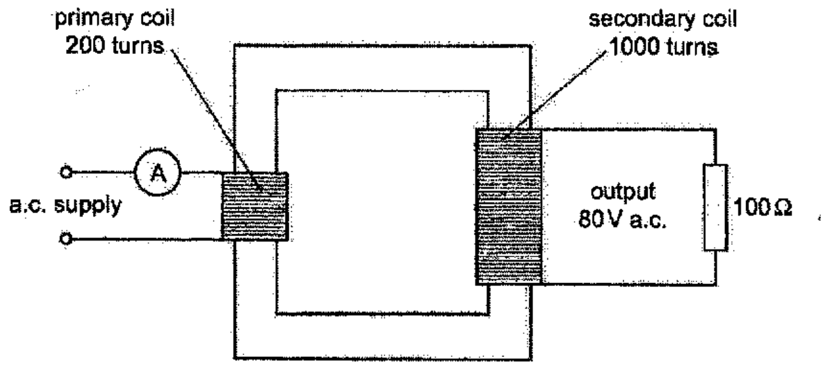


CD





26 Anideal transformer is connected as shown to a sinusoidal a.c. supply.



What is the reading on the ammeter?

A 0.16 A **B** 0.80 A **C** 2.8 A **D** 4.0 A

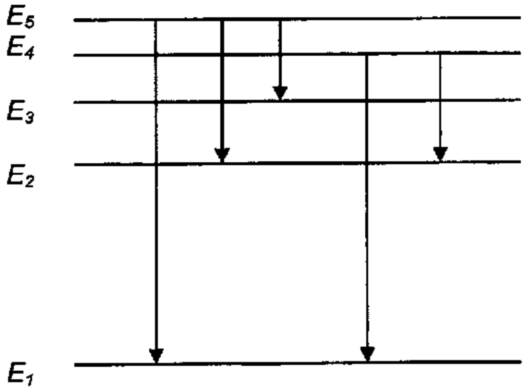
27 A mains electricity supply has a root-mean-square voltage of 240 V and a peak voltage of 340 V. When connected to this supply, a heater dissipates energy at a rate of 1000 W.

The heater is then connected to a 340 V d.c. supply and its resistance remains the same.

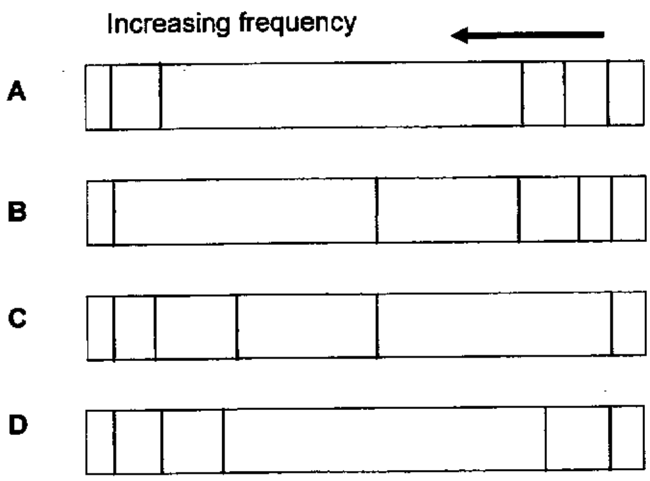
At what rate does the heater now dissipate energy?

A 1000W **B** 1400 W **C** 2000 W **D** 2800 W

28 The figure below shows five energy levels of an atom, E_1 being much lower than the other four. Five transitions between the levels are indicated, each of which produces a photon ofdefinite energy and frequency.

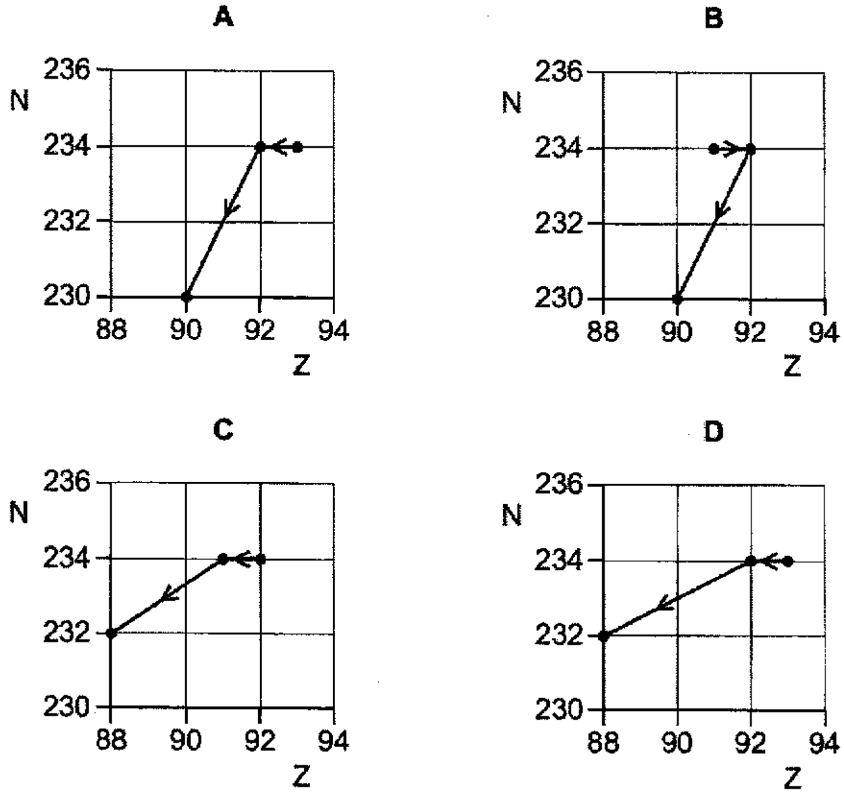


Which one of the following spectra below best corresponds to the set of transitions indicated?



29 A radioactive nucleus is formed by β-decay. This nucleus then decays by α-emission.

Which graph of nucleon number N plotted against proton number Z shows the β-decay followed by α-emission?



30 Nuclei of atoms can exist in excited states.

The mass of a nucleus in its ground state is 59.9308 *u*.

When this nucleus returns from an excited state to the ground state, a gamma ray photon of energy 2.13×10^{-13} J is emitted.

What is the mass of a nucleus in the excited state?

A 59.9280 *u*

B 59.9294 *u*

C 59.9322 *u*

D 59.9337 *u*

- END OF PAPER–

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DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

September 2019

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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

Answer **all** questions.

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

For Examiner's Use	
1	8
2	8
3	9
4	10
5	9
6	8
7	10
8	18
Total	80

This document consists of **22** printed pages and **0** blank page.

Data

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

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
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	=	$\frac{Q}{4\pi\varepsilon_o r}$
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 denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 A ball is projected with a horizontal velocity of 1.1 m s^{-1} from point A at the edge of a table, as shown in Fig. 1.1.

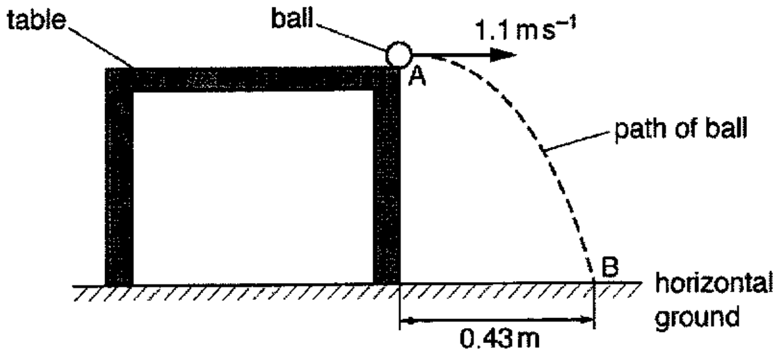


Fig. 1.1

The ball lands on the horizontal ground at point B which is a distance of 0.43 m from the base of the table. Air resistance is negligible.

(a) Calculate the time taken for the ball to fall from A to B.

time = ... s [1]

(b) Calculate the magnitude of the displacement of the ball at point B from point A.

displacement = ... m [3]

For Examiner's Use

(c) The ball leaves the table at time t =0.

For the motion of the ball between points A and B, sketch graphs on Fig. 1.2 to show the variation with time t of

(i) the acceleration a of the ball,

(ii) the vertical component s_v of the displacement of the ball from A.

Numerical values are not required.

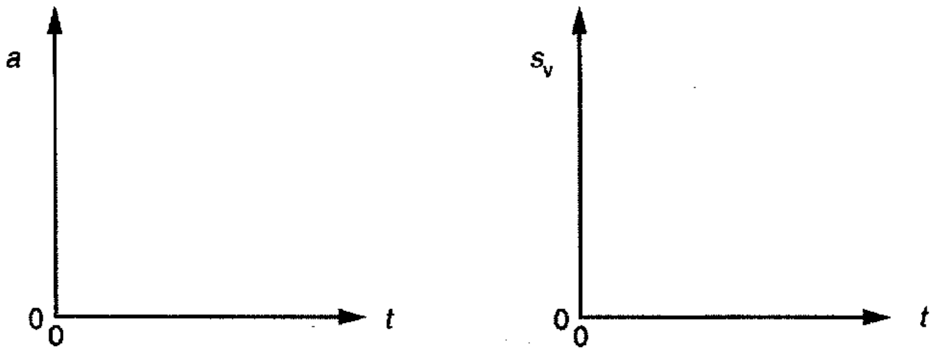


Fig. 1.2

[2]

(d) Explain why the distance travelled by the ball is different from the magnitude of the displacement of the ball.

....

....

....[1]

(e) Another ball of greater mass is projected from the table with the same horizontal velocity of 1.1 m s^{-1}. Air resistance is still negligible.

State and explain the effect, if any, of the increased mass on the time taken for the ball to fall to the ground.

....

....[1]

For Examiner's Use

2 Domestic washing machines often incorporate washing, rinsing, spinning and drying of clothes. This question is about the spin-dry function of a washing machine.

(a) The inner drum of the machine into which the clothes are placed has quite large holes in it.

Explain how, when the clothes are being spin-dried, the water gets out from the clothes and through the holes.

....

....

....

....

....

....[3]

(b) One of the spin speeds in one model of washing machine was listed as 1000 rpm (revolutions per minute).

Calculate the largest resultant force that could be exerted on a wet jacket of mass 0.500 kg given that the radius of the spinning drum is 12.5 cm.

largest resultant force = ... N [3]

For Examiner's Use

(c) If clothes are unevenly distributed in awashing machine, it vibrates slightly as it rotates.

The drumsof a washing machine are suspended from the casing by springs, at the top and bottom, as shown in Fig. 2.1.

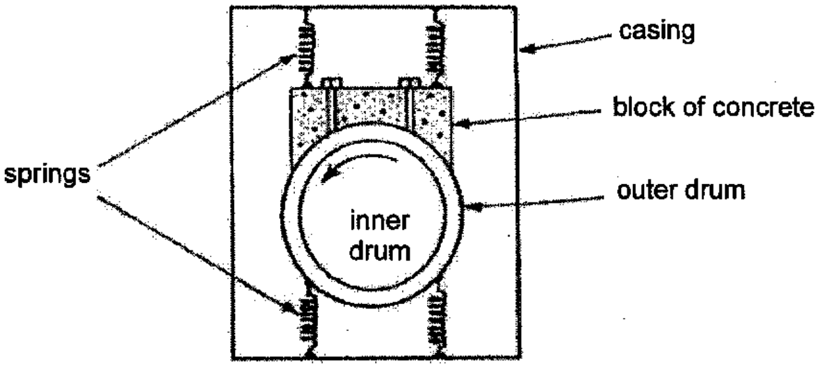


Fig. 2.1

Suggest and explain the purpose of these springs.

....

....

....

....

....[2]

For Examiner's Use

3 (a) State the meaning of the term *internal energy* of a system.

....

....

....[2]

(b) An ideal gas undergoes a cycle of changes A → B → C → A, as shown in Fig. 3.1.

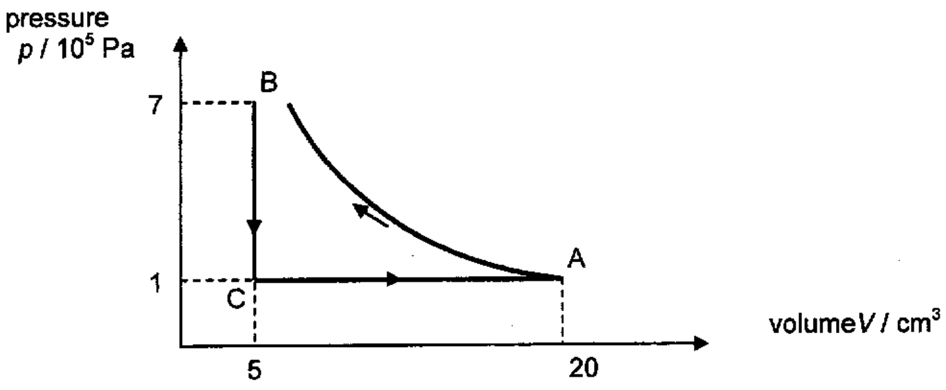


Fig. 3.1

(i) Calculate the work done by the gas during the change C → A.

work done by gas = ... J [2]

For Examiner's Use

(ii) Fig 3.2 is a table of energy changes during one cycle. Complete Fig. 3.2. [3]

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J
A → B	zero	4.2	
B → C	-8.5		
C → A			

Fig. 3.2

(c) Heat is a type of energy, but temperature is not a type of energy.

State two other differences between heat and temperature.

1. ....

....

2. ....

....[2]

4 **(a)** A mass is undergoing oscillations in a vertical plane.

The variation with displacement *x* of the acceleration *a* of the mass is shown in Fig. 4.1.

For Examiner's Use

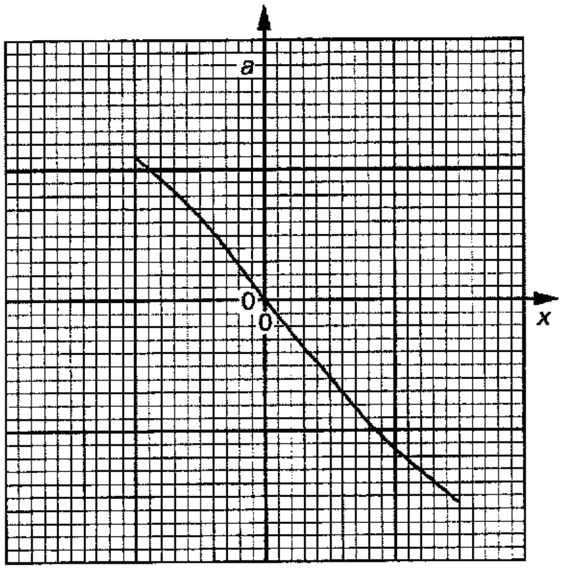


Fig. 4.1

Use Fig. 4.1 to state two reasons why the oscillations are not simple harmonic.

1. ....

....

2. ....

....[2]

(b) To illustrate simple harmonic motion, a student attaches a trolley to two similar stretched springs as shown in Fig. 4.2.

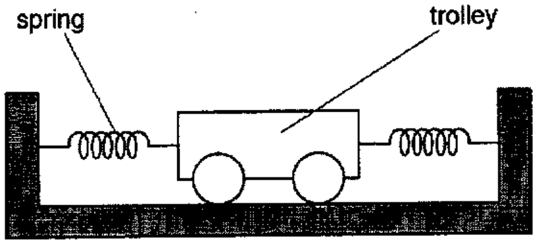


Fig. 4.2

The trolley has mass m of 810 g.
The trolley is displaced along the line joining the two springs and then released. The subsequent acceleration a of the trolley is given by the expression

$$a = -\frac{2kx}{m}$$

where the spring constant k for each of the springs is 64 N m^{-1} and x is the displacement of the trolley.

(i) Show that the frequency of oscillation of the trolley is 2.0 Hz. [2]

(ii) The maximum displacement of the trolley is 1.6 cm.
Calculate the maximum speed of the trolley.

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

(iii) As the trolley passes the position where x = 0 cm, a mass is dropped vertically from a small height above the trolleyand sticks to the trolley.

State and explain the change, if any, that occurs in the maximum speed and in the amplitude of the subsequent oscillations of the trolley.

speed..

....[2]

amplitude..

....[2]

5 An α-particle is emitted from a radium nucleus with a kinetic energy of 5.75 MeV.

The α-particle travels in a vacuum directly towards a gold ($^{197}_{79}Au$) nucleus, as illustrated in Fig. 5.1.

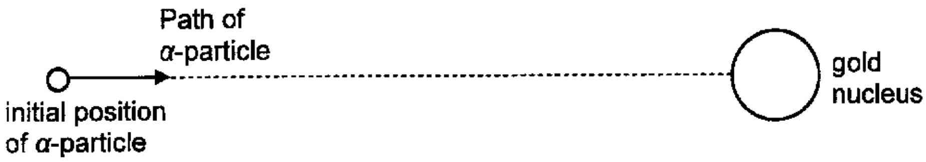


Fig. 5.1

(a) Explain why, as the α-particle approaches the gold nucleus, it comes to rest.

....

....

....[2]

(b) For the closest approach of the α-particle to the gold nucleus determine

(i) their separation,

separation = ... m [2]

(ii) the magnitude of the force on the α-particle.

force= ....N [1]

(c) State two assumptions made in the determination in **(b)**.

For Examiner's Use

1. ....

....

2. ....

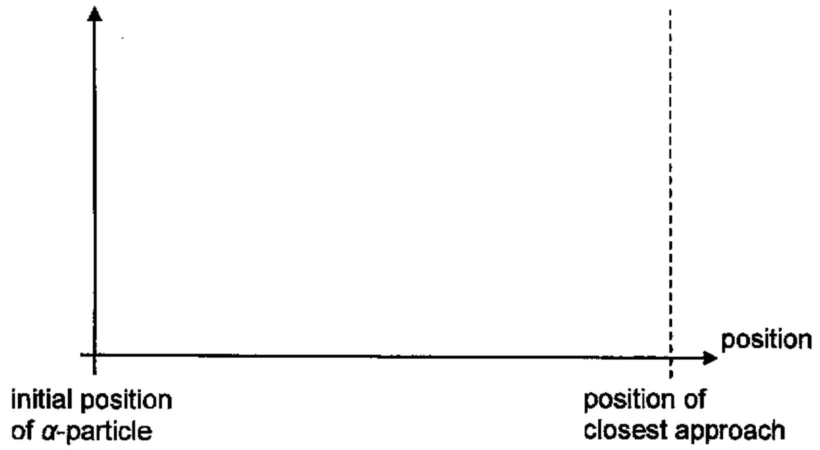
....[2]

(d) The α-particle travels from the initial position to the position of closest approach to the gold nucleus.

On Fig. 5.2, sketch the variation with position of

(i) the electric potential energy between the α-particle and the gold nucleus, labelled as *EPE*,

(ii) the kinetic energy of the α-particle, labelled as *KE*.



[2]

Fig. 5.2

6 **(a)** Explain how an electric field and a magnetic field may be used for the velocity selection of charged particles. You may draw a diagram if you wish.

For Examiner's Use

....

....

....

....[3]

(b) An ion of charge Q and mass m is moving with speed v normal to a magnetic field of magnetic flux density B. The ion will move in a circular path of radius r.

Derive an expression for r in terms of Q, m, v and B. [2]

(c) The isotopes strontium-87 ($^{87}_{38}Sr$) and strontium-86 ($^{86}_{38}Sr$) are found in samples of Moon rock. Particles of a sample of Moon rock are vaporised, releasing strontium isotopes that are sent into the velocity selector of a mass spectrometer as shown in Fig. 6.1. The

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positive ions of strontium isotopes then pass through a uniform magnetic field which makes them follow separate circular paths.

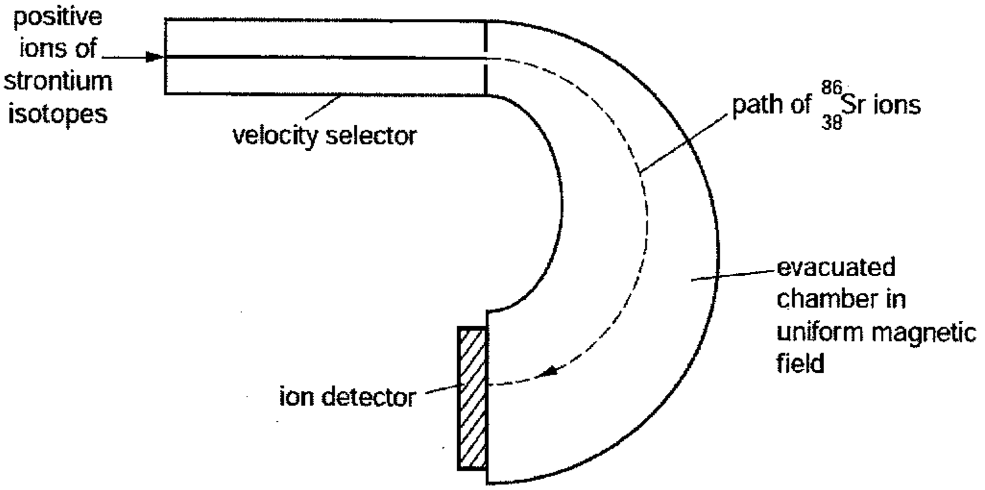

Fig. 6.1

(i) On Fig. 6.1, sketch a possible path for the strontium-87 ($^{87}_{38}$Sr) ions. [1]

(ii) The velocity selector allows strontium ions of speed 7.6×10^5 m s^{-1} to enter the evacuated chamber in uniform magnetic field of magnetic flux density 680 mT.

Determine the change in the magnetic flux density needed to make the strontium-87($^{87}_{38}$Sr)ions follow the same path taken initially by the strontium-86 ions.

change in magnetic flux density = ... T [2]

7 An evacuated tube contains two plane, parallel, metal electrodes, one of which is an emitter of electrons and the other a collector. When the emitter is illuminated with electromagnetic radiation of photon energy 4.7 eV at a power of 3.8 mW, photoelectrons are emitted.

The potential difference V between collector and emitter is adjusted, and the photocurrent I is measured.

Fig. 7.1 is a graph of the variation with the potential difference V of the photocurrent I.

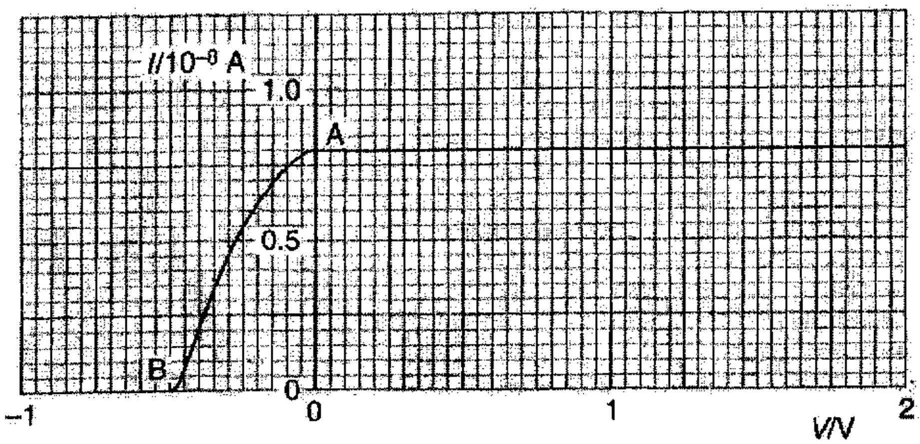

Fig. 7.1

(a) Calculate the rate at which photons are incident on the emitter.

rate = ... s^{-1} [2]

(b) Calculate the maximum rate at which electrons leave the emitter.

maximum rate = ... s^{-1} [1]

(c) Suggest two reasons to explain for the difference between your answers to **(a)** and **(b)**.

1. ....

....

2. ....

....[2]

(d) Calculate the maximum speed at which electrons leave the emitter.

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

(e) The intensity of illumination is then increased and the experiment repeated. Sketch, on Fig. 7.1, the new variation with the potential difference V of the photocurrent I. [2]

8 Prior to the alpha-scattering experiment conducted by Rutherford, the plum pudding model of the atom was widely assumed. In this model, the positive charge of the atom was thought to be evenly spread out through the entire volume of the atom, and its electrons vibrating about fixed positions within this sphere of charge.

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In the experiment conducted by Rutherford, alpha particles are directed towards a thin gold foil as shown in Fig. 8.1. A detector is used to record the number of alpha particles scattered by the foil. The experiment is performed in a vacuum. The detector can be rotated such that it is able to capture the alpha particles at various scattering angles θ. The variation with the scattering angle θ of the number of alpha particles N striking the detector are shown in Fig. 8.2. The vertical axis in Fig. 8.2 is logarithmic.

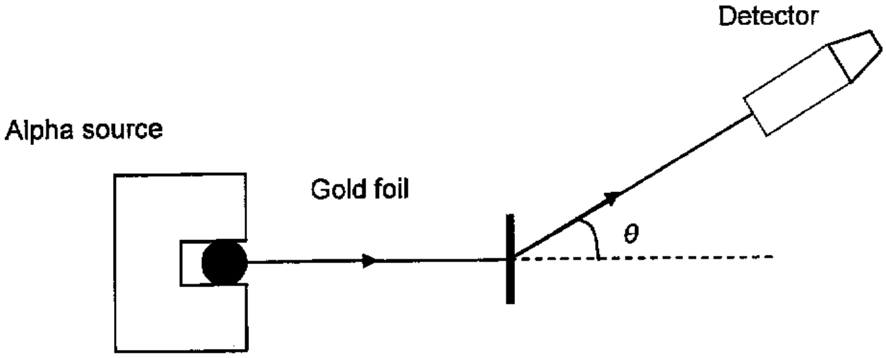


Fig. 8.1

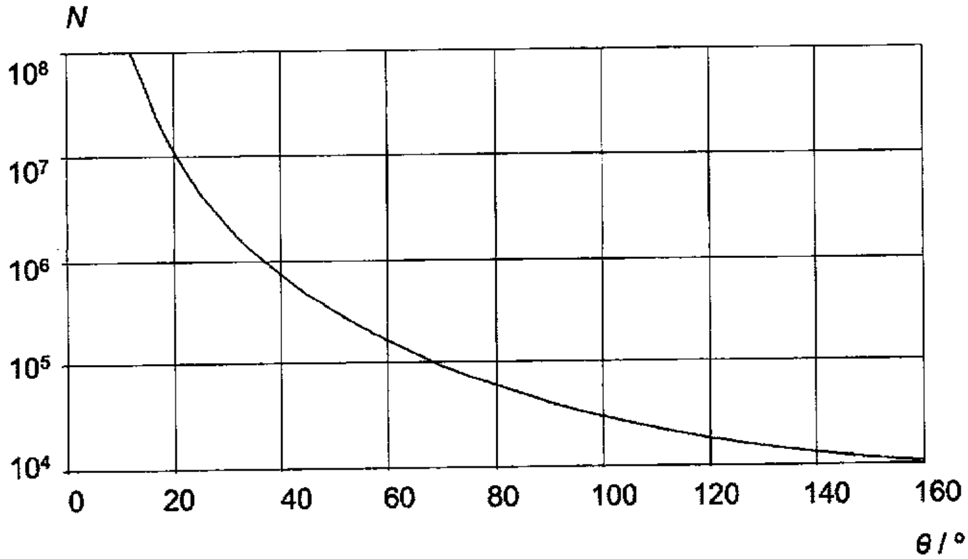


Fig. 8.2

(a) State and explain why

(i) the experiment is not conducted in air, and

....

....

....[2]

(ii) the vertical axis is logarithmic.

....

....

....[2]

(b) On Fig. 8.2, sketch the results expected if the structure of the atom was indeed that of a plum pudding. [1]

(c) It is thought that the number of alpha particles N striking the detector is directly proportional to $(\sin(\theta/2))^n$ where n is an integer. The variation with θ between 60° to 80° of N is shown in Fig. 8.3.

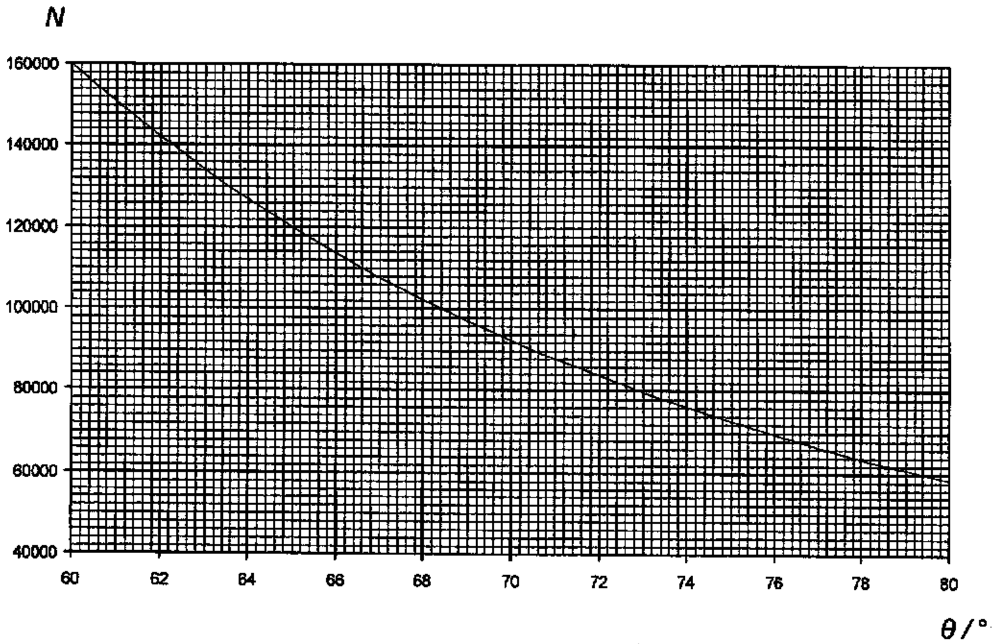
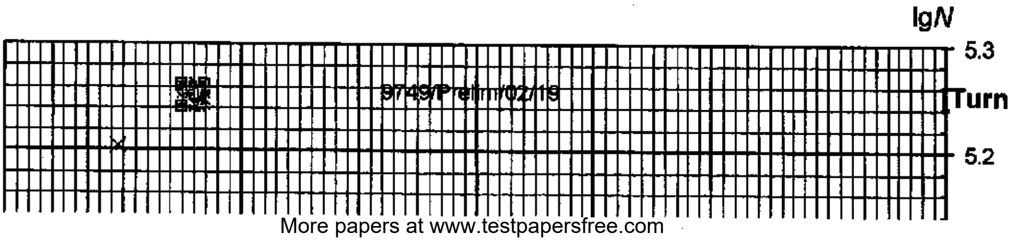


Fig. 8.3

Some corresponding values of lg (sin (θ/2)) and lg N are plotted on the graph of Fig. 8.4.



For Examiner's Use

Fig. 8.4

(i) On Fig. 8.4,

1. plot the point corresponding to $\theta = 72°$, and

2. draw the best-fit line for all plotted points. [2]

(ii) Determine the gradient of the line drawn in **c(i)2**.

gradient = ... [2]

(iii) Hence,deduce a value for n. Show your working clearly.

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n = ... [2]

(d) The experiment is repeated using target foils made of 3 other different elements- tungsten W, iridium Ir and platinum Pt. The results for the angles between 65° to 74° are shown in Fig. 8.5 together with that of gold Au.

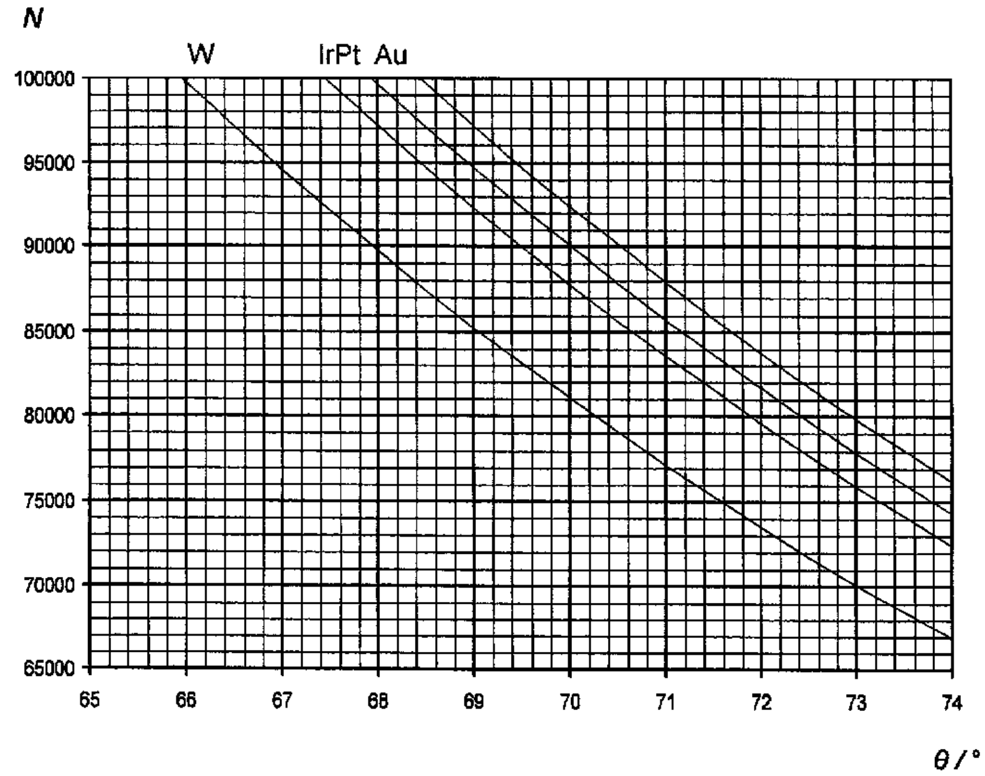

Fig. 8.5

Without drawing a further graph, show that, at θ = 70°, the value of N is directly proportional to Z^2, where Z is the proton number of the target foil.

The proton number of W, Ir, Pt and Au are 74, 77, 78 and 79 respectively. [3]

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(e) The overall relationship between N, Z and θ may be expressed as

$$N = kZ^2(\sin(\theta / 2))^n$$

where k is a constant.

Suggest twophysical quantities that determine the value of k.

1. ....

....

2. ....

....[2]

(f) The experiment is repeated with a foil made from a heavier isotope of gold.

State and explain how the results in Fig. 8.2 would be different.

....

....

....[2]

END OF PAPER

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME	

CLASS		INDEX NUMBER	

PHYSICS

9749/03

Paper 3 Longer Structured Questions

September 2019

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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 a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

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 a half hours on Section A and half an hour on Section B.

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 questionor part question.

For Examiner's Use	
1	5
2	12
3	10
4	7
5	12
6	6
7	8
8	20
9	20
Total	80

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

Data

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

Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
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	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_0^2 - x^2}$
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 denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A

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

1 (a) Make reasonable estimates of the following quantities.

(i) The mass of an adult.

mass = ...kg

(ii) The weight of a hand phone at Earth's surface.

weight = ...N

(iii) The energy required for an adult to climb up to the top row in the school auditorium.

energy = ...J

(iv) The pressure on your feet at a depth of 1.0 m in an adult swimming pool.

pressure = ...Pa

[2]

(b) (i) The theory of gas flow through small diameter tubes at low pressures is an important consideration of high vacuum technique.

One equation which occurs in the theory is

$$Q = \frac{kr^3(p_1 - p_2)}{L}\sqrt{\frac{M}{RT}}$$

where k is a number without units, r is the radius of the tube, p_1 and p_2 are the pressures at each end of the tube of length L, M is the molar mass of the gas, R is the molar gas constant and T is the thermodynamic temperature.

Use the equation to find the base SI units of Q.

base SI units of Q= .... [2]

For Examiner's Use

(ii) The value of r for the equation in **(b)(i)** is $(1.37 \pm 0.05) \times 10^{-4}$ m.

What percentage uncertainty does this introduce into the value of Q?

percentage uncertainty= .... % [1]

2 **(a)** State the two conditions necessary for a rigid body to be in equilibrium.

1. ....

....

2. ....

....[2]

(b) A horizontal force F is applied on a cube which remains stationary, as shown in Fig. 2.1. G is the centre of mass of the cube and is located at its geometric centre. The line of action of F is midway between G and the top of the cube.

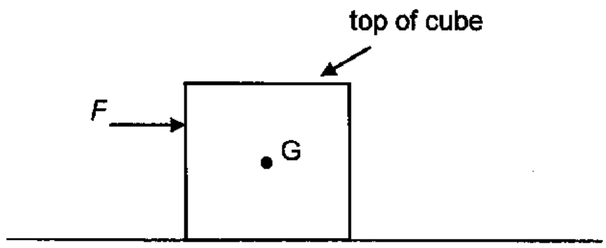


Fig. 2.1

(i) On Fig. 2.1, draw the following forces acting on the cube:

1. Weight of the cube, labelled as W. [1]

2. Resultant force, labelled as R, that the ground exerts on the cube. [2]

For Examiner's Use

(ii) If the mass of the cube is 200 g,calculate the maximum value of F such that the cube does not rotate.

maximum valueof F= .... N [2]

(c) A spring has an unstretched length of 8.0 cm. One end of the spring is fixed to a support and a mass of 140 g is attached to the other end of the spring. The length of the spring is now 10.8 cm.

Calculate the force constant of the spring.

force constant = ... N m^{-1} [2]

(d) The cube in **(b)** is now attached to one end of the spring in **(c)** and is submerged in a liquid, as shown in Fig. 2.2. The length of the spring is now 10.3 cm.

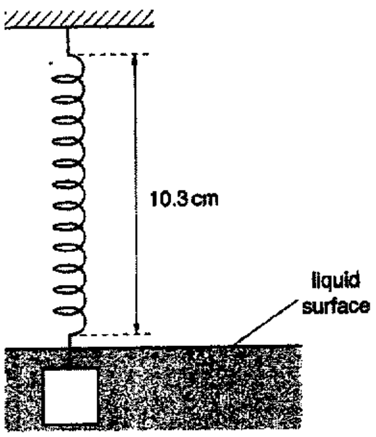


Fig. 2.2

(i) Show that the upthrust acting on the cube is approximately 0.83 N. [1]

(ii) The cube is made of concrete which has a density of 2.4 g cm^{-3}.

Determine the density of the liquid.

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

3 **(a)** Define *gravitational potential energy*.

....

....

....[2]

For Examiner's Use

(b) Fig. 3.1 shows part of the orbit of a satellite round the Earth.

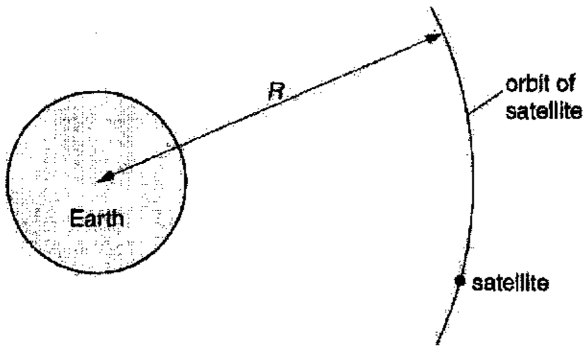


Fig. 3.1

The mass M of the Earth is 6.0×10^{24} kg. It may be assumed that the gravitational field of the Earth is the same as that of a point mass M situated at the centre of the Earth.

(i) On Fig. 3.1 show, by means of an arrow, the direction of the gravitational force on the satellite. **[1]**

(ii) Explain why the satellite does not move in the direction of the gravitational force.

....

....

....**[1]**

(iii) Show that v, the linear speed of the satellite in its orbit of radius R, is given by the expression

$$v = \sqrt{\frac{GM}{R}}$$

where G is the gravitational constant. **[1]**

For Examiner's Use

(c) The satellite is orbiting the Earth with a radius R of 6610 km at a speed v of 7780 m s^{-1}.

The satellite is boosted into a higher orbit of radius 6890 km. Determine the speed of the satellite in the new orbit.

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

(d) The satellite has a mass of 120 kg. Using the data in **(c)**, calculate the change in

(i) kinetic energy, and

change in kinetic energy = ……………………………… J [1]

(ii) gravitational potential energy.

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

4 **(a)** Explain why exposure to steam at 100 °C produces a more severe burn than exposure to the same amount of hot water at 100 °C.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(b) For each of the following statements, explain whether it is correct, stating clearly your reasons.

(i) The specific latent heat of fusion of a substance is always less than the specific latent heat of vaporisation of the substance.

....

....

....

....[2]

(ii) For the same mass, volume and temperature, the pressure exerted by a real gas is the same as that exerted by an ideal gas.

....

....

....

....[2]

5 (a) Two identical filament lamps are connected in series and then in parallel to a battery of electromotive force (e.m.f.) 12 V and negligible internal resistance, as shown in Fig. 5.1a and Fig. 5.1b respectively.

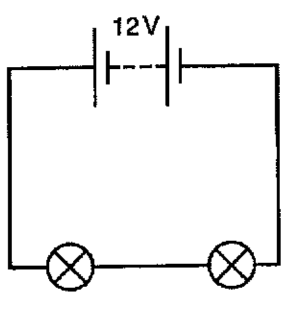


Fig. 5.1a

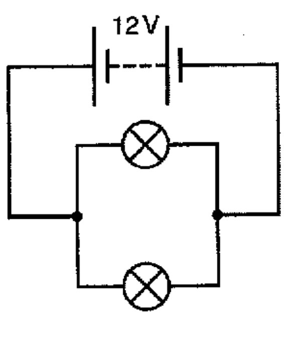


Fig. 5.1b

For Examiner's Use

The I-V characteristic of each lamp is shown in Fig. 5.2.

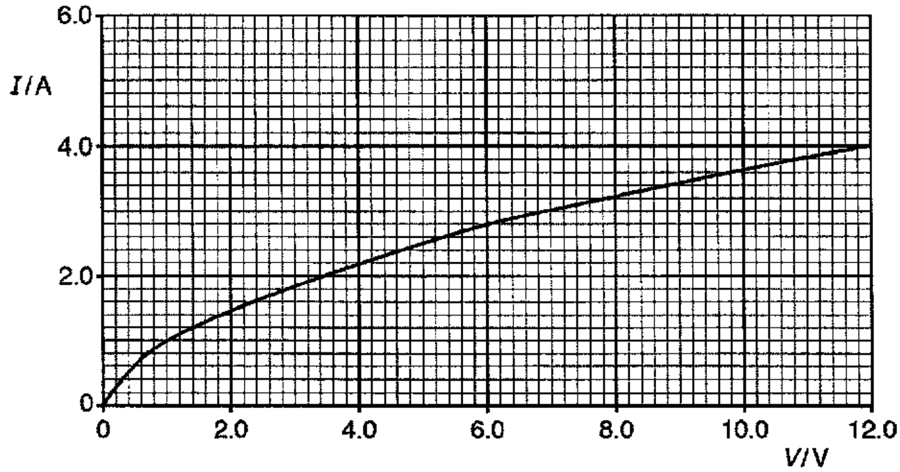


Fig. 5.2

(i) Use Fig. 5.2 to determine the current through the battery in the

1. circuit of Fig. 5.1a,

current = ... A

2. circuit of Fig. 5.1b.

current = ... A [2]

(ii) Calculate the total resistance in the

1. circuit of Fig. 5.1a,

resistance = ... Ω

2. circuit of Fig. 5.1b.

resistance = ... Ω [2]

(iii) Calculate the ratio

$$\frac{\text{power dissipated in a lamp in the circuit of Fig. 5.1a}}{\text{power dissipated in a lamp in the circuit of Fig. 5.1b}}$$

ratio = ... [2]

(b) A metal wire BD has a length of 100 cm and resistance of 4.0 Ω. The ends B and D of the wire are connected to a cell X as shown in Fig. 5.3.

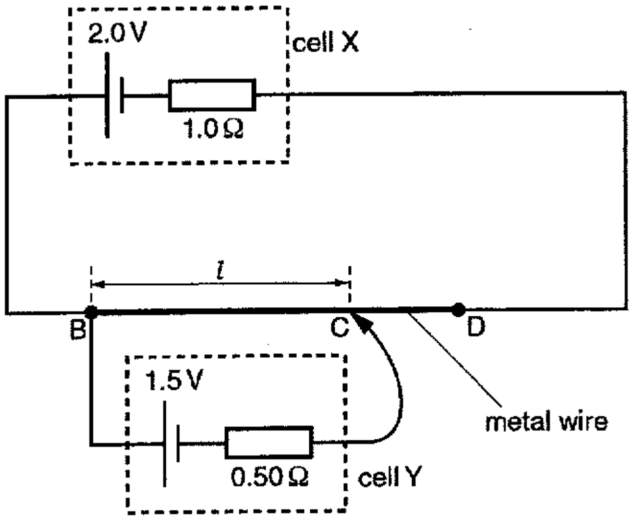


Fig. 5.3

The cell X has an e.m.f. of 2.0 V and internal resistance of 1.0 Ω.

A cell Y of e.m.f. 1.5 V and internal resistance 0.50 Ω is connected to the wire at points B and C, as shown in Fig. 5.3.

The point C is at a distance l from point B. The current in cell Y is zero.

Calculate

(i) the current in cell X,

current = ... A [1]

(ii) the distance l.

l= .... m [3]

(c) The connection at C in **(b)** is moved so that l is increased. Explain why the e.m.f. of cell Y is less than its terminal p.d.

....

....

....[2]

6 An ideal transformer is shown in Fig. 6.1.

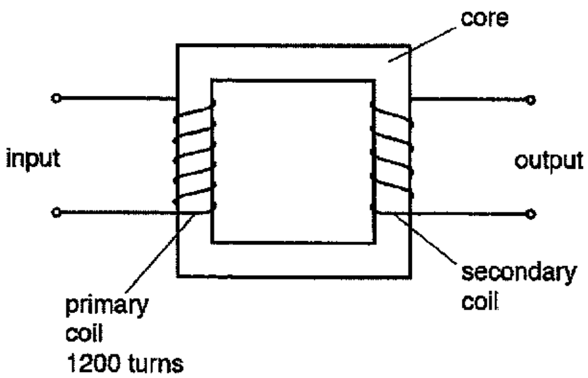


Fig. 6.1

(a) Explain why the core is

(i) made of iron,

....

....[1]

For Examiner's Use

(ii) laminated.

....

....[1]

(b) Use Faraday's law to explain the operation of the transformer.

....

....

....

....[2]

(c) An alternating voltage of peak value 150 V is applied across the 1200 turns of the primary coil. The variation with time t of the e.m.f. E induced across the secondary is shown in Fig. 6.2.

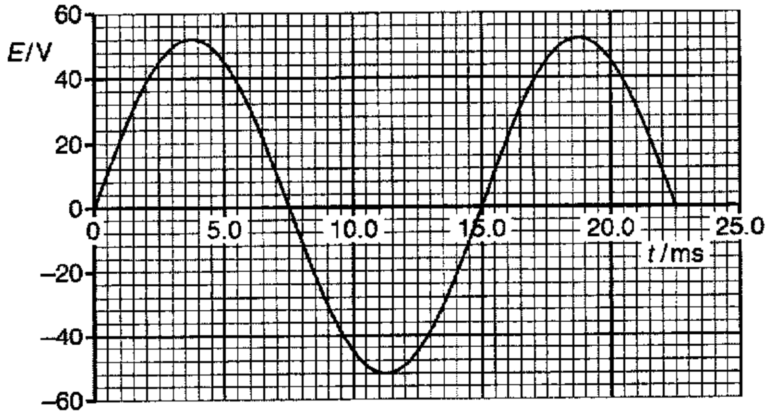


Fig. 6.2

Use data from Fig. 6.2 to

(i) calculate the number of turns of the secondary coil,

number = ... [1]

For Examiner's Use

(ii) state one time when the magnetic flux linking the secondary coil is a maximum.

time = ... ms [1]

7 Fig. 7.1 shows an X-ray spectrum produced by a medical X-ray tube operating at an accelerating potential of 40 kV.

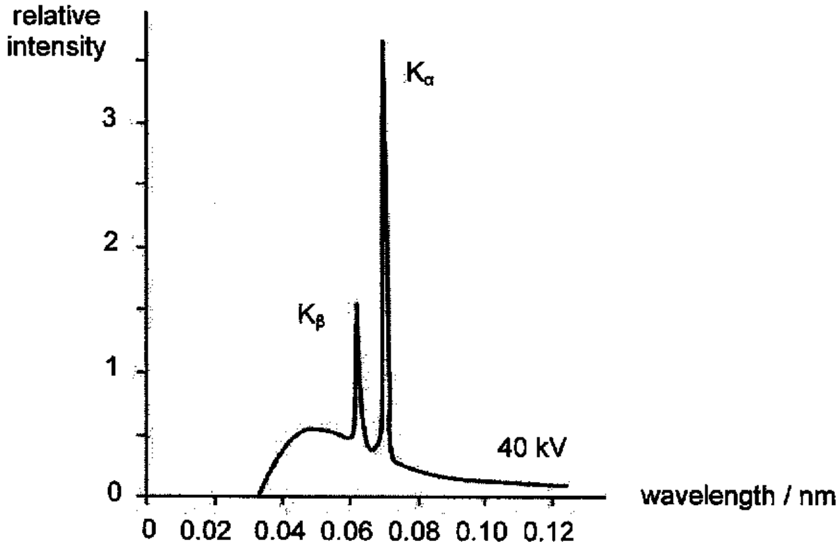


Fig. 7.1

(a) (i) Using Fig. 7.1, estimate the highest energy of the X-rays emitted by the tube.

highest energy= .... J [2]

For Examiner's Use

(ii) Calculate the maximum velocity of the high energy electrons hitting the target atom when the tube operates at 40 kV.

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

(iii) Hence calculate the de Broglie wavelength of the electrons at maximum velocity.

de Broglie wavelength= .... m [2]

(b) Explain how the characteristic X-ray lines K_α and K_β are producedin Fig. 7.1.

....

....

....

....[2]

For Examiner's Use

Section B

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

8 **(a)** Explain how stationary waves are formed.

....

....

....[2]

(b) A microphone that is connected to a cathode-ray oscilloscope (c.r.o.) is used by a student to detect the sound from a loudspeaker. Fig. 8.1 shows the trace on the screen of the c.r.o.

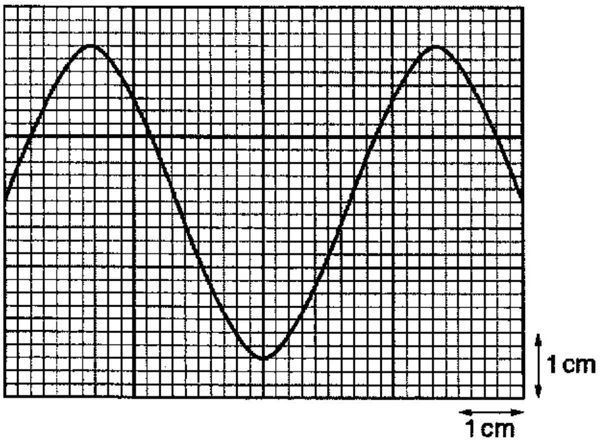


Fig. 8.1

In air, the sound wave has a speed of 330 m s^{-1} and a wavelength of 0.18 m.

(i) Calculate the frequency of the sound wave.

frequency = ... Hz [1]

(ii) Determine the time-base setting, in s cm^{-1}, of the c.r.o.

time-base setting = ...s cm^{-1} [1]

(iii) The intensity of the sound from the loudspeaker is now halved. The wavelength of the sound is unchanged. Assume that the amplitude of the trace is proportional to the amplitude of the sound wave.

On Fig. 8.1, sketch the new trace shown on the screen of the c.r.o. [2]

(c) Next, the student fills a long tube, fitted with a tap, with liquid. The loudspeaker in **(b)** is held above the top of the vertical tube as the liquid is allowed to run out of the tube, as shown in Fig. 8.2.

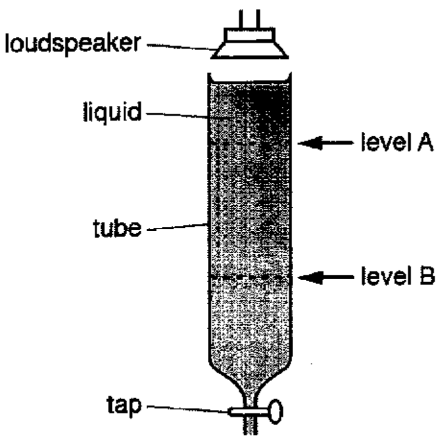


Fig. 8.2

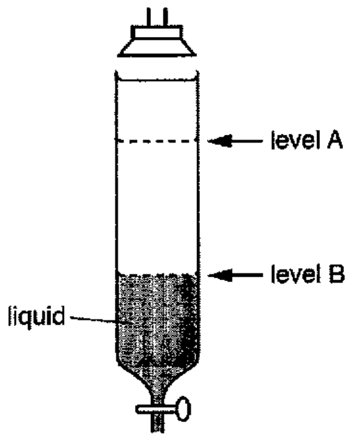


Fig. 8.3

A loud sound is first heard when the liquid level reaches level A and then heard again when the liquid level reaches B, as shown in Fig. 8.3.

(i) Calculate the vertical distance between level A and level B.

vertical distance = ... m [1]

(ii) The mass of the liquid leaving the tube per unit time is 6.7 g s^{-1}. The tube has an internal cross-sectional area of 13 cm^2. The density of the liquid is 0.79 g cm^{-3}.

Calculate the time taken for the liquid to move from level A to level B.

time = ... s [2]

For Examiner's Use

(d) The student sets up twoloudspeakers S_1 and S_2 that are situated 100 cm apart in air, as shown in Fig. 8.4. A microphone M is situated a distance 140 cm from S_1 along a line that is normal to S_1S_2.

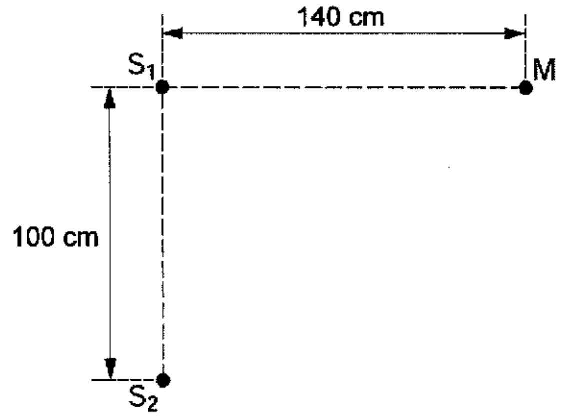


Fig. 8.4

The two loudspeakers always vibrate in phase and the frequency of vibration can be varied.

As the frequency of S_1 and S_2 is gradually increased, the microphone M detects maxima and minima of intensity of sound.

(i) State one condition that must be satisfied for the intensity of sound at M to be maximum.

....

....[1]

(ii) The speed of sound in air is 330 m s^{-1}.

The frequency of the sound from S_1 and S_2 is increased. Determine the number of maxima that will be detected at M as the frequency is increased from 1.0 kHz to 4.0 kHz.

number = ... [3]

(e) The student moves on to explore with a laser of wavelength 633 nm. The laser is placed behind a glass microscope slide that has been painted black. A single vertical slit of width 0.0800 mm has been produced by scratching through the paint with a razor blade.

Light from the laser passes through the slit and hits a wall at a distance of 5.12 m from the slit. A light sensor connected to a data logger is moved across the wall and the variation with distance moved by the sensor of the intensity of light is shown in Fig. 8.5.

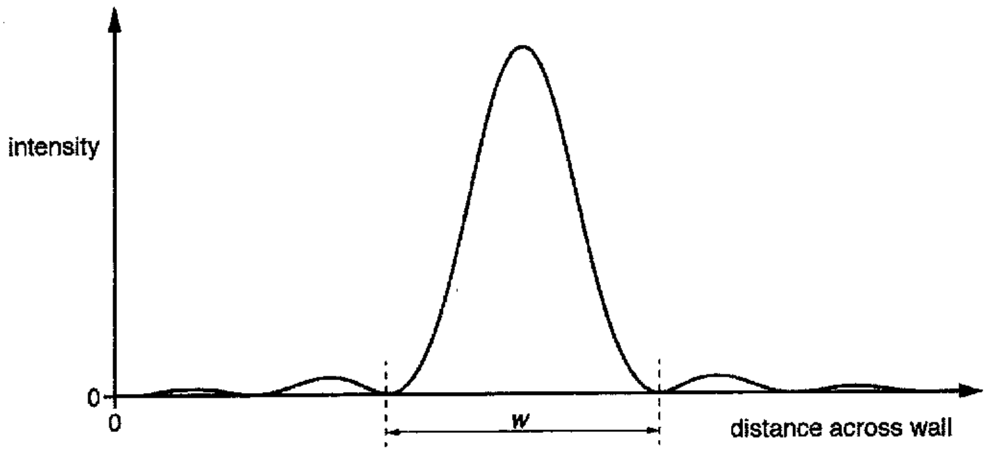


Fig. 8.5

The width w of the central patch is equal to the distance between the two minimum points on either side of the central patch where the intensity of the light is equal to zero.

(i) Determine w.

w= .... m [2]

(ii) A second vertical slit of width 0.0800 mm is scratched across the slide. The second slit is parallel to the first and its centre is a horizontal distance of 0.240 mm away from the centre of the first slit.

The slide now acts as a double slit. At the centre of the double-slit interference pattern on the wall, there are bright and dark fringes which are uniformly spaced.

For Examiner's Use

1. Some parts of the screen that were brightly lit when only the first slit was present are now dark, even though the light is still passing through the first slit in the same way.

Explain what causes this to happen.

....

....[1]

2. Determine the separation x of the bright fringes.

x= .... m [2]

3. Most of the bright fringes are separated from adjacent bright fringes by a distance x. In a few places, away from the centre, however, there are separations of $2x$ and there is no light in the middle of the gap where a bright fringe might be expected.

Using the results from **(e)(i)** and **(e)(ii)2**, explain why there is no light at such places.

....

....

....

....[2]

For Examiner's Use

9 **(a)** Explain what is meant by

(i) the *radioactive decay* of a nucleus, and

....

....[2]

(ii) *nuclear fusion*.

....

....[2]

(b) The nuclear fusion of two nuclei of deuterium is represented by the nuclear equation.

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{2}He + ^{1}_{0}n$$

Mass of a deuterium nucleus = 3.345×10^{-27} kg

Mass of a helium nucleus = 5.008×10^{-27} kg

Mass of a neutron = 1.675×10^{-27} kg

(i) Calculate the energy released during the fusion reaction.

energy released = ... J [2]

(ii) Calculate the energy released per kilogram of deuterium nucleus during the fusion reaction.

energy released per kg= .... J kg^{-1} [3]

For Examiner's Use

(c) Artificial pacemakers that are used to stimulate the heart may be designed to run on nuclear energy. Early types of such nuclear batteries contain 0.16 g of Plutonium-238 and produces 0.75mW of power when new.

(i) Given that the half-life of Plutonium-238 is 88 years, calculate its decay constant.

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

(ii) Hence determine the initial activity of 0.16 g of the Plutonium-238 source.

initial activity = ... s^{-1}[2]

(iii) One of the decay chain of Plutonium-238 involves a series of alpha decays which leads to Uranium-234, followed by Thorium-230 and then to Radium-226.The half-life of Uranium-234 is 246,000 years.

1. Determine the change in mass per Plutonium-238 decay into Uranium-234.

change in mass= .... kg[2]

2. State one assumption made in **(iii)1**.

....

....[1]

For Examiner's Use

(iv) Suggest why it is important to investigate the decay chain of Plutonium-238 in the design of such a nuclear battery.

....

....[1]

(d) Radioactivity as a source of radiation can have both good and bad effects. Some of the sources contributing to background radiation can be rocks and soil or medical treatment.

(i) Name another source of background radiation which makes a major contribution.

....

....[1]

(ii) Suggest why, when monitoring low radiation levels in the body for medical purposes, it is important to reduce background count rate to a minimum.

....

....

....

....[2]

END OF PAPER

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME	

CLASS		INDEX NUMBER	

PHYSICS

9749/04

Paper 4Practical

29th August 2019

2 hour 30 minutes

Candidates answer on the Question Paper.
Additional Materials: As listed on the Apparatus List

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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.
DO **NOT** WRITE IN ANY BARCODES.

Shift
Laboratory

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.

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 questionor part question.

For Examiner's Use	
1	**13**
2	**10**
3	**20**
4	**12**
Total	**55**

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

For Examiner's Use

1 In this experiment, you will investigate the movement of a metre rule on two sliding supports.

(a) Set up the apparatus with the metre rule resting on the rods of the clamps, as shown in Fig. 1.1. The metre rule should be parallel to the bench.

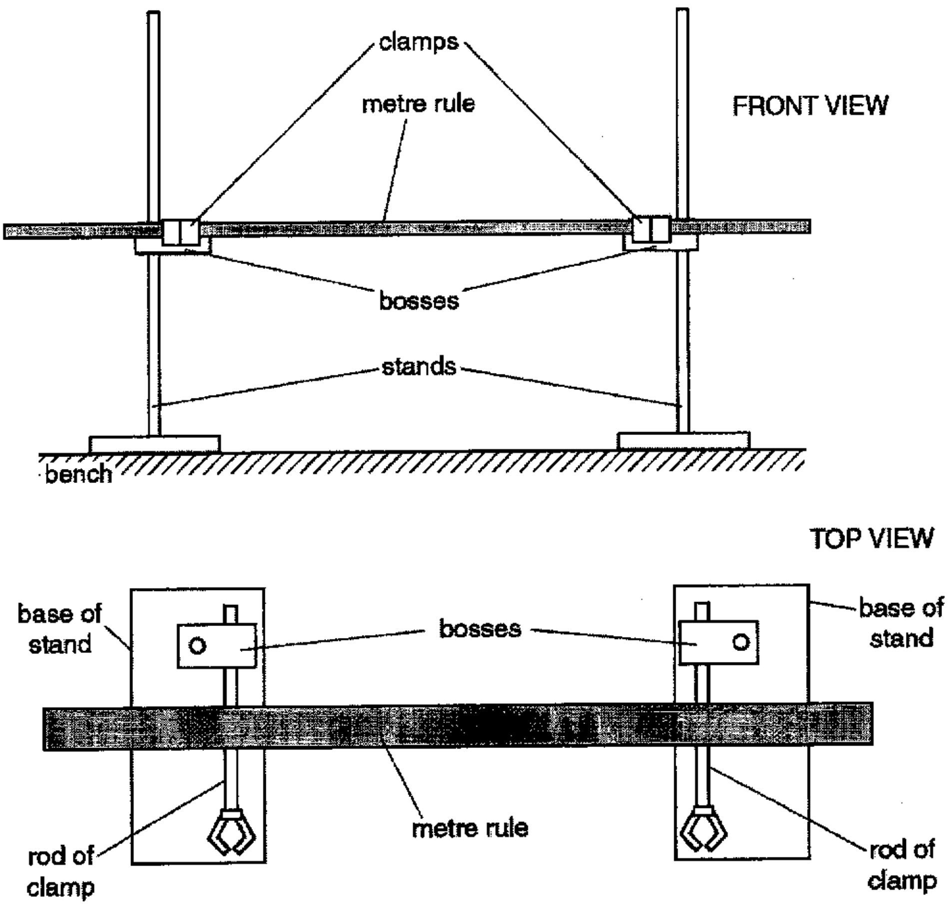


Fig. 1.1

(b) Measure and record the length (longest side) L of the wooden strip labelled A.

L = ... [1]

(c) (i) Position the stands so that the rod of one of the clamps is supporting the metre rule at the 10 cm mark, and the rod of the other clamp is supporting the metre rule at the 90 cm mark.

(ii) Using Blu-Tack, fix the wooden strip labelled A to the metre rule at the 0 cm end, as shown in Fig. 1.2.

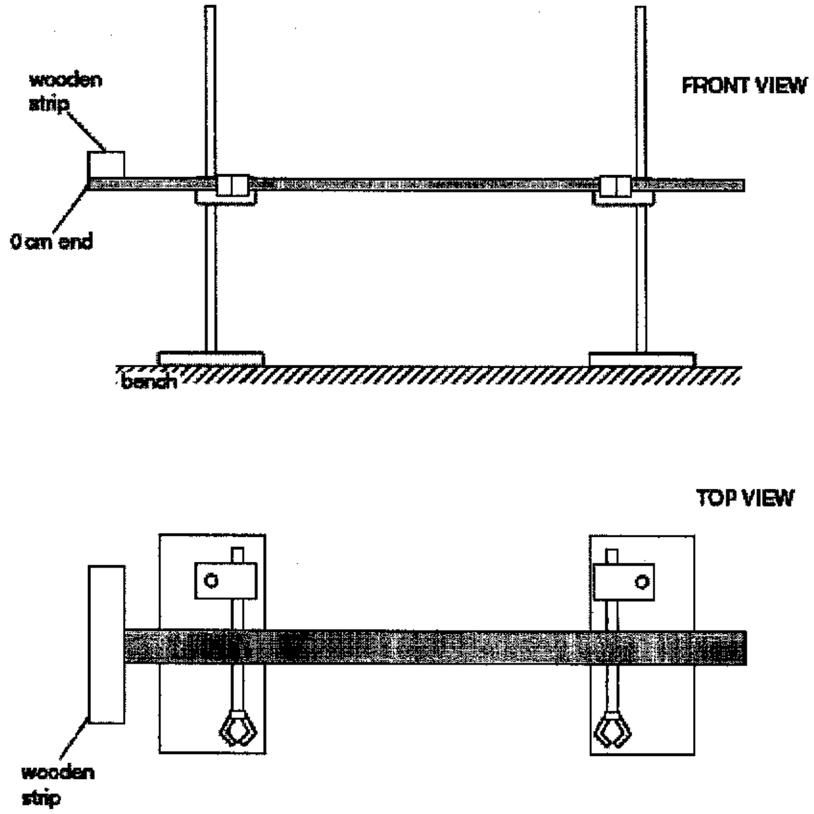


Fig. 1.2 (not to scale)

For Examiner's Use

(iii) Without touching the metre rule, slowly slide the stands towards each other until their bases touch each other, as shown in Fig. 1.3.

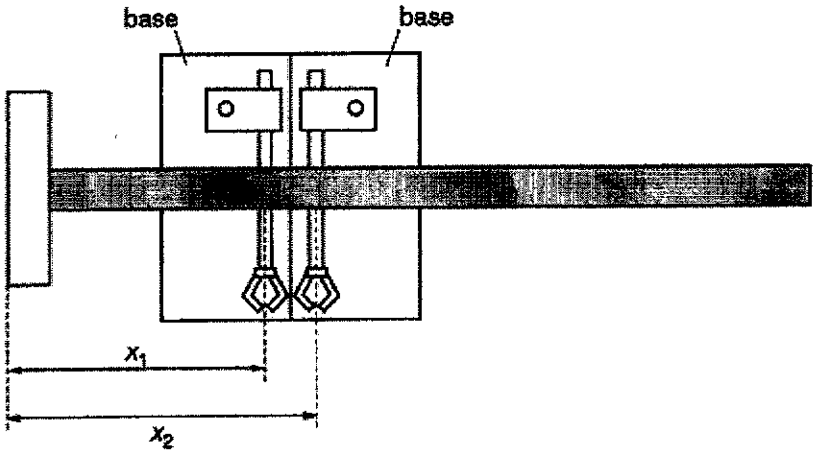


Fig. 1.3 (not to scale)

(iv) Measure and record the distances x_1 and x_2 of the points of contact from the end of the rule, as shown in Fig. 1.3.

x_1= ....

x_2= .... [2]

(v) Calculate the value of X, where $X = \frac{x_1 + x_2}{2}$.

X= ....[1]

(d) Estimate the percentage uncertainty in your value of X.

percentage uncertainty = ...[1]

For Examiner's Use

(e) It is suggested that the relationship between L and X is

$$LX = k(d - X)$$

where d = 50.0 cm and k is a constant.

Use the wooden strip labelled B to take further measurements to investigate this suggestion.

State and explain whether your measurements support the suggested relationship.

Present your measurements and calculated results clearly.

....

....

....

....

.... [6]

(f) Suggest and explain the value of X you would expect to obtain if the experiment was repeated with an identical wooden strip fixed at each end of the metre rule.

....

....

....[2]

[Total: 13 marks]

For Examiner's Use

2 In this experiment, you will investigate how the cooling rate of a hot liquid depends on the surface area of the liquid exposed to air.

(a) **(i)** Pour cold water into the beaker up to the 200 ml mark.

(ii) Pour the water into the cup and use the pen to place a mark on the inside surface of the cup, level with the water surface.

(iii) Empty out the cold water.

(b) **(i)** Pour boiling water into the cup up to the mark.

(ii) Bring the cup of boiling water and pour back into the beaker.

(iii) When the temperature of the water falls to approximately 75 °C, start the stopwatch. Record this starting temperature θ_0.

θ_0 = ... [1]

(iv) After two minutes, measure and record the temperature θ.

θ = ... [1]

(v) Calculate the change in temperature $\Delta\theta = (\theta_0 - \theta)$.

$\Delta\theta$= .... [1]

(c) **(i)** Measure and record the diameter d of the water surface.

d = ... [1]

For Examiner's Use

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

percentage uncertainty = ... [1]

(d) It is suggested that the relationship between $\Delta\theta$ and d is

$\Delta\theta = kd^2$

where k is a constant.

(i) Using your data, calculate the value of k.

k = ... [1]

(ii) Justify the number of significant figures that you have given for your values of k.

....

....

....[1]

(e) State twoother significant factors that will affect the cooling rate of the hot liquid. Suggest changes that could be made to the experiment to reduce the effect of one of the factors on the experiment. You are not expected to conduct the experiment.

....

....

....

....

....

.... [3]

[Total: 10 marks]

For Examiner's Use

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 wire that is attached to the card. Do not remove the wire from the card.

d = ... [1]

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

A = ... [1]

(iii) Determine the percentage uncertainty in *A*.

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

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

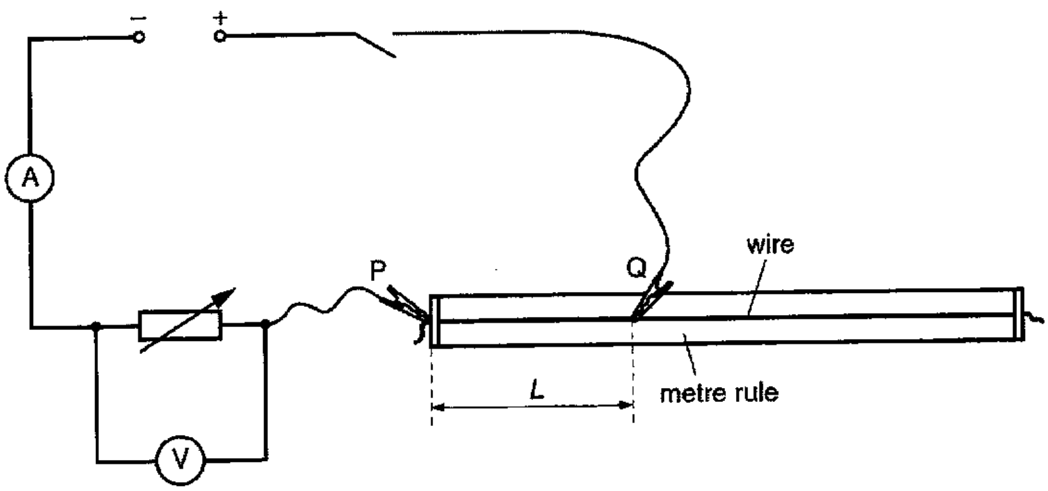


Fig. 3.1

There are two crocodile clips labelled as P and Q in Fig. 3.1.
P will remain in the same position throughout the experiment.
Q can be moved to different positions along the wire.

For Examiner's Use

(ii) Position the slider approximately half-way along the rheostat.

(iii) Attach Q approximately half-way along the wire.

(iv) Switch on the power supply.

(v) Measure and record the length *L* of wire between P and Q.
Record the voltmeter reading *V*.

L = ...

V = ... [2]

(vi) Record the ammeter reading *I*.

I = ...

(vii) Switch off the power supply.

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

(ii) Switch on the power supply.

(iii) Adjust the slider on 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 voltage reading *V*.

L = ...

V = ...

(v) Switch off the power supply.

For Examiner's Use

(d) Repeat **(c)** until you have six sets of readings of L and V. [7]

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 = ...

(e) Theory suggests that

$$\frac{V}{L} = \frac{a}{L} - b$$

where a and b are constants.

Plot a suitable graph to determine the values of a and b.

a = ...

b = ... [7]

For Examiner's Use

For Examiner's Use

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

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

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

ρ= .... Ω m **[1]**

[Total: 20 marks]

4 A fairground ride carries passengers in chairs which are attached by metal rods to a rotatingcentral pole, as shown in Fig 4.1. When the pole rotates with angular velocity ω, the rods make an angle θ to the vertical.

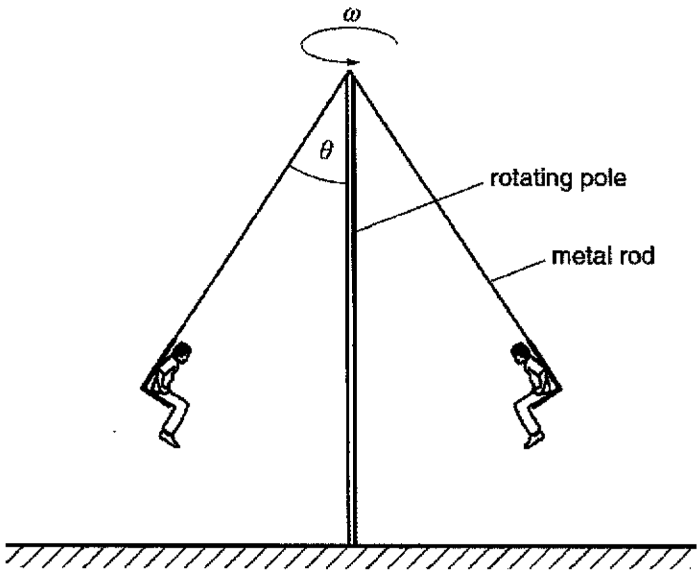


Fig. 4.1

It is suggested that cos θ is inversely proportional to ω^2.

Design a laboratory experiment, using a small object to represent an occupied chair, to test the relationship between θ and ω. You should draw a diagram, on page 14, showing the arrangement of your equipment.

In your account, you should pay particular attention to

(a) the procedure to be followed,

(b) the measurements to be taken,

(c) the control of variables,

(d) the analysis of the data,

(e) the safety precautions to be taken.

Diagram

For Examiner's Use

....

....

....

....

....

....

....

....

....

....

For Examiner's Use

For Examiner's Use

[12]

Dunman High School 2019Year 6Prelim ExamH2 Physics Answers

Paper 1

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

Paper 2

1	(a)	time = 0.43 / 1.1 = 0.39 s.	A1
	(b)	height = ½ gt^2 = ½ (9.81)(0.39)^2 = 0.75 m displacement = $\sqrt{0.43^2 + 0.75^2}$ = 0.86 m	C1 C1 A1
	(c) (1) (2)	horizontal line at a non-zero value of *a*. curved line from origin with increasing gradient.	A1 A1
	(d)	Distance is the <u>actual (curved) path</u> followed by the ball and Displacement is the <u>straight line / minimum distance</u> A to B.	B1
	(e)	acceleration (of free fall) is unchanged / not dependent on mass and so no effect on time taken.	B1

2	(a)	The rotating drum exerts a **normal reaction force** on the clothes and water which acts towards the centre of the rotation.	B1
		No such force is possible at the holes and so the water over each hole, according to Newton's 1st law, flies off at a **tangent** to the drum's motion.	B1
		While the **water can pass through the holes in the drum, the clothes are too large to do this**, so water is removed from the clothes during the spin-dry cycle. **OR** The clothes cannot provide sufficient centripetal force for the water, through their mutual attraction, at the holes.	B1
	(b)	ω = 1000 rev per min = 1000 x 2π / 60 = 105 rad s^{-1}	A1
		$F = m r \omega^2$ = 0.500 x 0.125 x 104.72^2 = 685 N	C1 A1
	(c)	When the inner drum is rotating, a purpose of the springs is to prevent**damage**to the machine / **excessive noise** by **damping** the shock of the vibrations **OR** When the inner drum is not rotating, a purpose of the springs is to maintain the drums and clothes as a system in **equilibrium** position via **tension** in the top springs and **compression** in the bottom springs. **OR** Any other suggestions with explanation based on good physics.	B1 B1

3	(a)	The internal energy of a substance is the sum of the **kinetic energy due to the random motion of the molecules** and **potential energy due to intermolecular forces of attraction.**	A1 A1
	(b)(i)	Work done by gas = area under CA **= (1 x 10^5)(20-5)x10^{-6}** **= 1.5 J**	C1 A1
	(b)(ii)	(see table below)	
	(c)	Temperature is a measure of the mean kinetic energy of the molecules of an object, i.e. it is the intrinsic property of **one system** only, but heat is a measure of energy transferred between **two systems.**	B1

section of cycle	heat supplied to gas / J	work done on gas / J	increase in internal energy of gas / J	
A → B	zero	4.2	+4.2	A1
B → C	-8.5	0	-8.5	A1
C → A	+5.8	-1.5	+4.3	A1

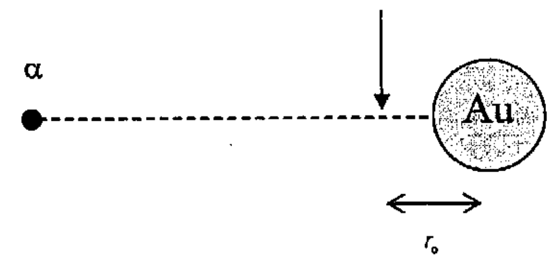
Last to be calculated : $\Delta U = Q + W$

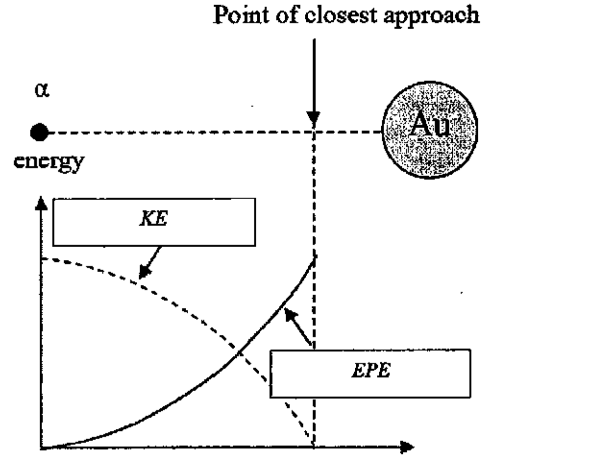
In one full cycle, the change in internal energy = 0 J

		Temperature can be measured using a **thermometer directly**, but heat **cannot be measured using a measuring instrument directly**. **OR** Any other differences based on good physics.	B1

4	(a)	magnitudes of <u>maximum</u> displacements / accelerations are different graph is curved / not a straight line (at both ends of graph)	B1 B1
	(b) (i)	Simple harmonic motion so $a = -\omega^2 x$ where ω is the angular frequency $\omega^2 = (2)(64)/(0.810)$ $\omega = 12.57$ rad s^{-1} $f = \omega / 2\pi$ $= 2.0$ Hz	B1 B1
	(b)(ii)	max speed = ωx_o = (12.57)(0.016) = 0.20 m s^{-1}	 C1 A1
	(iii)	momentum is conserved (horizontally), $m_{trolley}v_{trolley} = m_{total}v_{max}$ max speed decreases Or perfectly inelastic collision, energy is lost, so max speed decreases	M1 A1
		perfectly inelastic collision so energy lost less elastic potential energy so amplitude decreases	M1 A1

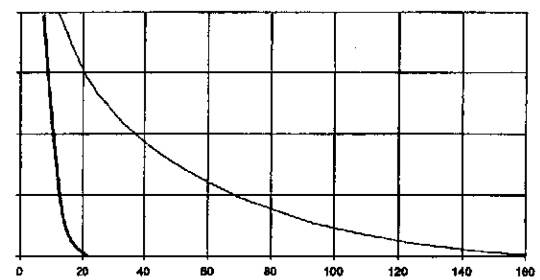
5	(a)	Both the alpha particle and the gold nucleus are **positively charged**. When the alpha particle travels head-on towards the gold nucleus, **allthe kinetic energy of the alpha particle is converted to the electric potential energy of the system of the alpha particle and gold nucleus.** **OR** the repulsive force between the alpha particle and the gold nucleus causes **deceleration** in the alpha particle until it is at its closest approach where it is instantaneously at rest.	B1 B1

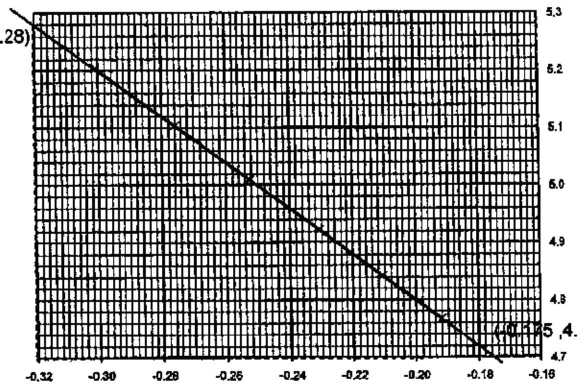
	(b)(i)		
		Loss in K.E. = gain in E.P.E. $5.75(10^6)(1.6 \times 10^{-19}) = \frac{q_\alpha q_{Au}}{4\pi\varepsilon_o r_o}$ $\Rightarrow r_o = \frac{(9.0 \times 10^9)(2e)(79e)}{(9.2 \times 10^{-13})} \approx 4.0 \times 10^{-14}$ m	 C1 A1
	(b)(ii)	$F = \frac{q_\alpha q_{Au}}{4\pi\varepsilon_o r_o^2} = \frac{(9.0 \times 10^9)(2e)(79e)}{(3.96 \times 10^{-14})^2} = 23.3$ N	A1
	(c)1./2.	The $^{197}_{79}$Au nucleus remains stationary during the interaction between $^{197}_{79}$Au and the α-particle. $^{197}_{79}$Au and the α-particle are very far apart initially. $^{197}_{79}$Au and the α-particle are point charges. The system consists of $^{197}_{79}$Au and the α-particle only. The radium nucleus and its daughter nuclide is not part of the system. (Thus, conservation of energy applies for the defined system and the radium nucleus and its daughter nuclide cannot provide an external force on the system.) The gravitational force between the $^{197}_{79}$Au and the α-particle is negligible compared to the electric force between them. **Any TWO**	 A1 A1

	(d)		A1 - KE A1 - EPE

6	(a)	uniform electric (E) and magnetic fields (B) normal to each other AND charged particle enters region normal to both fields correct B direction w.r.t. E for zero deflection For no deflection, $v = E/B$	B1 B1 B1
	(b)	magnetic force provides the centripetal force $BQv = mv^2/r$ $r = mv / BQ$	 M1 A1
	(c)	curve of larger radius starting from common entry point into the field	A1
	(d)	$r = mv / BQ$, so B proportional to m $B = (0.680) \times (87/86) = 0.6879$ T $\Delta B = 7.9 \times 10^{-3}$ T	 C1 A1

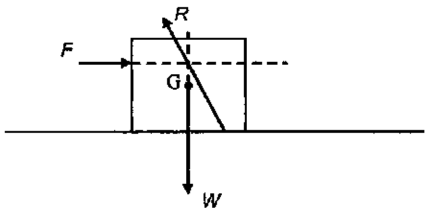
7	(a)	$P = \frac{Nhf}{t}$ $3.8 \times 10^{-3} = (N/t)(4.7 \times 1.6 \times 10^{-19})$ $N/t = 5.1 \times 10^{15}\ s^{-1}$	 C1 A1
	(b)	$I = \frac{Ne}{t}$ $0.800 \times 10^{-8} = (N/t)(1.6 \times 10^{-19})$ $N/t = 5.0 \times 10^{10}\ s^{-1}$	 A1
	(c)	1. Most of the photons are reflected from the metal surface. 2. Atoms are made up of mostly empty space and thus the probability of a photon hitting a surface electron is very small. Instead, photons may hit electrons which are deeper below the surface, and these electrons may lose all its kinetic energy on its way up to the surface. (due to collisions with the metallic ion core) 3. Electrons emitted may travel at an angle away from the normal and may not be collected at the anode.	Any two
	(d)	$eV_s = \frac{1}{2}mv^2$ $(1.6 \times 10^{-19})(0.500) = (1/2)(9.11 \times 10^{-31})v^2$ $v = 4.19 \times 10^5\ m\ s^{-1}$	C1 C1 A1

8	(a)(i)	The alpha particles has only **limited range in air** which is only a few **centimetres** (~ 5 cm). This is because alpha particles are highly ionizing and **lose theirkinetic energies** very quickly over a short distance due to the interaction with air particles.	B1 B1
	(a)(ii)	N values have a very **wide range**(from 0 to 10^5). Thus, it is **difficult to plot <u>smaller</u>N values** if vertical axis is non-logarithmic. OR **It compresses the scale** so that **widely differing values** can be **shown easily** on one graph.	B1 B1
	(b)	 - steep graph at small angles- no scattering at large angles.	A1
	(c)(i)	From Fig. 8.3, when $\theta = 72$, $N = 84000$. lg sin((72/2) / °) = -0.231, lg 84000 = 4.92	

1. (c)(i)2.	From Fig. 8.3, when $\theta = 72$, $N = 84000$. lgsin((72/2) / °) = -0.231, lg 84000 = 4.92  	**A1** - accurate plotted point **A1** - best fit line passes through all plotted points
(c)(ii)	Gradient = (5.28 - 4.7)/(-0.32 – (-0.175)) = -4	**M1** **A1**
(c)(iii)	Since $N \propto (\sin(\theta/2))^n$, $\lg N = \lg A + n\lg(\sin(\theta/2))$ where A **is a constant.** Thus if a graph of $\lg N$ is plotted against $\lg(\sin(\theta/2))$ and a straight line graph is obtained, then n **represents the gradient.** $n = -4$	**M1** **A1** - Answer must an integer
(d)	For Au, 92500/79^2 =14.8 For Pt, 90000/78^2 =14.8 For Ir, 88000/77^2 =14.8 For W, 81000/74^2 =14.8 Since the constant of proportionality is (approximately) the same to 3 significant figures, N is proportional to Z^2. (based on all the values of constant)	**A1**- Correct N values for the 4 data points **A1** – showed all the values of the constant **A1** – conclusion
(e)	The actual relationship between N and θ is $N = \left(\frac{A'' N_i n L C^2 e^4}{4r^2 KE^2}\right) Z^2 (\sin(\theta/2))^{-4}$ where $k = \frac{A'' N_i n L C^2 e^4}{4r^2 KE^2}$ and A'' = cross sectional area of detector that the scattered alpha particles are incident on N_i = number of incident alpha particles n = number of gold atoms per unit volume in thin gold foil L = thickness of gold foil e = electron charge r = gold foil-to-detector distance KE = kinetic energy of alpha particles $C = \frac{1}{4\pi\varepsilon_0}$ = Coulomb's constant, ε_0 = permittivity of free space	**A1**- any one physical quantities boxed **A2**- any two physical quantities boxed
(f)	There would be **no**(significant)**change** because the **scattering angle** θ **is** (approximately) **independent** on the **mass of the isotope** of gold that made up the foil.	**B1** **B1**

Paper 3

1	(a)	The mass of an adult — 40 - 100 kg The weight of a hand phone at Earth's surface — 1.0 - 2.0 N	A1
		The energy required for an adult to climb up to the top row in the school auditorium — 1200 - 3000 J The total pressure on your feet at a depth of 1.0 m in an adult swimming pool — 1.02×10^5 Pa- 1.11×10^5 Pa	A1
	(b)(i)	Units of $\frac{kr^3(p_1-p_2)}{l}\sqrt{\frac{M}{RT}} = \frac{m^3 Pa}{m}\sqrt{\frac{kg\ mol^{-1}}{J\ K^{-1} mol^{-1} K}}$ $= kgms^{-2}\sqrt{\frac{kg\ s^2}{kgm^2}}$ $= kgs^{-1}$	C1 A1
	(ii)	$\frac{\Delta Q}{Q} x100 = \frac{3\Delta r}{r} x100 = \frac{3 \times 0.05}{1.37} x100$ $= 11\ \%$	A1

2	(a)	The conditions are ▪ resultant force acting on a rigid body must be zero in any direction. ▪ resultant torque acting on a rigid body must be zero about any axis of rotation.	A1 A1
	(b)(i)1. (b)(i)2.		A1 - W A1 - direction of R A1 – line of action of 3 forces meet at the same point
	(b)(ii)	Let the cube has side a, taking moments about the corner of the cube at X, $F\left(\frac{3}{4}a\right) = W\left(\frac{1}{2}a\right)$ ➔ $F = \left(\frac{2}{3}\right)\left(\frac{200}{1000}\right)g \approx 1.3$ N	C1 A1

	(c)	Using Hooke's Law i.e. $F = ke$, ➔ $k = \frac{F}{e}$ ➔ $k = \frac{(140)/1000(9.81)}{(10.8-8)/100} \approx 49\ N\ m^{-1}$	C1 A1
	(d)(i)	Upthrust + Tension = Weight of Cube ➔Upthrust = $\left(\frac{200}{1000}\right)g - (49.05)\left(\frac{10.3-8}{100}\right) \approx 0.83$ N	B1
	(d)(ii)	Mass of block = density of block x volume of block Moreover, upthrust = density of liquid displaced x volume of block x acceleration of free fall ➔ 0.83 = density of liquid x (200/1000)/2400 x 9.81 ➔ density of liquid ≈ 1000 kg m^{-3} Note: This is the approximate density of water.	C1 A1

3	(a)	The gravitational potential energy at a point is defined as the <u>work done</u> in bringing <u>asmall test mass</u> from infinity to that point.	B2
	(b) (i)	Correct direction	B1
	(ii)	The gravitational force <u>provides the centripetal force</u> for the circular orbit of the satellite.	B1
	(iii)	$\frac{mv^2}{R} = \frac{GMm}{R^2}$ $v = \sqrt{\frac{GM}{R}}$	C1
	(c)	$\frac{v^2}{7780^2} = \frac{6610}{6890}$ v = 7620 m s^{-1}	C1 A1
	(d)(i)	$\frac{1}{2}m(7620^2 - 7780^2) = -1.48x10^8 J$	A1
	(ii)	$-\frac{GMm}{R_f} - \left(-\frac{GMm}{R_i}\right) = mv_i^2 - mv_f^2$ $m(7780^2 - 7620^2) = 2.96x10^8 J$	C1 A1

4	(a)	Consider the same mass of steam m and the same mass of water m at 100 °C. When in contact, both steam and skin reaches a thermal	

		equilibrium.	A1
		The same happens for boiling water with skin. However, the difference is that for steam, the **process of condensation occurs prior to the drop in temperature.**	B1 - for stating the difference between the processes
		$Q_{steam} = ml_v + mc\Delta\theta$ $Q_{hotwater} = mc\Delta\theta$	
		When steam condenses into water at 100 °C, there is a release of a large amount of thermal energy. Since **specific latent heat of vaporisationof water is far greater than specific heat capacity of water**, the thermal energy transferred to the skin due to steam condensing is greater than that due to boiling water.	A1
	(b)(i)	True. When a **solid melts**, the **increase in potential energy is less** than the increase that occurs when a **liquid vaporises**.	A1
		Significant work is also **done against external pressure** when a **liquid vaporises** compare to when a **solid melts.**	A1
	(b)(ii)	False. Pressure of a real gas **is less** than that of an ideal gas for the same mass, volume and temperature. This is because **attractive** forces exist **between the atoms/molecules** in a real gas and not in an ideal gas.	A1
		Thus, the molecules of a real gas **hit the wall of a container with lessforcecompare** to an ideal gas as they are held back by attractive forces.	A1

5	(a)(i)	current = 2.8 A 4.0 A in each lamp, total current in circuit = 8.0 A	A1 A1
	(ii)	series, resistance = 2.1 + 2.1 = 4.2 or 4.3 Ω parallel, resistance 1.5 Ω	A1 A1
	(iii)	power = IV or V^2R or I^2R ratio = (2.8 × 6.0) / (4.0 × 12) = 0.35	C1 A1
	(b) (i)	$I = V/R$ = 2.0 / 5.0 = 0.40 A	A1
	(ii)	p.d. across BD = 4 × 0.40 = 1.6 V p.d. across BC = 1.5 V l = 1.5/1.6 × 1.00 = 0.94 m	C1 C1 A1
	(c)	p.d. across BC not at balancing e.m.f. Cell Y has current going from left to right through cell, so total terminal p.d. higher.	B1 B1

6	(a) (i)	to reduce flux loss/ to increase flux linkage with secondary coil	B1
	(ii)	to reduce heat/energy losses caused by eddy currents (in core)	B1
	(b)	changing current in primary gives rise to changing flux in core flux links by core to the secondary coil, and changing flux (in secondary) induces e.m.f. in secondary	B1 B1
	(c) (i)	N = (52/150) 1200 = 416 turns	A1
	(ii)	time = 0 ms or 7.5 ms or 15.0 ms or 22.5 ms	A1

7	(a)(i)	Estimate wavelength about 0.030nm to 0.035 nm	B1
		$c = f\lambda$, $E = hc/\lambda$ $E = 6.6 \times 10^{-34} \times 3.0 \times 10^8 \div (0.032 \times 10^{-9})$ $E = 6.6 \times 10^{-15}$ J to 5.6×10^{-15} J (35 keV to 41 keV)	A1
	(ii)	$eV = \frac{1}{2}mv^2$ $v = \sqrt{\frac{2eV}{m}}$ $= \sqrt{2 \times 1.6 \times 10^{-19} \times 40000 \div (9.11 \times 10^{-31})}$ $= 1.2 \times 10^8\ m\ s^{-1}$	C1 A1
	(iii)	$\lambda = h/p$ $= h/mv$ $= 6.6 \times 10^{-34} \div (9.11 \times 10^{-31} \times 1.2 \times 10^8)$ $= 6.1 \times 10^{-12}\ m$	C1 A1
	(b)	When an <u>inner</u> shell electron is knocked out by a bombarding electron and an outer shell electron fills in this vacancy, this transition results in X-rayphotons of a specific frequency to be emitted.	B1 B1

8	(a)	two waves of the same kind travelling in opposite directions overlap waves have same frequency/wavelength and speed	B1 B1
	(b) (i)	v=fλ f= 330/0.18 = 1800 Hz	A1
	(ii)	T = 1/1800 time base = (1.5 × 5.5 × 10^{-4}) / 8.0 or 1/(1800 × 5.3) = 1.0 × 10^{-4} s cm^{-1}	A1
	(iii)	waveform drawn with same period as original waveform waveform drawn with amplitude of 1.7 cm	B1 B1
	(c) (i)	distance = λ / 2 = 0.090 m	A1
	(ii)	m = ρAx = 0.79 × 13 × 9.0 = 92.4 time = 92.4 / 6.7 =14 s	C1 A1
	(d) (i)	Waves must meet in phase / path difference is nλ, n is integer	B1

	(ii)	path difference = $\sqrt{140^2 + 100^2} - 140 = 32$ cm freq changes from 1kHz to 4kHz so λ changes from 33 to 8.25 cm when λ =33, path diff (32 cm) is 0.96 λ, and λ =8.25, path diff is 3.87 λ so 3 maxima (when λ = 32, 16 and 10.7 cm)	B1 C1 A1
	(e) (i)	bsinθ = λ ➔ sinθ = 633 × 10^{-9} / (0.0800 × 10^{-3}), θ = 0.453° w = 2 × 5.12 × tanθ = 2 × 5.12 × tan(0.453°) = 0.0810 m	C1 A1
	(ii) 1.	light from second slit meets anti-phase with light from first slit or destructive interference for lights from both slits	B1
	2.	x = 633 × 10^{-9} × 5.12 / 0.240 × 10^{-3} = 0.0135 m	C1 A1
	3.	At these places are single slit minimums No light to interfere (a factor of 3 recognised) (Note: 3x = 0.0405 m which is equal to w/2)	B1 B1

9	(a)(i)	The radioactive decay of a nucleus is the spontaneous and random emission of alpha, beta and gamma rays from the nucleus with the release of energy.	B2
	(ii)	Nuclear fusion is the combining of 2 smaller nuclei to form a larger and more stable nucleus with the release of energy in the process.	B2
	(b)(i)	Energy released , E = (2 × 3.345 × 10^{-27} - 5.008 × 10^{-27} - 1.675 × 10^{-27}) × (3 × 10^8)^2 = 6.3 × 10^{-13} J	 M1 A1
	(ii)	number of nuclei in 1kg of deuterium ≈ 1/ (3.345 × 10^{-27}) ≈ 2.99 × 10^{26} number of fusion reactions = 2.99 × 10^{26} /2 = 1.495 × 10^{26} Energy released per kg = 1.495 × 10^{26} × 6.3 × 10^{-13} J = 9.42 × 10^{13} J	C1 C1 A1
	(c)(i)	$\lambda = 0.693/t_{½} = 0.693 / (88 \times 365 \times 24 \times 60 \times 60)$ □ □ ⊜ $2.5 \times 10^{-10}\ s^{-1}$	C1 A1
	(ii)	$N = 0.16 / 238 \times N_A = 4.05 \times 10^{20}$ $A = \lambda N$ $= 2.5 \times 10^{-10} \times 4.05 \times 10^{20} = 1.01 \times 10^{11}$ Bq	C1 A1
	(iii)1.	$0.75\ mW \div 1.01 \times 10^{11}$ $= 7.43 \times 10^{-15}$ J released per Plutonium atom decayed $m = E/c^2 = 8.25 \times 10^{-32}$ kg converted to energy per Plutonium decay	 C1 A1
	(iii)2.	Battery is 100% efficient OR U234 does not contribute to power generated due to long half-life	B1
	(iv)	Check for alpha or beta decay due to the needs to shield patient from its harmful effects OR check for battery lifespan	B1
	(d)(i)	Cosmic radiation	B1
	(d)(ii)	Variations in body radiation levels might go undetected as a result of random variation in background count. The total count rate is the sum of count rate due to trace elements in	B1 B1

		the body and background count rate. For low radiation count rate, the background count rate become significant.	

Paper 4

Qns			Skills Assessed and Marking Instructions		M
1	b		L in range 4.4 cm to 4.6 cm to the nearest mm, with unit.		1
	c	(iv)	Values for x_1 and x_2 to nearest mm and $x_2 > x_1$. Evidence of repeat readings of x_1 and x_2.		1 1
		(v)	Correct calculation of X (X_1).		1
	d		Absolute uncertainty in X in range 2 mm to 10 mm (1.s.f.). Correct method of calculation to obtain percentage uncertainty. Percentage uncertainty recorded to 2.s.f.		 1
	e		Measurement and record of second value of L (L_2). L_2 in range 5.4 cm to 5.6 cm to the nearest mm, with unit. Value of second pair of x_1 and x_2 (x_3 and x_4 respectively; $x_4 > x_3$). Correct calculation of second X (X_2). Quality of result: larger L gives smaller X. Determination of a constant of proportionality k (two values of k where $k = LX/(d-X)$), with unit. Draw conclusion based on the calculated values of k. Candidate must test against a specified criterion (e.g. 20 % difference in values of k, with reference to the uncertainty calculated (d)).	 E1 E2 E3 E4 E5 E6	 1 1 1 1 1 1
			e.g. For X_1, $\frac{\Delta k_1}{k_1} = \frac{\Delta L_1}{L_1} + \frac{\Delta X_1}{X_1} + \frac{\Delta(d - X_1)}{d - X_1}$ ➔ $\frac{\Delta k_1}{k_1} = \frac{\Delta L_1}{L_1} + \frac{\Delta X_1}{X_1} + \frac{\Delta X_1}{d - X_1} = \frac{0.2}{4.5} + (\text{ans in (d)})/100 + \frac{0.2}{50.0 - (\text{ans in (c)(v)})}$ Note:		

			1. The % error in k_1 is ~ 12 % (theoretical). Candidate must verify that k_2 is outside this range. 2. A has dimensions 4.5 cm (L_1) x 4.5 cm x 1.0 cm and a mass of 15.4 g; B has dimensions 6.5 cm (L_2) x 5.2 cm x 3.1 cm and a mass of 49.2 g. Since A and B have different cross-sectional areas, theoretically the expression, based on the conservation of moments, is not valid! 3. The metre rule has dimensions 1 m x 2.7 cm x 0.5 cm and a mass of 95.5 g.		
	f		Value for X = 50.0 cm Due to symmetry and uniform density of the objects, the centre of gravity of the system should be at its geometric centre.		1 1

Qns			Skills Assessed and Marking Instructions	M
2	b	(iii)	Value of θ_0 to the nearest degree Celsius in range between 70 °C to 80 °C.	1
		(iv)	Value of θ to the nearest degree Celsius with unit, $\theta<\theta_0$	1
		(v)	Correct calculation of (θ_0 - θ)	1
	c	(i)	Value of raw d with unit to the nearest mm.	1
		(ii)	Absolute uncertainty in 2mm < d < 5 mm If repeated readings have been taken, then the absolute uncertainty can be half the range. Correct method shown to find the percentage uncertainty.	1
	d	(i)	Values of k calculated correctly with units.	1
		(ii)	Justification of s.f. in k linked to significant figures in d and $\Delta\theta$	1
		(iii)	Heat lost through sides and /or bottom. Temperature difference between the exposed area and the surroundings Mass of water Specific heat capacity of liquid (Any two mentions) Lag/insulate Use of lid/heat loss in warming cup/draughts/heat loss to surroundings.	1 1 1 0

Qns			Skills Assessed and Marking Instructions		M
3	a	(i)	Value of d in the range 0.25 mm to 0.45 mm. d read to the nearest 0.01 mm with unit		1
		(ii)	Area calculated correctly with the correct unit		1
		(iii)	Correct calculation of percentage uncertainty in A. Δdiameter = 0.01 mm and percentage uncertainty can be calculated usingΔArea/Area = 2Δdiameter/diameter		1
	b	(v)	Value of L in range 0.1 m < L < 1 m and value of V in range 0.1 V to 2.0 V. Correct units are given for both L and V.		1 1
	d		• Award 2 marks if student has successfully collected 6 or more sets of data (V, L) without assistance/intervention. • 5 sets one mark. • 4 or fewer sets zero mark. • Deduct 1 mark if minor help from supervisor, deduct 2 if major help. • Deduct 1 mark if wrong trend in L (or V). V decreases with increase in L.	D1	2
			Each column heading must contain a quantity and a unit where appropriate. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected, V/L / V m^{-1}. Do not allow V(V) / L (m).	D2	1
			Consistency of raw readings. All values of raw L must be given to the nearest mm. All values of V given to nearest 0.001 V.	D3	1
			Range of L: ΔL ≥ 60 cm	D4	1
			For each calculated value, the number of d.p in calculated value should reflect the number of s.f. in the raw readings. All values must be given to an appropriate number of s.f. for this mark to be awarded.	D5	1
			Correctly calculated values of V/L, $1/L$.	D6	1
	e		Linearising equation and deriving expressions that equate e.g. gradient to aand y-intercept to -b.	E1	1

			Graph: Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Scales must be labeled with the quantity which is being plotted.	E2	1
			All observations must be correctly plotted. Work to an accuracy of half a small square. Diameter of the plotted point must be less than half the small square.	E3	1
			Line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line. Allow only one anomalous point if clearly indicated (i.e. labelled or circled) by the student. Line must not be kinked or thicker than half a small square.	E4	1
			Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).	E5	1
			y-intercept – must be read off to nearest half a small square or determined from $y=mx+c$ using a point on the line. The value of b <u>must be positive</u>.	E6	1
			Values of a and b calculated correctly with units.	E7	1
	f		Answer in range: $2.0 \le \rho \le 20.0 \times 10^{-7}$ Ω m. Consistent with units.		1

4

Code	Description		
A	*Basic Procedure* ✓ Labelled diagram of apparatus: small <u>object</u>, pole attached to <u>a rotating device</u> (motor or turntable) ✓ Procedure OK (i.e. measure period/frequency; change frequency and measure new angle for at least 8 sets of readings).	1 1	A1 A2
	✓ Method to change the speed of rotating device (e.g. change power of motor) ✓ Use fiducial mark or light gates perpendicular to motion of object	1 1	A3
	✓ $w = 2\pi f = 2\pi/T$ ✓ frequency or period of rotation or w is the independent variable and θ is the	1	A4

	dependent variable or vary f or T or w and measure θ		
B	*Method of measuring Independent Variable* ✓ Stopwatch to time number of oscillation, light gates connected to a timer/frequency meter, rev counter/tachometer	1	B1
B	*Method of measuring Dependent Variable* ✓ Use protractor or rule for measurements for trigonometry methods	1	B2
B	*Processing and Analyzing Experimental Data* ✓ Plot a graph of the dependent variable (cos θ) against the independent variable ($1/w^2$). ✓ Relationship is valid if straight line through the origin.	1	B3
C	*Method of keeping Variables Constant (note: do NOT use control of variables)* ✓ Keep the length of the rigid rod <u>constant</u>; ignore the reference to mass	1	C1
C	*Safety Aspect* ✓ Use a protective screen in case mass detaches from the pole. Do not use goggles.	1	C2
D	*Additional Details in Procedure* ✓ Large motor speed to produce measurable θ ✓ Additional detail on measuring angle. e.g. <u>large</u> protractor fixed to pole ✓ Projection method, slow motion freeze frame video, camera with <u>detail</u> ✓ cos $\theta = h/l$ or equivalent ✓ method of checking pole is vertical – use a set square ✓ additional detail on measuring angular velocity, e.g. time at least 10 rotations/timing greater than 20 s ✓ wait for motion to become stable Do not allow <u>vague</u> computer method	Max 2	D1 D2 D3 D4 D5 D6 D7
	Total	12	