Class	Index Number	Name
16S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2017
Preliminary Examination

PHYSICS, Higher 2 **9749/01**

Paper 1 Multiple Choice **19th September 2017**
1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil..
Do not use staples, paper clips, glue or correction fluid.
Write your name, index number and Civics Group the Answer Sheet in the spaces provided.

There are **thirty** questions in 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.

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

For Examiner's Use	
Total	**/ 30**

This document consists of **15** printed pages including this page.

Data

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

Formulae

uniformly accelerated motion,	$s = u t + \frac{1}{2} a t^2$
	$v^2 = u^2 + 2 a s$
work done on/by a gas,	$W = p \Delta V$
hydrostatic pressure,	$p = \rho g h$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_o \sin \omega t$
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,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{1/2}}$

1 Frankie times the oscillations of a simple pendulum but accidentally starts by counting "1", instead of "0", when the bob is released and finishes at a count of "10".

What is the percentage error in the student's calculation of the period due to this mistake?

A 10% low **B** 10% high **C** 11% low **D** 11% high

2 Cynthia found that the magnetic flux density B at the centre of a solenoid is given by $B = \mu_o n I$ where μ_o is the permeability of vacuum, n is the number of turns per unit length and I is the current in the solenoid.

Which of the following gives the correct SI units of the permeability of vacuum?

A kg m^2 s^{-2} A^{-2}
B kg m s^{-2} A^2
C kg m^2 s A^{-2}
D kg m s^{-2} A^{-2}

3 A projectile is launched at an angle θ above the horizontal. Ignoring air resistance, what fraction of its initial kinetic energy does the projectile have at the top of its trajectory?

A $\cos \theta$
B $\cos^2 \theta$
C $\sin \theta$
D 0, since the projectile is momentarily at rest at maximum height

4 The velocity - time ($v - t$) graph of a particle is shown in Fig. 4

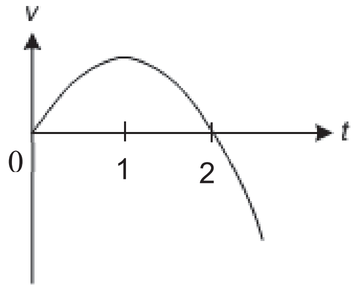
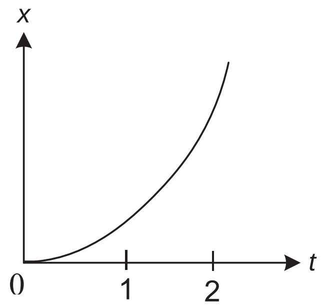
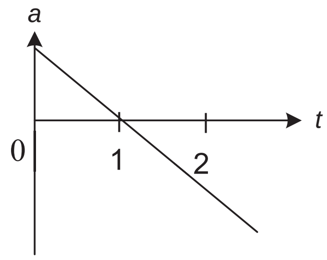


Fig. 4

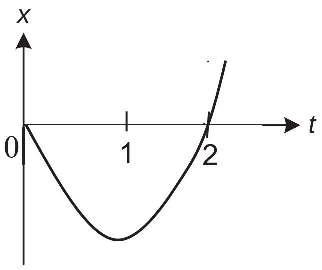
Which of the following pairs of graphs best represents the displacement - time (x - t) and acceleration - time (a - t) graphs for the particle?

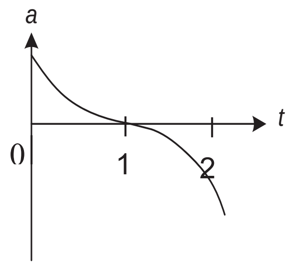
A



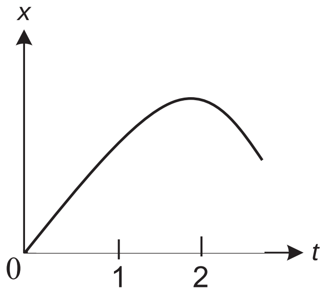


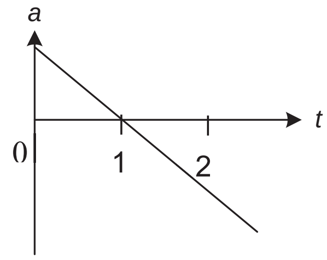
B



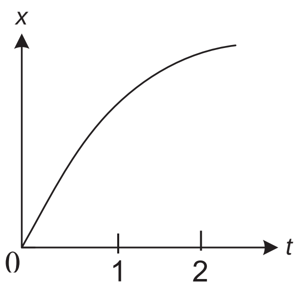


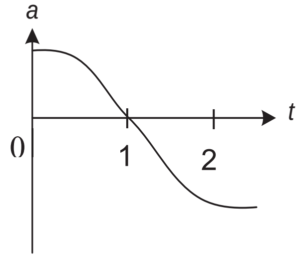
C



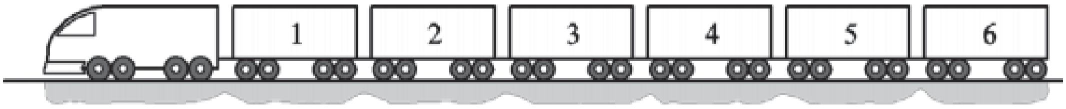


D





5 A train consisting of six trucks each of mass 6.0 x 10^4 kg is pulled at a constant speed by a locomotive of mass 24 x 10^4 kg along a straight horizontal track. The horizontal force resisting the motion of each truck is 4000 N.

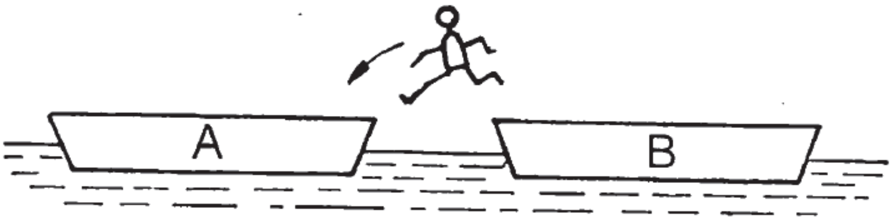


The coupling between trucks 2 and 3 snaps.

What is the initial acceleration of the locomotive?

A 0.022 m s^{-2}
B 0.044 m s^{-2}
C 0.067 m s^{-2}
D 0.133 m s^{-2}

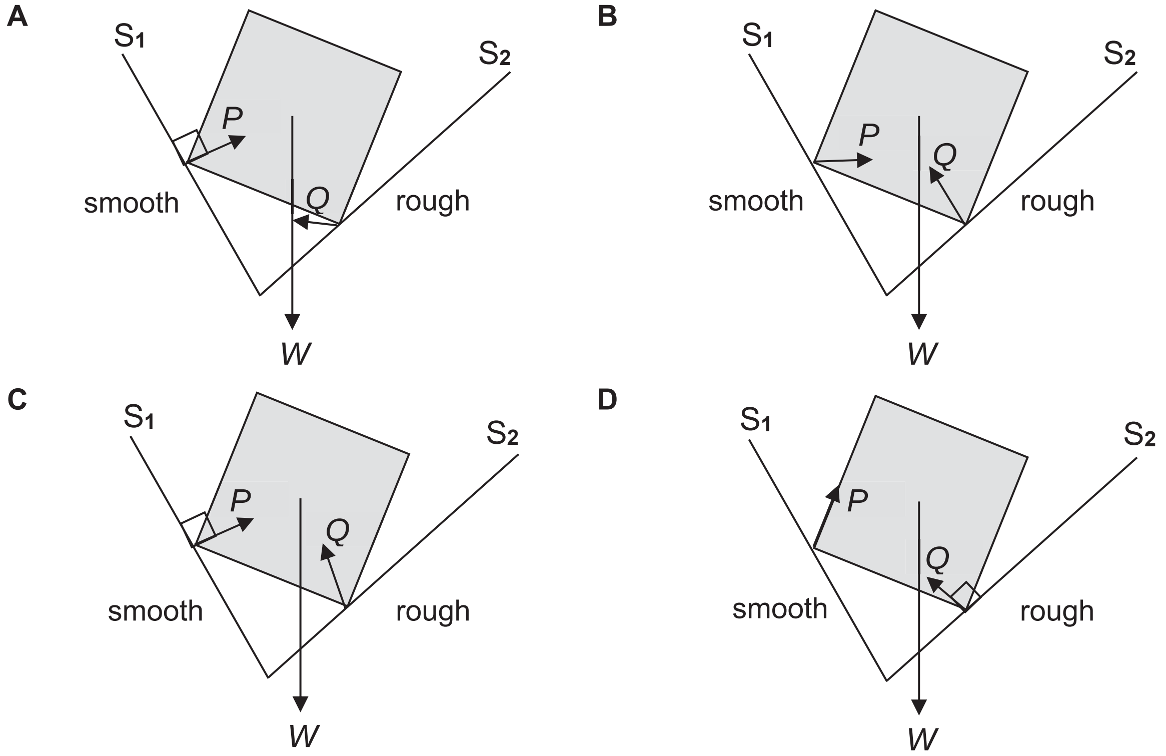
6 Two boats, each of mass *M*, are at rest adjacent to each other on calm water. A boy, of mass *m*, jumps from boat B to boat A.



Neglecting any dissipative forces the boats may experience, the ratio of the final speed of boat A to that of boat B is

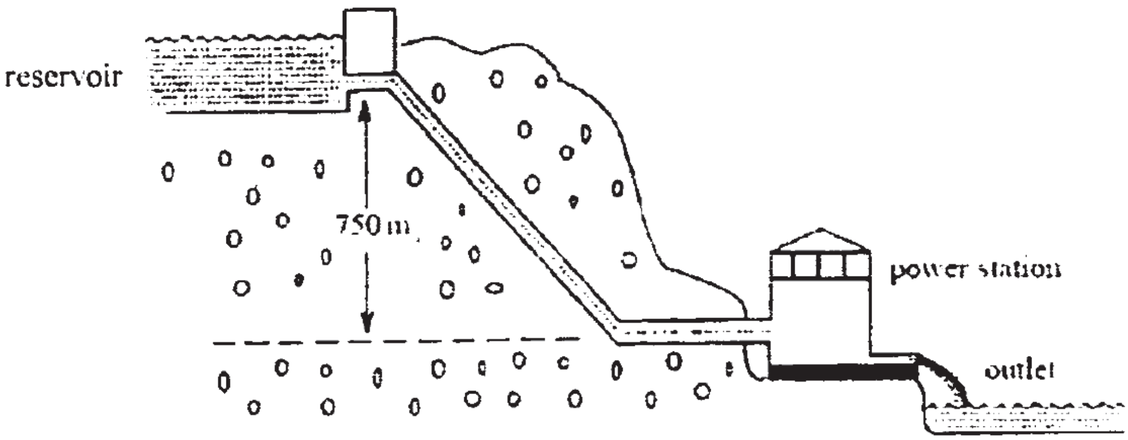
A 1 : 1
B *m* : *M*
C (*m* + *M*) : *M*
D *M* : (*M* + *m*)

7 Two straight edges of a uniform cube are leaning on smooth surface S_1 and rough surface S_2 and is about to slip. If the cube has weight W and the contact forces on the cube by surface S_1 and S_2 are P and Q respectively, which one of the following diagrams shows the possible directions of these forces?



8 This question is about a hydroelectric power station. Water is supplied from a reservoir which is 750 m above the power station turbines, as shown in the diagram. The water passes through its turbines at a rate of 1.4 $m^3 s^{-1}$.

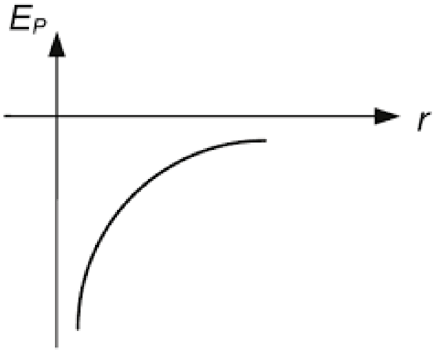
(Density of water = 1000 kg m^{-3})



If the efficiency of the power station is 20%, what is its power output?

A 2.1 kW
B 2.1 MW
C 5.2 kW
D 52 MW

9 The gravitational potential energy E_P of a body varies with its distance r from the centre of a planet as shown in the diagram below.



What does the gradient at any point on the curve represent?

A The gravitational potential at that value of r
B The gravitational field strength at that value of r
C The force pulling the body towards the planet
D The acceleration of the body towards the planet

10 Two spherical planets have the same average density and respective radii R_1 and R_2. The ratio of the gravitational field on the surface of the first planet to that of the second is

A $R_1 : R_2$
B $R_2 : R_1$
C $R_1^2 : R_2^2$
D $R_2^2 : R_1^2$

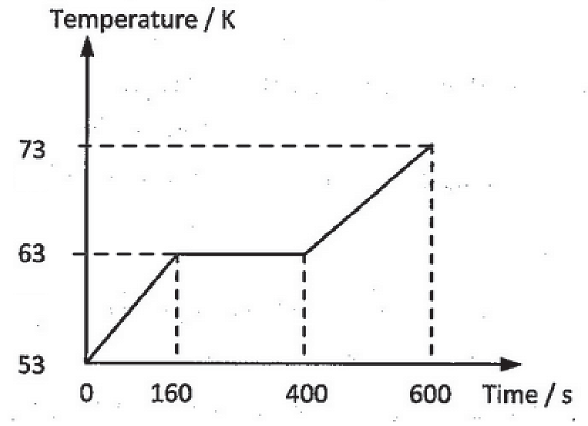
11 A gas with a total mass of 1.60 kg exerts a pressure of 1.00 x 10^5 Pa in a container of volume 0.500 m^3.

What is the root-mean-square speed of the gas molecules?

A 250 m s^{-1}
B 286 m s^{-1}
C 300 m s^{-1}
D 306 m s^{-1}

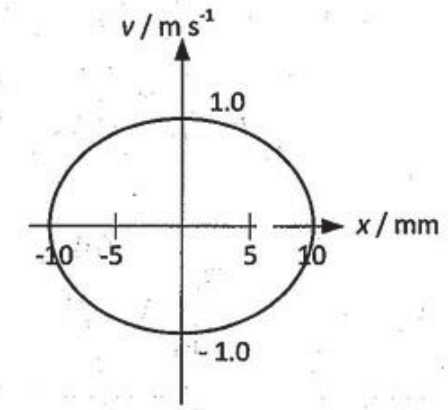
12 The graph shows how the temperature of a specimen changes with time when heated by a constant power source.

Given that the specific heat capacity of the specimen when in the liquid state is 1.60×10^3 J kg^{-1} K^{-1}, what is the heat capacity of the specimen when in the solid state?



A 1.28×10^3 J kg^{-1} K^{-1}
B 1.40×10^3 J kg^{-1} K^{-1}
C 1.92×10^3 J kg^{-1} K^{-1}
D 2.00×10^3 J kg^{-1} K^{-1}

13 The graph shows the velocity variation with displacement of a body undergoing simple harmonic motion.



What is the frequency of the oscillation?

A 10.9 Hz
B 15.9 Hz
C 50.5 Hz
D 100 Hz

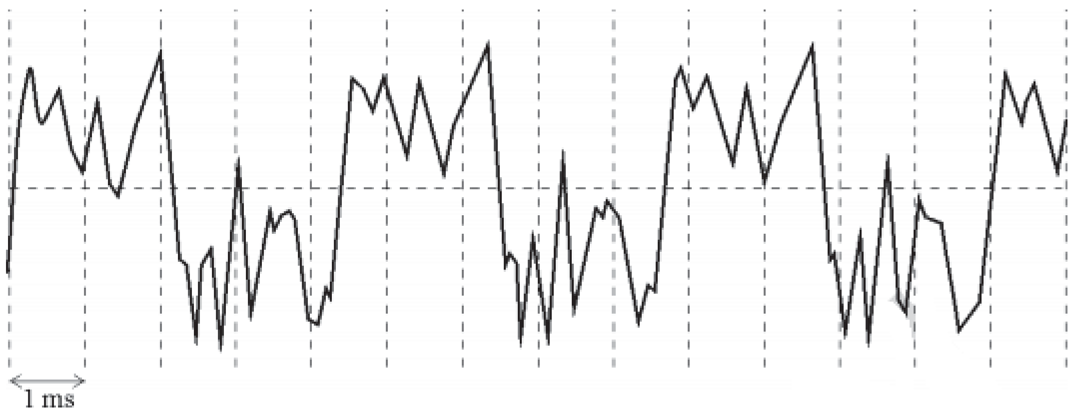
14 A force that varies sinusoidally is applied to a system that is lightly damped.

Which of the following must be true of the force for resonance to occur?

A It must always be in anti-phase with the oscillations of the system.
B Its direction must always be in the direction of motion of the oscillations of the system.
C Its frequency must be equal to the frequency of oscillation of the system.

D Its amplitude must be equal to the amplitude of oscillation of the system

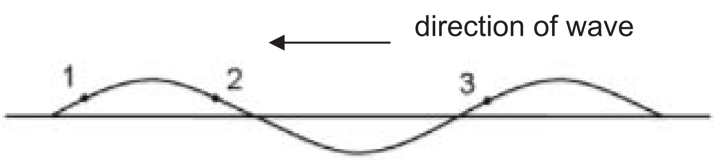
15 A musical note played by a clarinet is recorded. The signal is shown in the diagram below with the time-scale indicated.



What is the fundamental frequency of the note played by the clarinet?

A 77 Hz
B 120 Hz
C 230 Hz
D 2200 Hz

16 The diagram below shows an instantaneous position of a string as a transverse progressive wave travels along it from *right* to *left*.

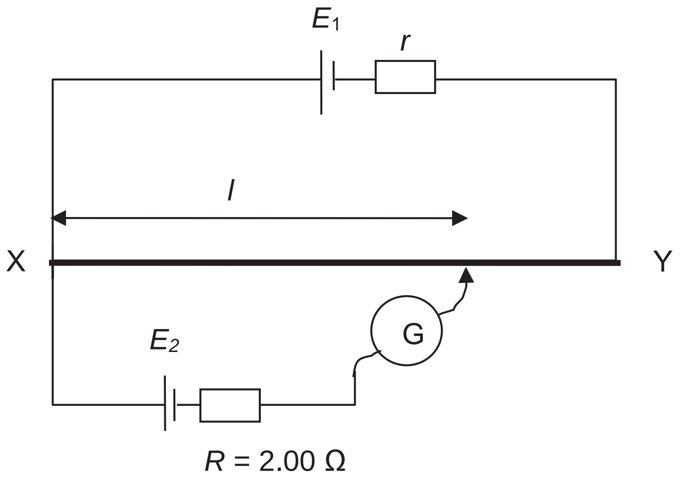


Which of the following correctly shows the directions of the velocities of the points 1, 2 and 3 on the string?

	1	2	3
A	↑	↓	↑
B	↓	↑	↓
C	←	←	←
D	→	→	→

17 A potentiometer consists of a 1.000 m long resistance wire **XY** in series with a battery of e.m.f. E_1 = 9.00 V and internal resistance r = 1.42 Ω. The resistance of **XY** is 8.30 Ω.

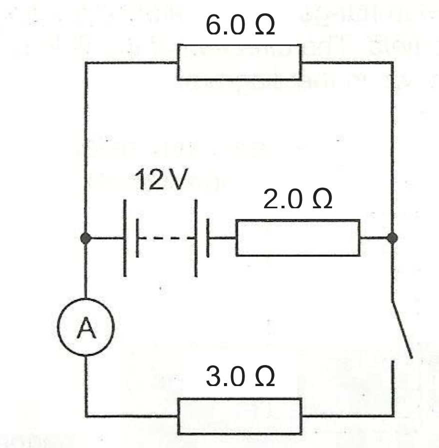
Determine the emf of cell E_2 if the balance length l is found to be 0.745 m.



A 0.636 V
B 2.72 V
C 5.73 V
D 9.00 V

18 In the circuit, the battery has an e.m.f. of 12 V and an internal resistance of 2.0 Ω. The ammeter has negligible resistance.

The switch is closed.



What is the reading on the ammeter?

A 0.50 A **B** 1.0 A **C** 1.3 A **D** 2.0 A

19 Two parallel plates are connected to an E.H.T. (Extra high Tension) of 4.5 kV. Electric breakdown occurs when the separation of the plates is reduced to 1.5 mm.

Estimate the maximum acceleration of an electron between the plates at this separation.

A 1.0×10^{9} m s^{-2}
B 1.2×10^{12} m s^{-2}
C 1.6×10^{15} m s^{-2}
D 5.3×10^{17} m s^{-2}

20 The diagram Fig. 20.1 below shows an insulating rod with equal and opposite charges at its ends, placed in a non-uniform electric field for which field lines (lines of force) are shown.

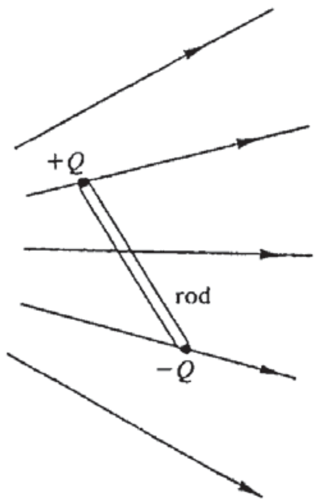
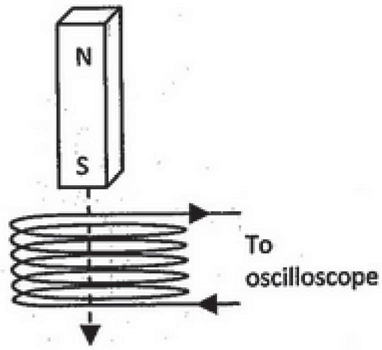


Fig. 20.1

The rod experiences

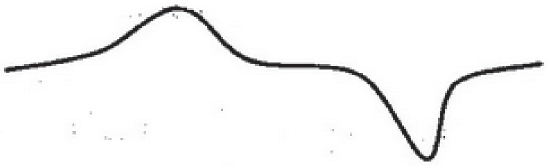
A a resultant force and a net clockwise moment.
B a resultant force and a net anti-clockwise moment.
C a resultant force only.
D a net moment only.

21 A wire coil with its plane horizontal is connected to an oscilloscope. A long magnet falls from rest through the coil along its axis.



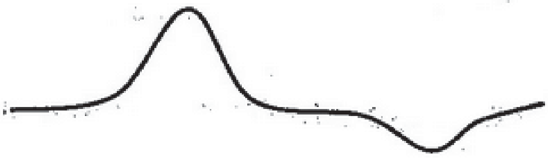
The trace observed on the oscilloscope screen is best represented by

A

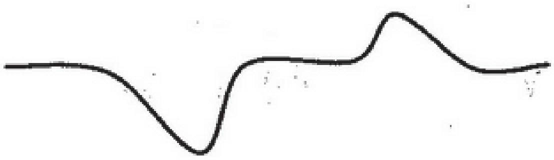


B

C

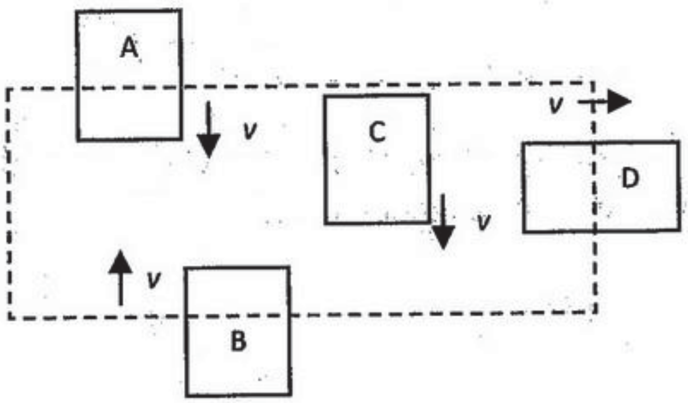


D

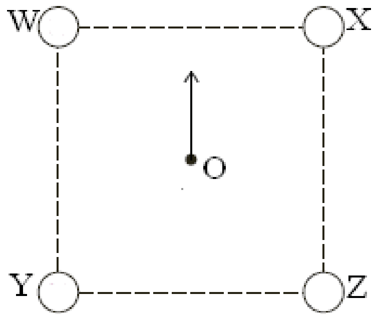


22 A uniform magnetic field *B* permeates the rectangular region shown by the dotted line. The direction of *B* is pointing into the page.

Which of the wire loops, moving with velocity *v*, has a current that flows in the clockwise direction?



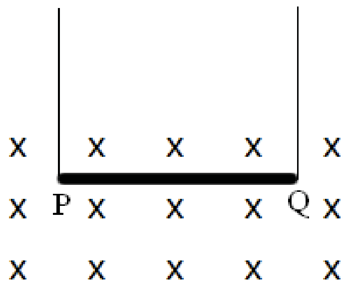
23 Parallel conductors **WXYZ** carry the same magnitude of currents and pass vertically through the four corners of a square.



Which of the following is the current directions of the current in order to produce a resultant magnetic field in the direction shown at **O**, the centre of the square?

	Into the page	**Out of the page**
A	W, X	Y, Z
B	W, Y	X, Z
C	X, Z	W, Y
D	Y, Z	W, X

24 A wire **PQ** of 60 cm long and of mass 10 g is suspended by a pair of leads in a magnetic field of flux density 0.40 T.



What is the magnitude and direction of current flowing in the wire if the net tension in the leads is negligible?

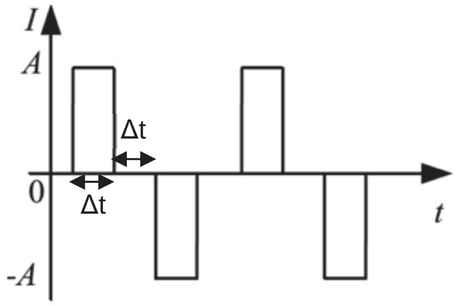
	Magnitude	**Direction**
A	0.409 A	P to Q
B	0.354 A	P to Q
C	0.354 A	Q to P
D	0.409 A	Q to P

25 A transformer with turns ratio of primary to secondary coil of 20:1 is 95% efficient due to joule heating effects. A 240 V alternating voltage is connected to the primary coil and a 5.0 Ω resistor is connected to the secondary coil.

What is the current flowing in the primary coil?

A 2.40 A
B 0.120 A
C 0.126 A
D 48.0 A

26 An alternating current with equal time interval during each constant current interval is shown below.



What is the root-mean-square current?

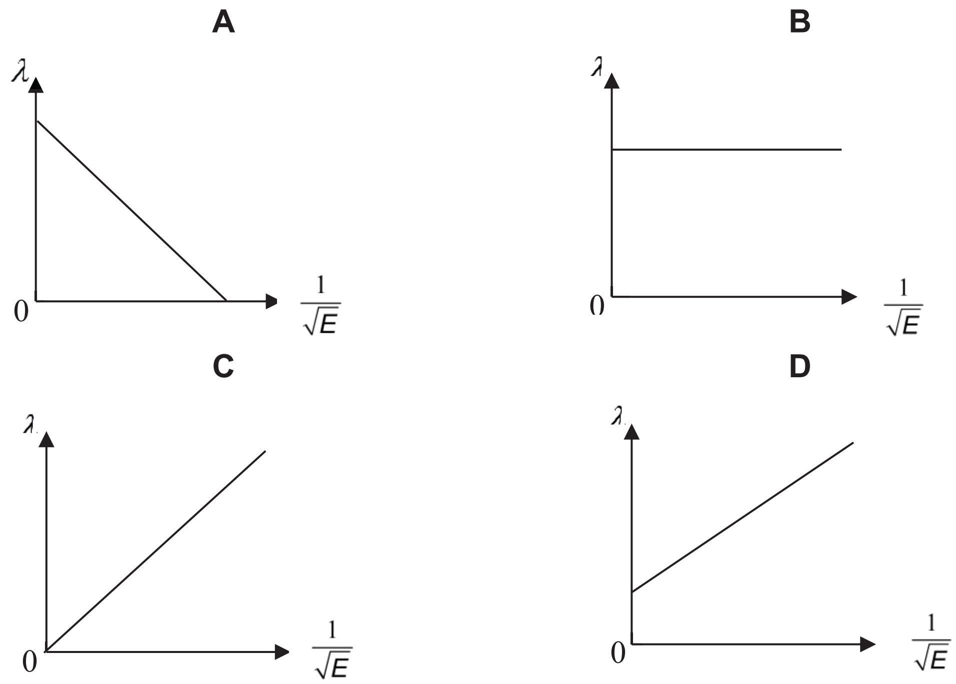
A $A/\sqrt{2}$ **B** A/2 **C** A/3 **D** A/4

27 Light quanta each of energy 3.5×10^{-19} J fall on the cathode of a photocell. The current through the cell is just reduced to zero by applying a reverse voltage to make the cathode 0.25 V positive with respect to the anode.

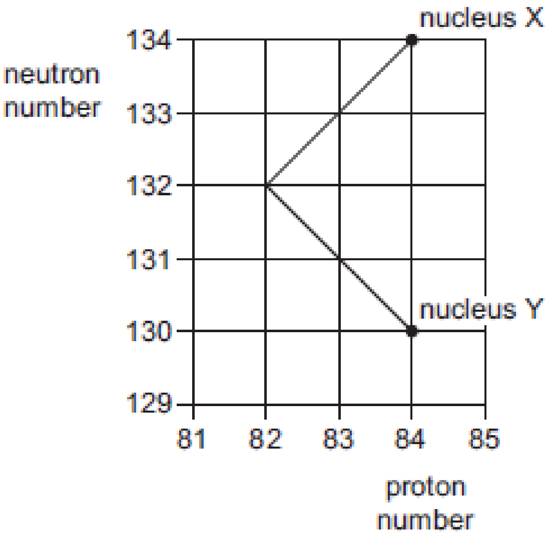
The minimum energy required to remove an electron from the cathode is

A 2.9×10^{-19} J
B 3.1×10^{-19} J
C 3.5×10^{-19} J
D 3.9×10^{-19} J

28 An electron with kinetic energy *E* has a de Broglie wavelength of λ. Which of the following graphs correctly represents the relationship between λ and *E*?



29 The graph of neutron number against proton number represents a sequence of radioactive decays.



Nucleus **X** is at the start of the sequence and, after the decays have occurred, nucleus **Y** is formed.

What is emitted during the sequence of decays?

A one α-particle followed by one β-particle
B one α-particle followed by two β-particles
C two α-particles followed by two β-particles
D two β-particles followed by one α-particle

30 The nuclear reaction $P + Q \rightarrow X + Y$ proceeds with a release of energy. Which of the following statement must be correct?

A Mass of X and Y is larger than mass of P and Q.
B Momentum of X and Y is larger than momentum of P and Q.
C Total binding energy of X and Y is larger than total binding energy of P and Q.
D Binding energy per nucleon of both X and Y are larger than binding energy per nucleon of P or Q.

End of paper

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16S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2017
Preliminary Examination

PHYSICS, Higher 2 **9749/02**

Paper 2 Structured Questions **14th September 2017**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

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

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

Answer **all** questions.

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

For Examiner's Use	
1	/ 9
2	/ 10
3	/ 10
4	/ 10
5	/ 10
6	/ 10
7	/ 21
Total	/ 80

This document consists of **23** printed pages including this page.

Data

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elementary charge,	$e = 1.60 \times 10^{-19}$ C
the Planck constant,	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant,	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron,	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton,	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant,	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant,	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant,	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant,	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall,	$g = 9.81$ m s^{-2}

Formulae

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	$v^2 = u^2 + 2 a s$
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mean translational kinetic energy of an ideal gas molecule,	$E = \dfrac{3}{2}kT$
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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,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \dfrac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 n I$
radioactive decay,	$x = x_o \exp(-\lambda t)$
decay constant,	$\lambda = \dfrac{\ln 2}{t_{1/2}}$

1 **(a)** Distinguish between a couple and the torque of a couple.

……..

……..

…… [2]

(b) A uniform plank of mass 1.00 kg is held up by 2 identical, massless and inextensible strings, each 1.00 m from the centre of the plank. A block of mass 4.50 kg is supported by the plank at a distance of 1.50 m away from the left string as shown in Fig. 1.1 below (not drawn to scale). The size of the block is insignificant compared to the length of the plank.

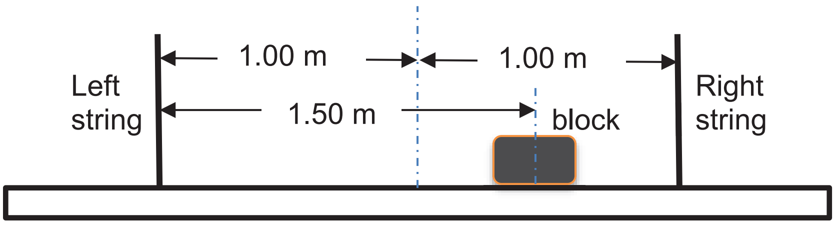


Fig. 1.1

Calculate the tension in each string.

tension in left string = …..………………. N

tension in right string = …………………. N [3]

(c) The National Day Parade last month saw a light show performed by 300 unmanned drones developed by Intel, called the Shooting Star drones. Each of these multirotor drones has a mass of 330 grams and four sets of propellers, as shown in Fig. 1.2, and the propellers cannot tilt like in helicopter rotors.

Fig. 1.2

When such a drone is in a stable hover, propellers **1** and **2** are spinning clockwise and anti-clockwise respectively as shown in the top-view diagram of the drone in Fig. 1.3.

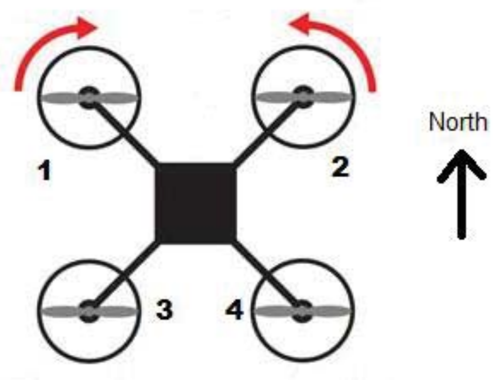


Fig. 1.3

(i) Draw in Fig. 1.3 above curved arrows to show the spins for propellers **3** and **4**. [1]

(ii) Explain how the drone can hover in the sky.

……………………………………………………………………………………………

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

(iii) Explain, in terms of the speeds of the propellers, how the drone can fly forward (Northward) from a hovering position without a change in height.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

2 **(a)** Use Newton's laws of motion to explain why a body moving with uniform speed in a circle must experience a force towards the centre of the circle.

....

....

....

.... [3]

(b) A massless spring of force constant k = 78.4 N m^{-1} is fixed on the left side of a level track. A block of mass m = 0.50 kg is pressed against the spring and compresses it by a distance d as shown in Fig. 2.1. The block is then released from rest and travels toward a circular loop-the-loop of radius R = 1.5 m.

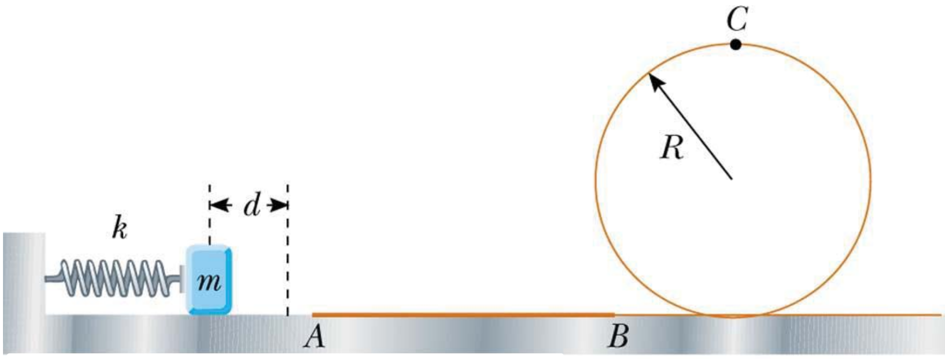


Fig. 2.1

The entire track and the loop-the-loop are frictionless except for the section of track between points **A** and **B**.

Given that the friction between the block and the track along **AB** is 1.47 N and the length of **AB** is 2.5 m, determine the minimum compression d of the spring that enables the block to just make it through the loop-the-loop at point **C**.

minimum compression = ... m [3]

(c) An elastic cord has an un-extended length of 13.0 cm. One end of the cord is attached to a fixed point **C**. A small mass of weight 5.0 N is hung from the free end of the cord. The cord extends to a length of 14.8 cm, as shown in Fig. 2.1.

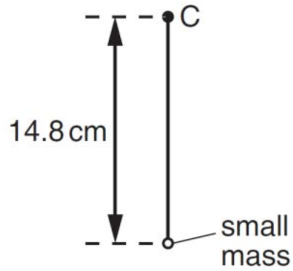


Fig. 2.1

The cord and mass are now made to rotate at *constant* angular speed ω in a vertical plane about point **C**. When the cord is vertical and above **C**, its length is the un-extended length of 13.0 cm, as shown in Fig. 2.2.

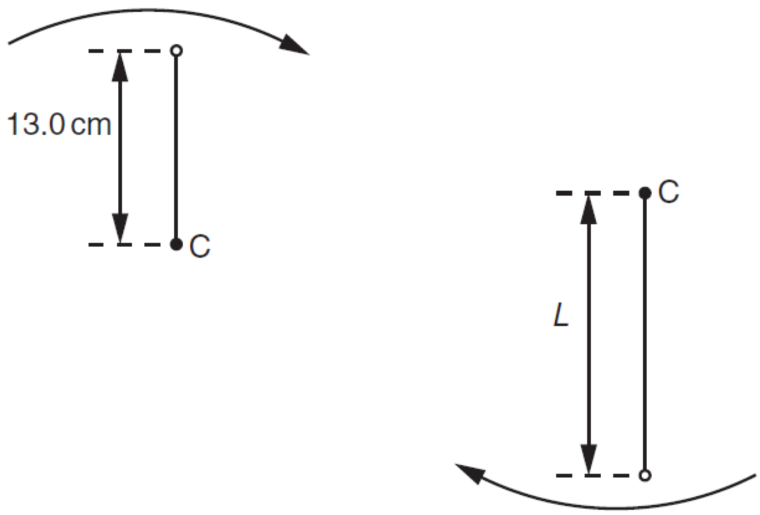


Fig. 2.2 **Fig. 2.3**

The cord and mass rotate so that the cord is vertically below **C**, as shown in Fig. 2.3.

Calculate the length L of the cord, assuming it obeys Hooke's law.

L = ………………………….. cm [4]

3 A uniform beam is clamped at one end. A metal block of mass m is fixed to the other end of the beam causing it to bend, as shown in Fig. 3.1.

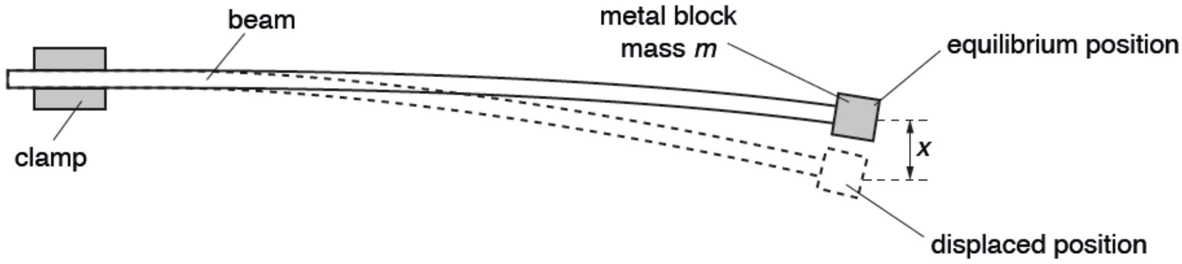


Fig. 3.1

The block is given a small vertical displacement and then released so that it oscillates with an acceleration a given by the expression

$$a = -\frac{k}{m}x$$

where k = 4.0 kg s^{-2} and m = 0.25 kg.

(a) Explain how it can be deduced from the expression that the block moves with simple harmonic motion.

....

....

.... [2]

(b) Calculate the period of the oscillation.

period = ... s [2]

(c) The initial amplitude of the oscillation of the block is 3.0 cm. Calculate the maximum speed of the object.

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

(d) Over a certain interval of time, the maximum kinetic energy of the oscillations in **(c)** is reduced by 20%. It may be assumed that there is negligible change in the angular frequency of the oscillations.

Determine the amplitude of oscillation.

amplitude =……………………. m [2]

(e) Permanent magnets are now positioned so that the metal block oscillates between the poles, as shown in Fig. 3.2.

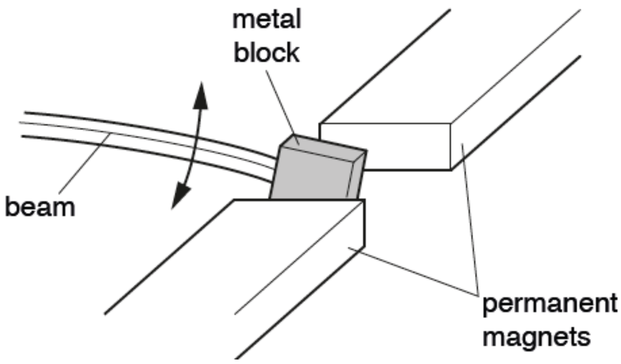


Fig. 3.2

The block is made to oscillate with the same initial amplitude as in **(c)**. Use energy conservation to explain why the energy of the oscillations decreases more rapidly than in **(d)**.

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

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

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

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

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

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

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

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

(b) The diagram below shows the equipotential lines (dotted lines) due to two charges (solid dots).

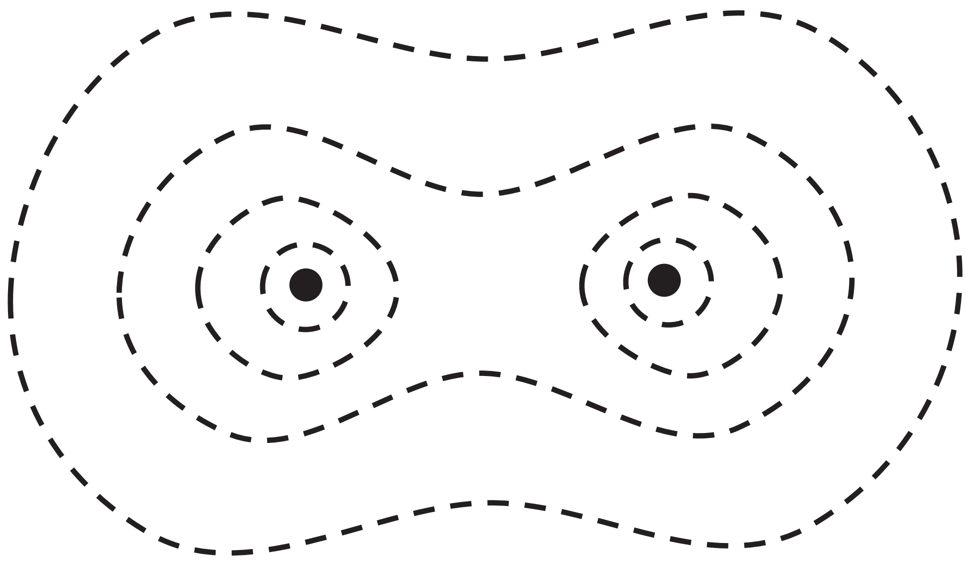


Fig.4.1

(i) State whether the two charges are like or unlike charges and comment on the relative magnitude of the two charges. Explain your reasoning.

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

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

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

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

(ii) State the angle between an equipotential line and an electric field line. Explain your answer.

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

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

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

(iii) Hence, draw on Fig. 4.1 the electric field lines of these two charges. You do not need to indicate the direction of the field lines.

[2]

(c) Two charged spheres with charges q_1 and q_2 are fixed at their positions as shown in Fig. 4.2.

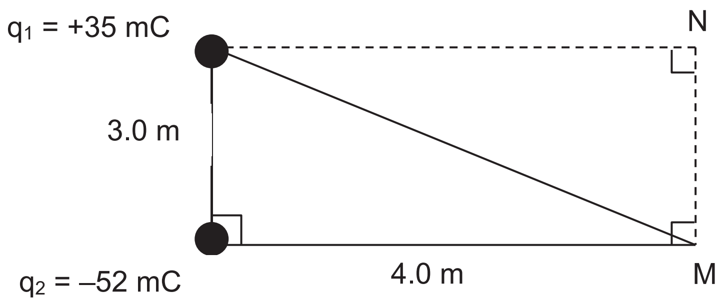


Fig. 4.2

Determine the work done by an external force on a third charged sphere q_3 of +4.5 μC as q_3 is moved from point M to point N.

work done = ……………………… J [3]

5 **(a)** State Faraday's law of electromagnetic induction.

……..

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

(b) The diameter of the cross-section of a long solenoid with 15 turns is 3.2 cm, as shown in Fig. 5.1

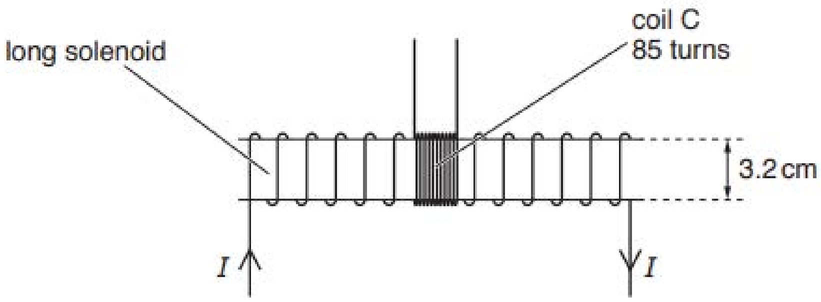


Fig. 5.1

A coil **C**, with 85 turns of wire, is wound tightly around the centre region of the solenoid. The magnetic flux density *B*, in tesla, at the centre of the solenoid is given by the expression

$$B = \pi \times 10^{-3} \times I$$

where I is the current in the solenoid in ampere.

(i) Calculate, for a current I of 2.8 A in the solenoid, the magnetic flux linkage of the coil **C**.

magnetic flux linkage = …………………. Wb [1]

(ii) The current I in the solenoid in **(b)(i)** is reversed in 0.30 s. Calculate the mean e.m.f. induced in coil **C**.

e.m.f. induced = …………………. V [2]

(iii) The current I in the solenoid in **(b)(i)** is now varied with time t as shown in Fig. 5.2.

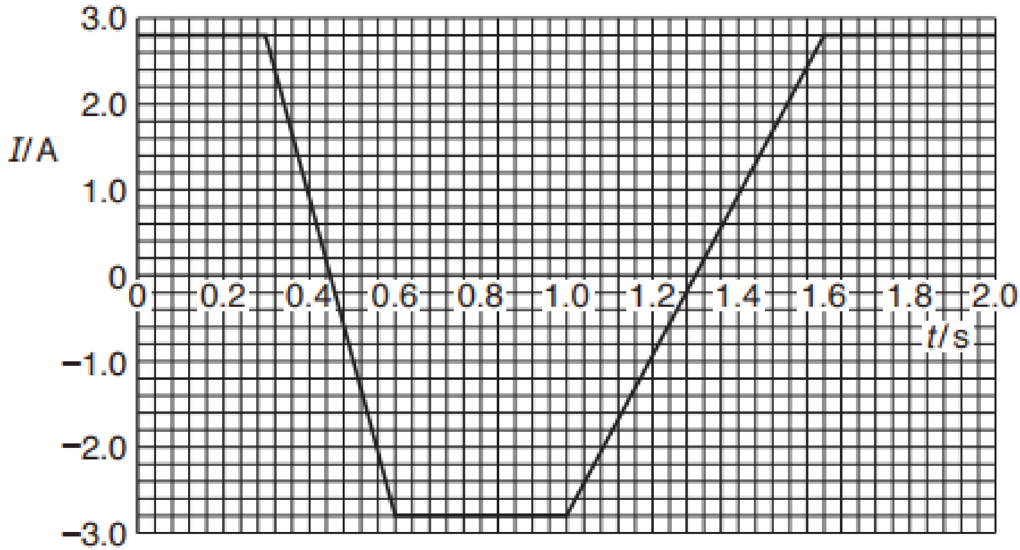


Fig. 5.2

Use your answer to **(b)(ii)** to show, on Fig. 5.3, the variation with time t of the e.m.f. E induced in coil **C**. [3]

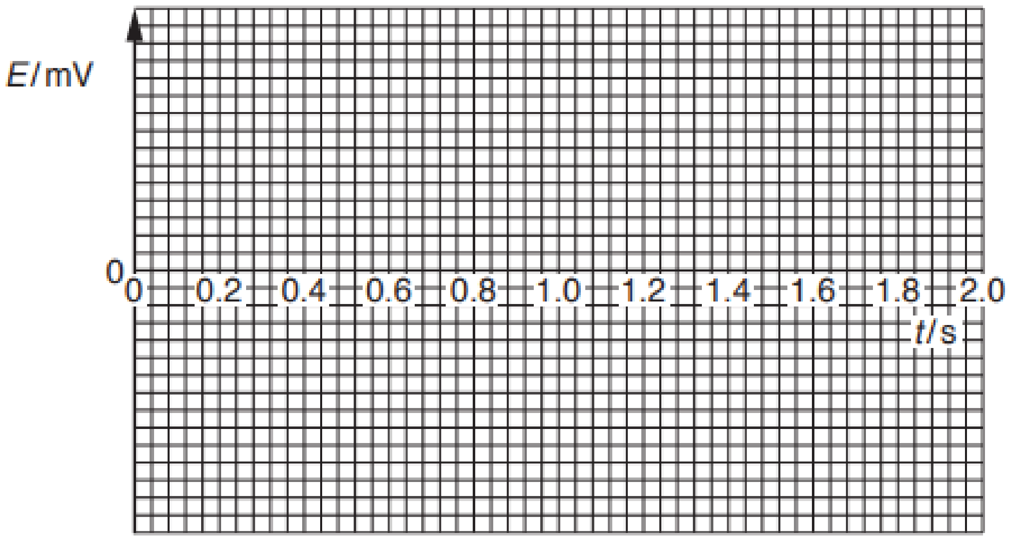


Fig. 5.3

(iv) The current supplied to the solenoid is now replaced by an alternating voltage V given by the expression

$$V = 2.55 \sin (100\pi t)$$

Calculate the root-mean-square voltage of coil **C**, assuming that the setup behaves like an ideal transformer.

root-mean-square voltage = …………………. V [2]

(v) Explain why the assumption used in **(b)(iv)** is not valid.

…………………………………………………………………………………………….

…………………………………………………………………………………………….

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

6 **(a)** Fig. 6.1 below shows three of the electron energy levels of mercury gas.

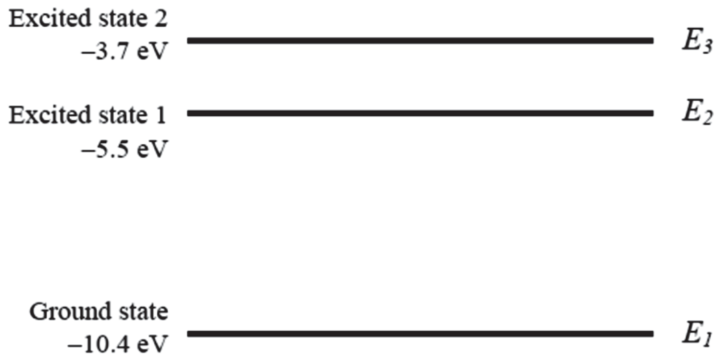


Fig. 6.1

When a current is passed through the gas at low pressure, a line spectrum is observed. Three of the lines which correspond to transitions between the energy levels are shown in Fig. 6.2.

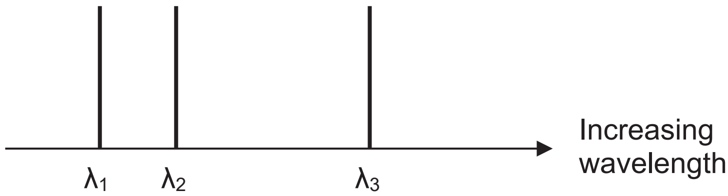


Fig. 6.2

(i) Determine the ionisation energy of mercury in J with respect to the electron in the ground state as given in Fig. 6.1.

ionisation energy = ………………………….. J [1]

(ii) Identify the electronic transition responsible for the line spectrum of wavelength λ_3. Explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iii) Describe what happens to the atom in the ground state in order for the atom to emit light of wavelength λ_3.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Fig. 6.3 below shows a setup used to investigate the photoelectric effect.

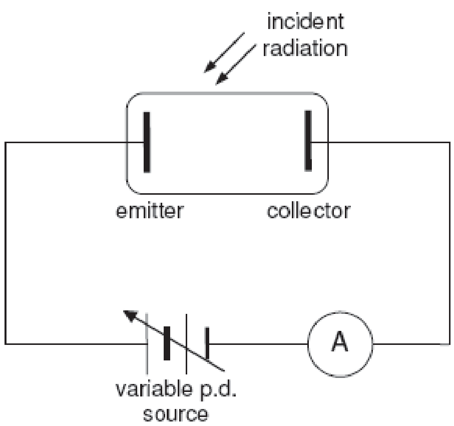


Fig. 6.3

When radiation of wavelength 225 nm is incident on the emitter, photoelectrons are emitted.

Fig. 6.4 below shows how the photocurrent I varies with the applied p.d. V between the emitter and the collector of the setup. The graph is obtained when the power of the radiation incident on the emitter is 2.85 mW.

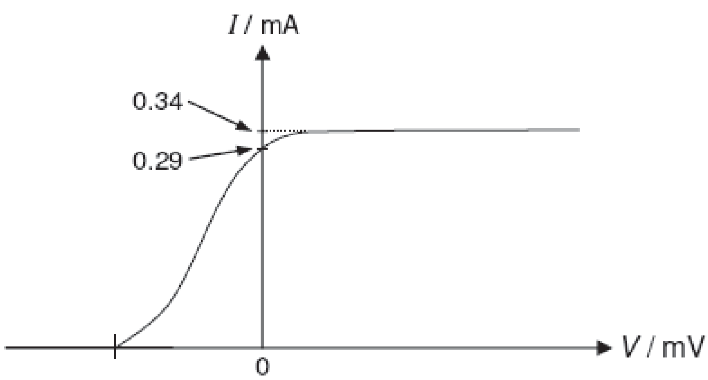


Fig. 6.4

(i) Define *stopping potential*.

……..………………………….………………………………………………………

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

(ii) A ratio, known as the *photoelectric quantum yield* is a measure of the efficiency of the photoelectric effect.

Photoelectric quantum yield is defined as

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

Calculate the *photoelectric quantum yield* for this given experiment.

photoelectric quantum yield = ………………………….. [3]

7 The article below is based on an article on the Internet.

Read the article and then answer the questions that follow.

Photovoltaic (PV) Efficiency: The Temperature Effect

A photovoltaic (PV) cell absorbs light energy and converts this into electrical energy. A PV panel consists of a large number of photovoltaic cells. A PV system consists of a PV panel and the rest of the circuit to which it is connected.

Temperature generally affects current in an electrical circuit by changing the speed at which the electrons travel. In metals, this is due to an increase in resistance of the circuit that results from an increase in temperature. The opposite effect is seen in semiconductor materials where an increased temperature results in a decrease in resistance due to a change in the number density of charge carriers.

It is important that the equipment associated with a PV panel is appropriate for the context in which it will be used. The current and voltage output of a PV cell is affected by changing weather conditions. A PV system at a higher temperature will have a lower maximum voltage, lower efficiency and lower power output than the same system at a lower temperature.

Engineers must carefully choose the PV system for different temperature environments to ensure that the output voltage is not too high, which could damage the equipment. It is also important to consider the average operating voltage and current of a PV system for safety concerns, equipment capabilities and choices, and to minimise the amount of wire required for construction.

Since PV panels are more efficient at lower temperatures, engineers design systems with active and passive cooling. An example of active cooling is to pump water behind the panels to remove the heat. An example of passive cooling is to let the system be cooled by convection currents in the air.

While it is important to know the temperature of a solar PV panel to predict its power output, it is also important to know the PV panel materials because the efficiencies of different materials have varied levels of dependence on temperature. Therefore, a PV system must be engineered not only accordingly to the maximum, minimum and average environmental temperatures at each location, but also with an understanding of the materials used.

The temperature dependence of a material is described with a temperature coefficient. For monocrystalline PV panels, if the temperature decreases by 1 °C, the voltage increases by 0.48 V, so the temperature coefficient is 0.48 V °C^{-1}. The general equation for estimating the open circuit voltage V of a material at the temperature T of the panel is

$$V = \mu(T_R - T) + V_R$$

where μ is the temperature coefficient, T_R is a reference temperature and V_R is the open circuit voltage at the reference temperature. The temperatures are in degrees Celsius.

The variation with voltage of current at two different temperatures for one cell of the panel is shown in Fig. 7.1.

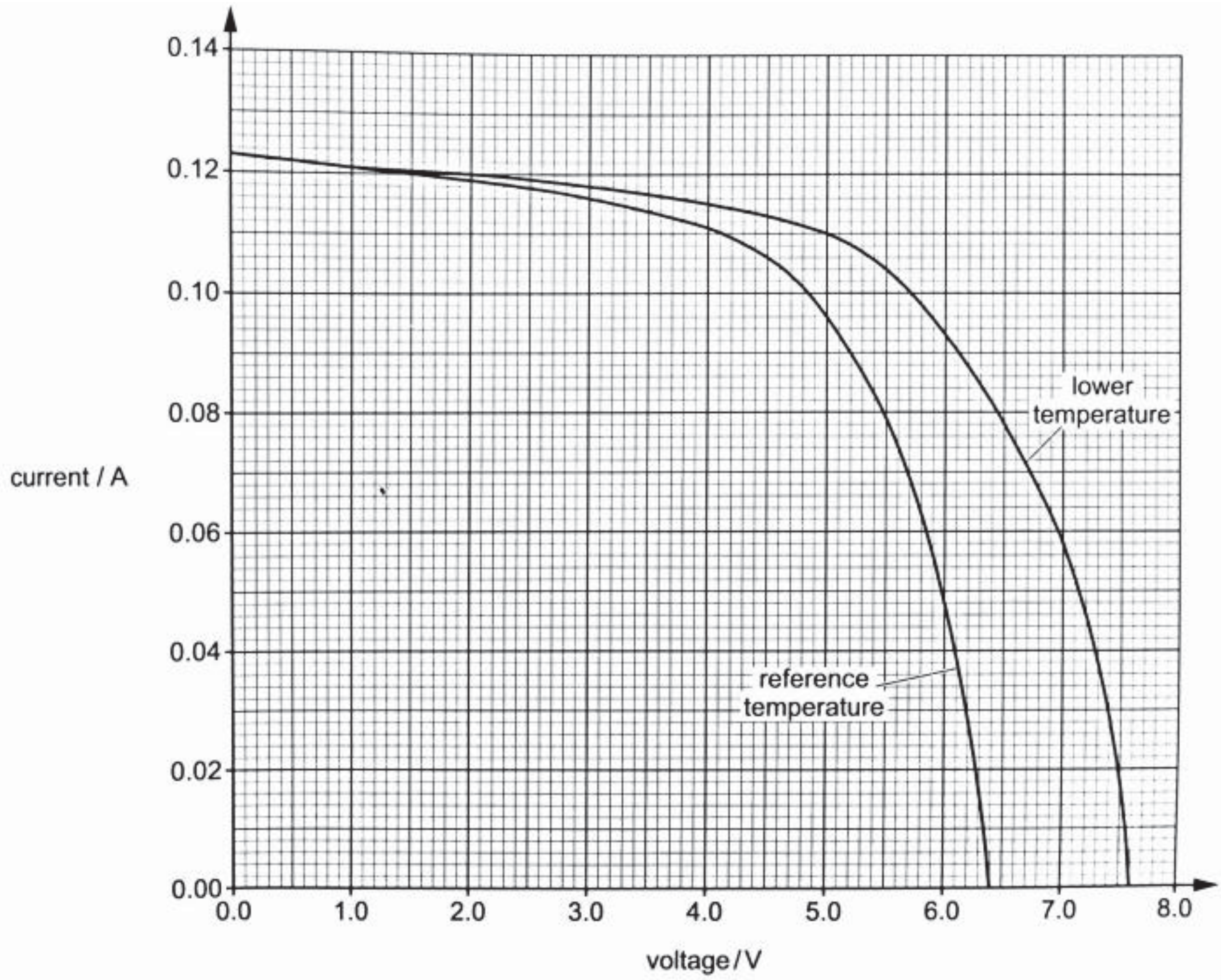


Fig. 7.1

(a) State and explain why the resistance of metals increases with temperature.

……

……

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

(b) The panel produces a much larger voltage or current than an individual cell. State how the cells are connected in a panel such that

(i) the voltage is increased,

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

(ii) the current is increased.

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

(c) **(i)** Suggest what is meant by *passive cooling*.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(ii) Suggest why engineers do not design systems with active cooling alone.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(d) Suggest how passive air cooling may be enhanced for a PV panel.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(e) **(i)** Use Fig. 7.1 to state the open circuit voltage (e.m.f.) of the PV cell at both the reference temperature and the lower temperature.

V_R = …………………….. V

V = ……………………….V

[1]

(ii) Use Fig. 7.1 to describe qualitatively the variation with temperature of the current in the cell.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(iii) Fig. 7.2 shows the variation with temperature T of the open circuit V. Draw the line of best fit. [1]

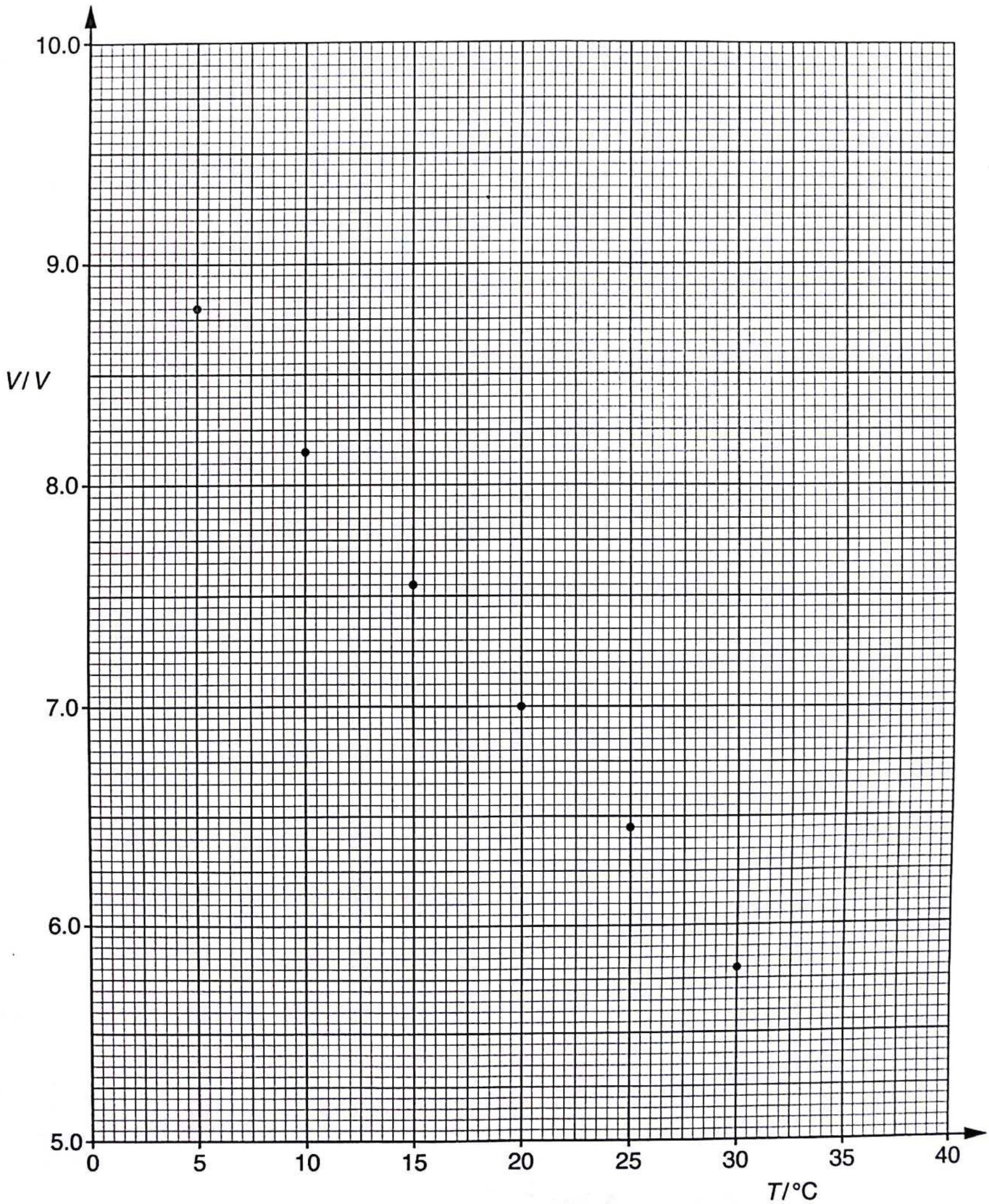


Fig. 7.2

(iv) Use Fig. 7.2 to determine the constants μ and T_R.

μ = ………………………………. V °C^{-1}

T_R = ……………………………….. °C

[3]

(v) Use your answers to **(e)(i)** and **(e)(iv)** to determine the lower temperature used to obtain the data for Fig. 7.1.

lower temperature = ……………………………….. °C [1]

(vi) The PV cell is producing 6.0 V at the reference temperature.

On Fig. 7.1, indicate the area which represents the output power of the cell. [2]

(vii) Use Fig. 7.1, to estimate the maximum power output of the PV cell at the reference temperature.

maximum power output = ………………………………. W [2]

(f) **(i)** A PV cell may have multiple layers of different semi-conducting materials. As the number of layers increases, the efficiency of conversion of light energy to electrical energy increases.

Suggest a reason why the efficiency increases.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) Suggest how the angle between the PV panel and the incident sunlight affects the power output of the PV panel.

…………………………………………………………………………………………………

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

End of paper

Class	Index Number	Name
16S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2017
Preliminary Examination

PHYSICS, Higher 2 **9749/03**

Paper 3 Longer Structured Questions **18th September 2017**
2 hours

Candidates answer on the Question Paper.
No additional materials are required.

READ THESE INSTRUCTIONS FIRST

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

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

Section **A**
Answer **all** questions.

Section **B**
Answer any **one** question

You are advised to spend about one hour on each Section.

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	
Section A	
1	**/ 10**
2	**/ 10**
3	**/ 10**
4	**/ 10**
5	**/ 20**
Section B	
6	**/ 20**
7	**/ 20**
Total	**/ 80**

This document consists of **23** printed pages including this page.

Data

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

Formulae

uniformly accelerated motion,	s	$= u t + \frac{1}{2} a t^2$
	v^2	$= u^2 + 2 a s$
work done on/by a gas,	W	$= p \Delta V$
hydrostatic pressure,	p	$= \rho g h$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
displacement of particle in s.h.m.,	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.,	v	$= v_0 \cos \omega t$
	v	$= \pm \omega \sqrt{x_0^2 - x^2}$
mean kinetic energy of a molecule of an ideal gas,	E	$= \dfrac{3}{2} kT$
resistors in series,	R	$= R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	$= 1/R_1 + 1/R_2 + \ldots$
electric potential,	V	$= \dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	x	$= x_o \sin \omega t$
transmission coefficient,	T	$\alpha \exp(-2 k d)$
	where $k = \sqrt{\dfrac{8\pi^2 m (U - E)}{h^2}}$	
radioactive decay,	x	$= x_o \exp(-\lambda t)$
decay constant,	λ	$= \dfrac{0.693}{t_{1/2}}$

Section A

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

1 A fixed mass of an ideal gas undergoes a cycle **ABCA** of changes, as shown in Fig. 1.1.

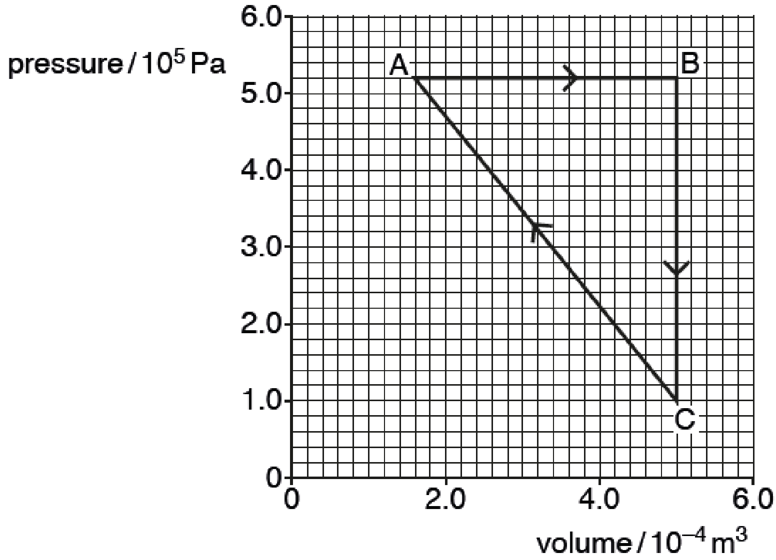


Fig. 1.1

(a) During the change from **A** to **B**, the energy supplied to the gas by heating is 442 J. Use the first law of thermodynamics to calculate the change in internal energy of the gas.

change in internal energy = ………………..… J [2]

(b) During the change from **B** to **C**, the internal energy of the gas decreases by 313 J.

By considering molecular energy, state and explain qualitatively the change, if any, in the temperature of the gas.

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

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

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

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

(c) For the change from **C** to **A**, calculate the energy supplied to the gas by heating.

energy supplied by heating = …………………..… J [2]

(d) The temperature of the gas at point **A** is 227 °C. Calculate the number of molecules in the fixed mass of the gas.

number of molecules = …………….……….. [2]

(e) Calculate the root-mean-square speed of the gas molecules at point **B** if the root-mean-square speed at point **A** is 350 m s^{-1}.

root-mean-square speed = …………….………. m s^{-1} [2]

2 **(a)** Noise cancelling headphones, as shown in Fig. 2.1 below, were first invented to cancel the noise in aeroplane and helicopter cockpits. They work using the principle of superposition of waves.

Fig. 2.1

Sound waves enter and pass through the headphone and are detected by a microphone. An electric circuit sends a signal to the loudspeaker so that it produces an 'opposite wave', as shown in Fig. 2.2.

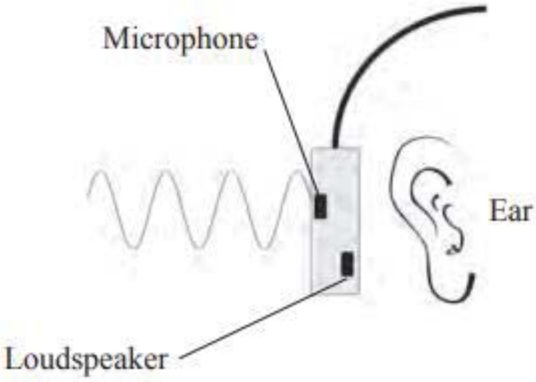


Fig. 2.2

(i) State the conditions necessary to produce complete cancellation of the two waves that reach the ear drum.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) In practice, noise-cancelling headphones are more effective in cancelling noise from a jet engine rather than from a speech or music. Suggest a reason for this.

……………………………………………………………………………………………

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

(b) Explain the term *diffraction*.

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

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

(c) A diffraction grating has slits of separation d. The grating is capable of producing only up to the third order maxima when illuminated normally by light of wavelength λ.

Determine the range of possible values of d in terms of λ.

range of d is ……………………………………………………………………………… [2]

(d) When one receives a chest x-ray in a hospital, the x-rays pass through a series of parallel ribs in the chest. Suggest why the ribs do not produce an interference and diffraction pattern like a diffraction grating.

....

.... [1]

(e) Two point sources of light are placed 12 mm apart and emit light of wavelength 0.60 μm.

Calculate the maximum distance at which the two sources can just be distinguished by an observer with an eye pupil diameter of 4.0 mm.

maximum distance = …………………… m [2]

3 **(a)** A student attempts to measure the resistivity of soil using two parallel copper plates driven into the ground as shown in Fig. 3.1.

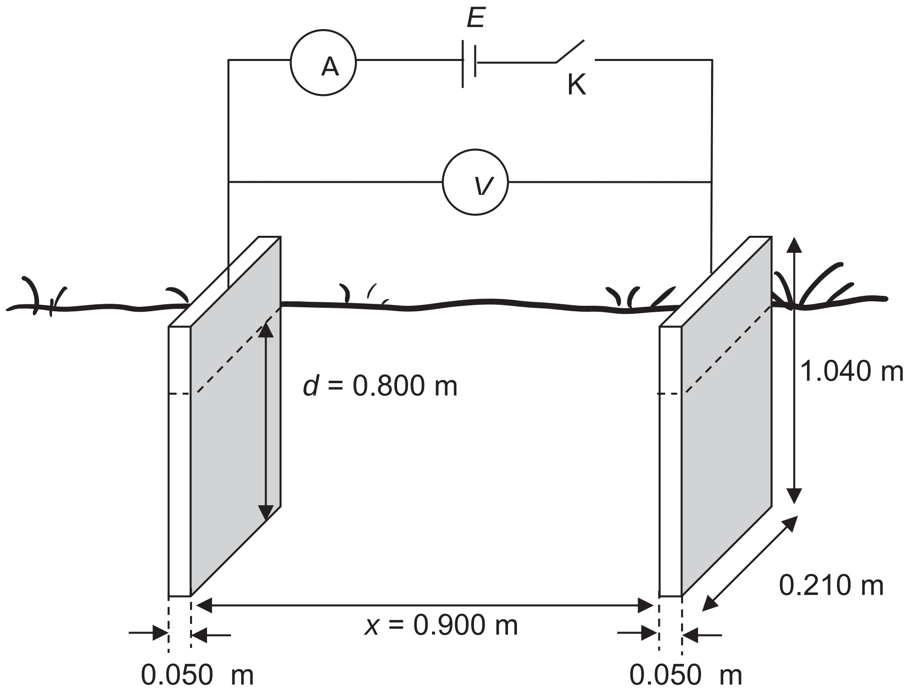


Fig. 3.1

Each copper plate has a height of 1.040 m, a width of 0.210 m and a thickness of 0.050 m. Assume that the ammeter has zero resistance and the voltmeter has infinite resistance.

The copper plates are driven to a depth d of 0.800 m and separated by a distance x = 0.900 m. When switch K is closed, the student obtained a voltmeter reading of 1.398 V and an ammeter reading of 0.31 mA.

(i) Determine the resistance of the soil between the copper electrodes.

resistance = ... Ω [2]

(ii) Hence, calculate the resistivity of the soil.

resistivity = …………………… [2]

(b) Explain what is meant by the statements:

(i) A battery has an electromotive force (e.m.f.) of 3 V.

……………………………………………………………………………………....

……………………………………………………………………………………....

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

(ii) The potential difference across a resistor is 2 V.

……………………………………………………………………………………....

……………………………………………………………………………………....

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

(c) A cell of negligible internal resistance is connected in series with a microammeter of negligible resistance and two resistors whose resistances are 10 kΩ and 15 kΩ. The current is 200 μA.

(i) Calculate the e.m.f. of the cell.

emf = …………………V [1]

(ii) When a voltmeter is connected in parallel with the 15 kΩ resistor, the current in the microammeter increases to 250 μA.

Calculate the resistance of the voltmeter.

resistance = ………………….Ω [3]

4 **(a)** State what is meant by a magnetic field.

……

…… [1]

(b) A particle of charge +*q* and mass *m* is travelling in a vacuum with speed *v*. The particle enters a uniform magnetic field of flux density *B* at 90°, as shown in Fig. 4.1.

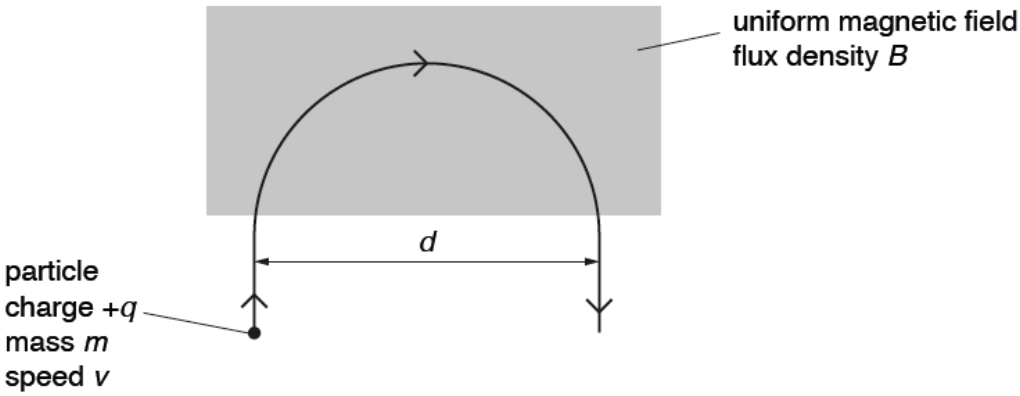


Fig. 4.1

The particle leaves the field after following a semi-circular path of diameter *d*.

(i) State the direction of the magnetic field

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

(ii) Explain why the kinetic energy of the particle is not affected by the magnetic field.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(iii) Show that the diameter *d* of the semi-circular path is given by the expression

$$d = \frac{2mv}{Bq}$$

[2]

(iv) Show that the time T spent in the field by the particle is independent of its speed v. [2]

(v) The positively-charged particle disintegrates into 2 oppositely charged particles in a direction which has a component perpendicular to the plane of the paper.

Describe the path of the negatively-charged particle going out of the plane of the paper.

…………………………………………………………………………………………...

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

(vi) Suppose the positively-charged particle did not disintegrate.

Draw on Fig. 4.1 the direction of an electric field that can be applied so that the charged particle travels in a straight line through the magnetic field.

[1]

5 **(a)** An α-particle **A** approaches and passes by a stationary gold nucleus **N**. The path is illustrated in Fig. 5.1.

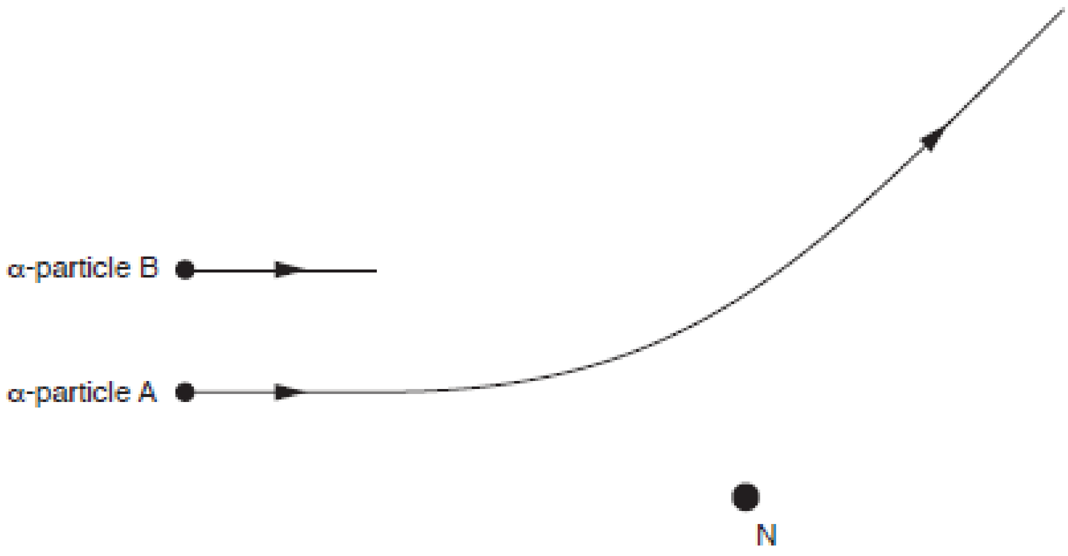


Fig. 5.1

(i) A second α-particle **B** has the same initial direction and energy as α-particle **A**.

On Fig. 5.1, complete the path of α-particle **B** as it approaches and passes nucleus **N**. [1]

(ii) State what can be inferred about atoms from the observations that very few α-particles experience large deviations.

……………………………………………………………………………………………

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

(iii) The nucleus **N** could be one of several different isotopes of gold.

Suggest, with an explanation, whether different isotopes of gold would give rise to different deviations of a particular α-particle.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iv) The α-particles in this experiment originated from the decay of a radioactive nuclide. Suggest why β-particles from a radioactive source would be inappropriate for this type of scattering experiment.

……………………………………………………………………………………………

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

(b) When a neutron is captured by a uranium-235 nucleus, the outcome may be represented by the nuclear equation shown below.

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + x\,^{1}_{0}n + 7\,^{0}_{-1}e$$

Some data for the nuclei in the reaction are given in Fig. 5.2.

		mass / u	binding energy per nucleon / MeV
uranium-235	($^{235}_{92}U$)	235.123	
molybdenum-95	($^{95}_{42}Mo$)	94.945	8.09
lanthanum-139	($^{139}_{57}La$)	138.955	7.92
proton	($^{1}_{1}p$)	1.007	
neutron	($^{1}_{0}n$)	1.009	

Fig. 5.2

(i) Determine the value of *x*.

x = …………………………… [1]

(ii) Show that the binding energy per nucleon of a nucleus of uranium-235 is 7.18 MeV.

[3]

(iii) In Fig. 5.2, the binding energy *per nucleon* of molybdenum-95 is stated as 8.09 MeV.

Explain what is meant by this statement.

…………………………………………………………………………………………………

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

(iv) The kinetic energy of the neutron before the reaction is 10.0 MeV. Calculate the total energy released in this reaction.

energy released = …………………… MeV [2]

(c) The curie (Ci) is a non-SI unit of radioactivity named in honour of the pioneers of radioactivity research, Pierre Curie and Marie Curie. It was taken to be the activity of 1.0 g of isotope radium-226 which has a half-life of 1600 years.

(i) Show that 1 Ci = 3.7×10^{10} Bq. [2]

(ii) Given that the Solar System is about 5×10^{9} years old, suggest why radioactive nuclei of radium-226 can still be found in nature.

……………………………………………………………………………………………

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

(d) **(i)** State what is meant by the *decay constant* of a radioactive isotope.

……………………………………………………………………………………………

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

(ii) In order to determine the half-life of a sample of a radioactive isotope, a student measures the count rate near the sample, as illustrated in Fig. 5.3.

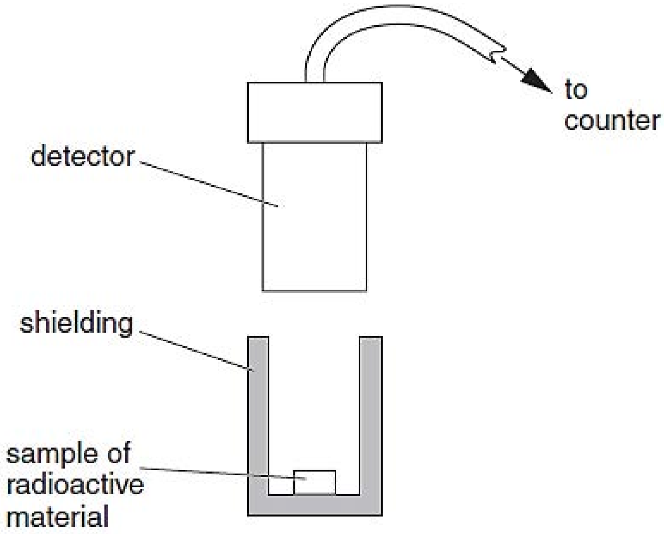


Fig. 5.3

Initially, the measured count rate is 538 per minute. After a time of 8.0 hours, the measured count rate is 228 per minute.

Use these data to estimate the half-life of the isotope.

half-life = …………………………. hours [2]

(iii) The accepted value of the half-life of the isotope in **(d)(ii)** is 5.8 hours. The difference between this value for the half-life and that calculated in **(d)(ii)** cannot be explained by reference to faulty equipment.

Suggest two possible reasons for this difference.

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

……………………………………………………………………………………………

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

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

Section B

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

6 **(a)** Fig. 6.1 below shows an M777 howitzer firing a projectile at an angle of 50° to the horizontal. The projectile exits the muzzle at a speed of 800 m s^{-1}.

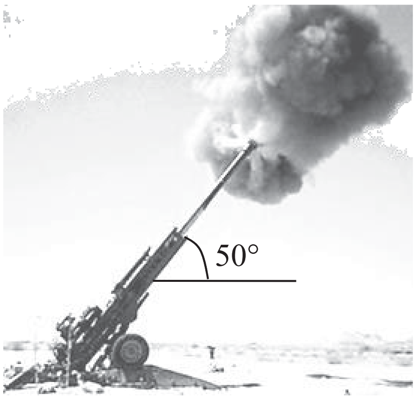


Fig. 6.1

(i) Neglecting air resistance and the height of the howitzer, determine the range of this projectile, d, for the angle given.

d = ……………………… km [3]

(ii) It can be proven that launching the projectile at 40° will achieve the same range.

Suggest one advantage of launching the projectile at this smaller angle.

……………………………………………………..…………………………………….

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

(b) A howitzer is set up to destroy enemy tank by aiming its projectile to land at the expected position of the moving tank.

The enemy tank, initially stationary, is 3.0 km away from the landing point of the howitzer's projectile as shown in Fig. 6.2 below.

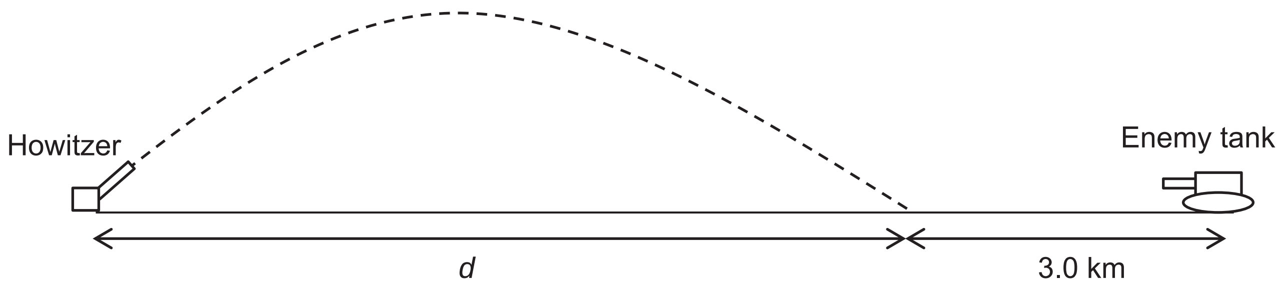


Fig. 6.2

The tank has a maximum speed of 60 km h^{-1} and a maximum acceleration of 1.0 m s^{-2}.

(i) Calculate the minimum time required for the tank to reach the landing point of the howitzer's projectile.

time = ………………….. s [4]

(ii) Calculate how long after the tank starts moving should the howitzer start firing so that the projectile will hit the tank.

time = ………………… s [1]

(c) In reality, the projectile experiences a large magnitude of air resistance that limits its maximum range.

(i) In Fig. 6.3(a) and 6.3(b), draw and label the forces acting on the projectile as it is moving up and as it is moving down. [2]

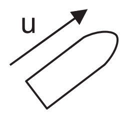


Fig. 6.3(a) Projectile moving up

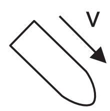


Fig. 6.3(b) Projectile moving down

(ii) Draw a labelled graph on Fig. 6.4 below to show the variation with time of the vertical velocity of the projectile. Take downward as positive.

Indicate on the x-axis the time to reach maximum height t_m and time to reach the ground again t_g.

[3]

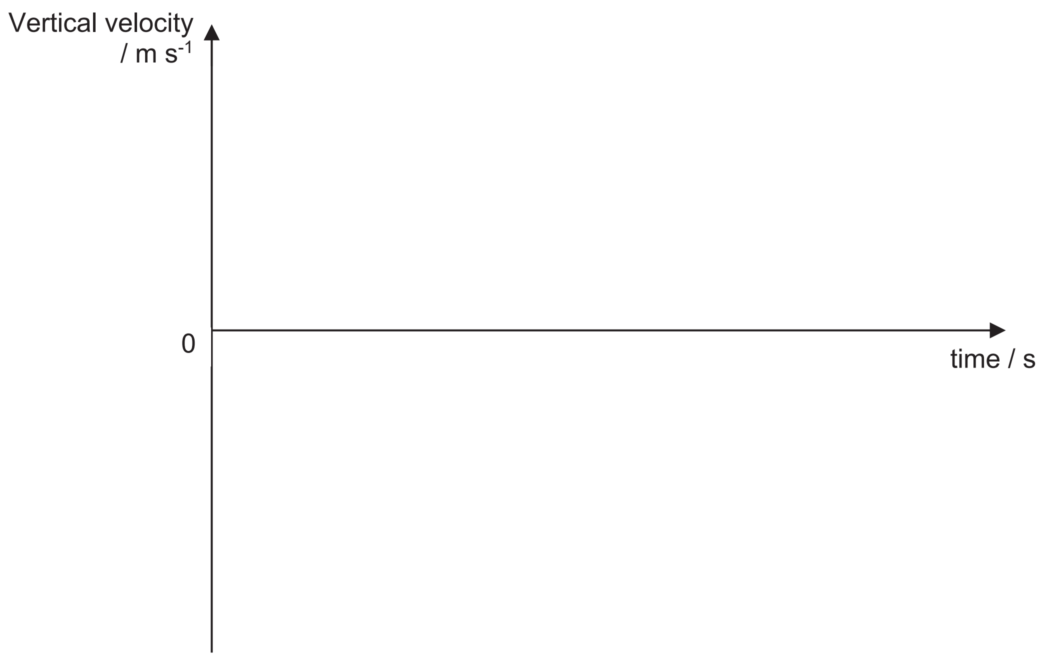


Fig. 6.4

(iii) On the same Fig. 6.4, draw a graph to show the variation with time of the vertical velocity of the projectile *without air resistance*. Label this graph N. [2]

(iv) Explain whether you would expect the time taken for the projectile to reach its maximum height to be longer or shorter than the time taken for it to land from its maximum height in the presence of air resistance.

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

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

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

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

(d) If the howitzer and the projectile are considered as a system, explain whether the principle of conservation of momentum could be applied to this system during the firing process.

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

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

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

7 **(a)** Define the following terms,

(i) angular velocity, and

…………………………………………………………………………………………...

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

(ii) the radian.

…………………………………………………………………………………………...

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

(b) At the Marina Bay Street Circuit which is the track for the 2017 Formula One Singapore Grand Prix held yesterday, the slowest part of the circuit is at **Turn 8** where the race car drivers make a sharp turn in front of the Stamford Grandstand, as shown in Fig 7.1.

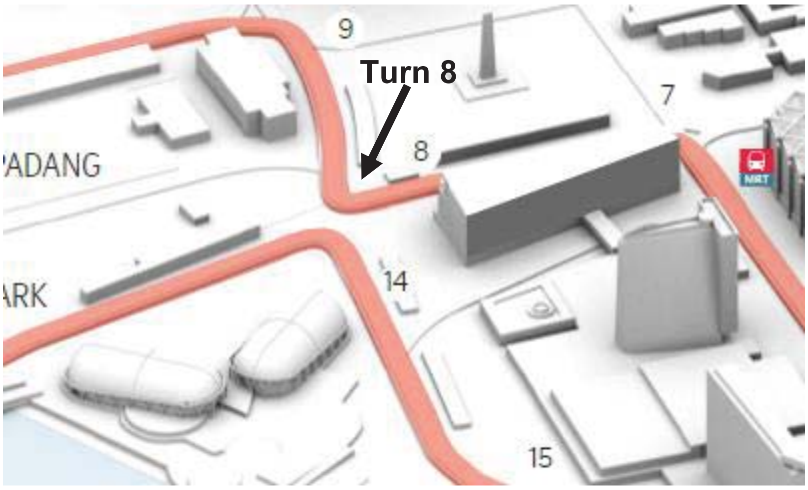


Fig. 7.1

Assuming that the slowest point of **Turn 8** is part of a *circular road* of radius 19.0 m, and a race car (with driver, fuel and equipment all included) has a mass of 900 kg and it moves at a speed of 68.0 km h^{-1} at that slowest point,

(i) determine the resultant force acting on the vehicle at that point.

resultant force = ………………….. N [3]

(ii) State the force acting on the vehicle that provides for this resultant force.

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

(iii) Explain why a banked turn (with the road inclined at an angle), as shown in Fig. 7.2 below, can assist the Formula One car to maneuver that turn at a higher speed.

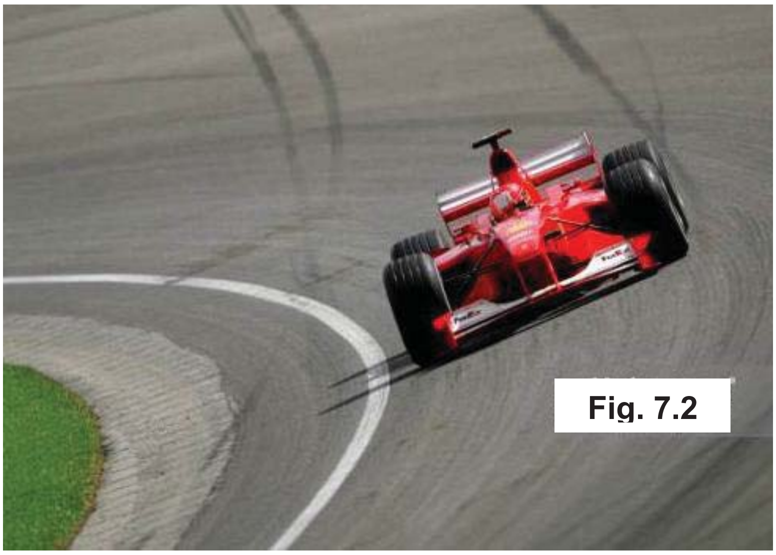


Fig. 7.2

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

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

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

(c) Artificial satellites are used to monitor weather conditions on Earth, for surveillance and for communications. Such satellites may be placed in a *geo-synchronous* (geostationary) orbit or in a low polar orbit.

Describe the properties of the geo-synchronous orbit and the advantages it offers when such a satellite is used for communications.

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

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

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

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

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

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

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

(d) A satellite of mass 2.5 x 10^3 kg is to be moved from the surface of the Earth to an orbit of radius 1.6 x 10^7 m around the Earth. The mass of the Earth is 6.0 x 10^{24} kg.

(i) Calculate the gravitational force acting on the satellite when in orbit.

gravitational force = ………………… N [2]

(ii) Given that the gravitational potential at the surface of the Earth (due to the Earth) is – 63 MJ kg^{-1}, calculate the increase in the gravitational potential energy (GPE) of the satellite when it is placed in the orbit.

increase in GPE = …………………….J [3]

(e) One of the moons of Jupiter, Ganymede, is the largest satellite in the solar system. Its orbital period is equal to 7.15 Earth days and the radius of its orbit is 1.07×10^9 m.

Calculate the mass of Jupiter.

mass = …………………….kg [4]

End of paper

Civics Group	Index Number	Name
16S		

ST. ANDREW'S JUNIOR COLLEGE
JC 2 2017
Preliminary Examination

PHYSICS

9749/04

Paper 4 Practical

23rd August 2017 **2 hours 30 minutes**

Candidates answer on the Question Paper.

Additional Materials: As listed on the Confidential Instructions.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and Civics Group in the spaces at the top of this page.
Write in dark blue or black pen.
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 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.

Shift
Laboratory

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

For Examiner's Use	
1	
2	
3	
4	
Total	**/50**

This question paper consists of 16 printed pages including this page.

1 In this experiment, you will alter the positions of two extended springs and measure how the coiled length of one of the springs varies with the angle between the springs.

Two springs, supporting a mass hanger and masses, are resting on a blade. You will alter the separation of the springs and measure the coiled length of one of the springs.

Take care when moving the springs along the sharp edge of the blade.

(a) Gently remove the mass hanger and masses leaving the springs on the blade. Measure the unextended length L_0 of the **right-handed** spring using the rule as shown in Fig. 1.1. Record L_0.

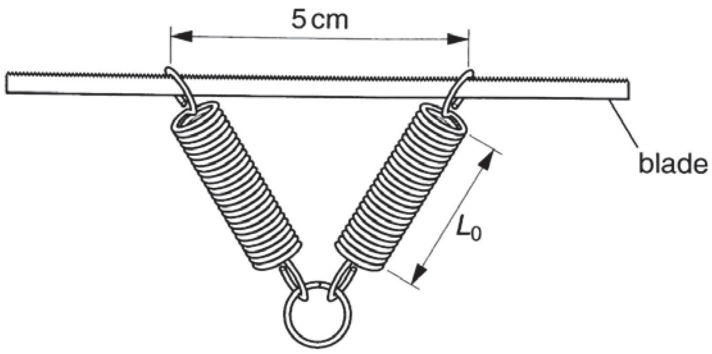


Fig. 1.1

L_0 = ...[1]

(b) Set the separation of the tops of the springs to 25 cm. Carefully replace the mass hanger and masses, as shown in Fig. 1.2.

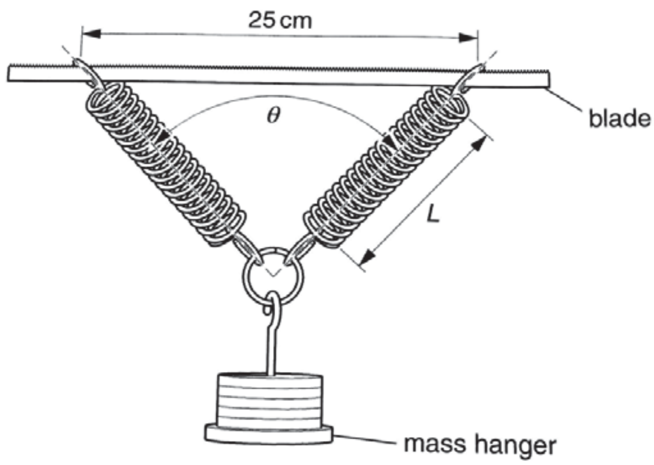


Fig. 1.2

(i) Measure and record the angle θ between the springs.

θ= ....

(ii) Measure and record the length L of the **right-handed** spring.

L =..............................

(c) Change the separation of the springs to vary θ in the range $30^0 < \theta < 80^0$ and repeat steps **(b)(i)** and **(b)(ii)** until you have five sets of readings of θ and L.

Include values of $\dfrac{1}{\cos(\theta/2)}$ in your table.

[7]

(d) Suggest a reason why the minimum value of θ was restricted to 30^0.

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

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

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

(e) **(i)** Plot a graph of $\dfrac{1}{\cos(\theta/2)}$ against L. Draw the line of best fit.

(ii) Determine the gradient of the line.

gradient = ………………………[1]

(iii) Determine the y-intercept of the line.

y-intercept = ………………………[1]

graph paper 3 marks

(f) θ and L are related by the expression

$$\frac{1}{\cos(\theta/2)} = P\,L - Q$$

where P and Q are constants.

Use values from **(e)(ii)** and **(e)(iii)** to determine a value for Q/P.

Q/P = ……………………………[2]

(g) State two major sources of error in this experiment.

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

……………………………………………………………………………………………

……………………………………………………………………………………………

2. ……………………………………………………………………………………..

……………………………………………………………………………………………..

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

[Total: 18 marks including 3 for graph work]

2 In this experiment you will investigate an oscillating system.

(a) **(i)** Put the ball of modelling clay on the bench. Press the board on the ball to flatten it and form the modelling clay into a cylinder as shown in Fig. 2.1. Work with a value of *d* between about 4 cm and 5 cm.

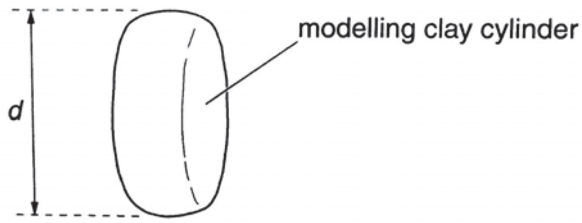


Fig. 2.1

(ii) Measure and record the diameter *d* of the cylinder using the vernier caliper.

d = …………………….[1]

(iii) Determine the percentage uncertainty in your value of *d*.

percentage uncertainty in *d* = ……………………….[1]

(b) **(i)** Push the nail through the cylinder near the edge to produce a hole, as shown in Fig. 2.2.

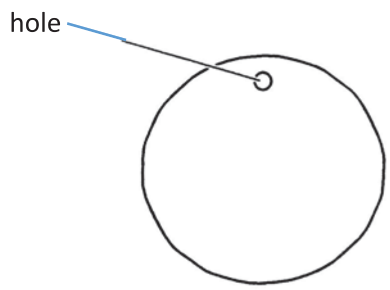


Fig. 2.2

(ii) With the nail in the hole, hold the cylinder and gently lift the nail so that it opens up a gap in the cylinder as shown in Fig. 2.3. You may have to push the nail a little to open up a gap. Ignore any remnant of clay that remains stuck to the nail.

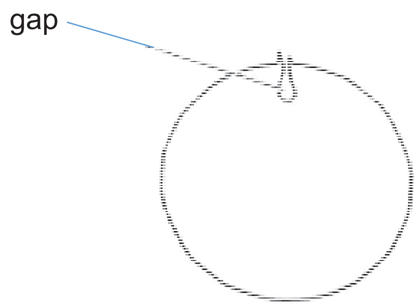


Fig. 2.3

(iii) Insert the rubber band into the gap in the cylinder. Close the gap by pushing the modelling clay together. Use Sellotape to tape over the region to prevent the rubber band from opening up a gap. The rubber band should be positioned in the cylinder as shown in Fig. 2.4.

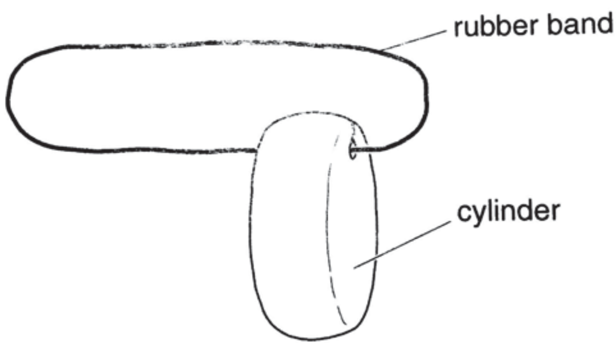


Fig . 2.4

(c) (i) Place the rubber band on the end of the rod of the clamp to arrange the apparatus as shown in Fig. 2.5.

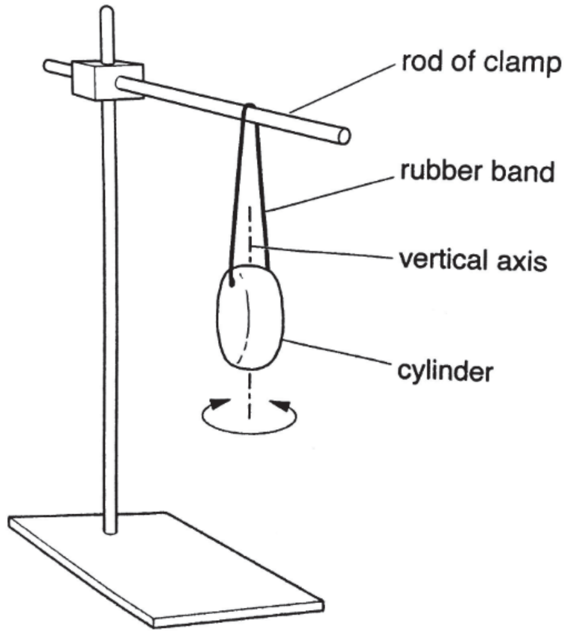


Fig. 2.5

(ii) Rotate the cylinder through approximately 90^0 about the vertical axis as shown in Fig.2.5. Release the cylinder and allow it to oscillate.

Determine the period *T* of these oscillations.

T = ……………………………….[1]

(d) **(i)** Remove the rubber band from the cylinder.

(ii) Flatten the cylinder further between the board and the bench so that the value of *d* is at least 6 cm.

(iii) Repeat **(a)(ii), (b)** and **(c).**

d = …………………………..[1]

T = …………………………..[1]

(e) It is suggested that *T* and *d* are related by the expression

$$T^2 = k\,d^3$$

where *k* is a constant.

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

first value of *k* = …………………………

second value of *k* = ………………………..[1]

(ii) State whether or not the results of your experiment support the suggested relationship.

Justify your conclusion**.**

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

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

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

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

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

(f) **(i)** Suggest **two** significant sources of error in this experiment.

1………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………

2………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………[2]

(ii) Suggest **two** improvements that could be made to the experiment to address the errors identified in **(f)(i)**. You may suggest the use of other apparatus or a different procedure.

1………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………

2………………………………………………………………………………………..

………………………………………………………………………………………..

………………………………………………………………………………………[2]

[**Total: 11 marks**]

3 In this experiment, you will determine the resistance of a voltmeter and of an unknown resistor.

You are provided with two resistors of approximately equal resistances R_1 and R_2. You are also provided with a cell, a voltmeter, an ammeter and sufficient connecting wires.

(a) Connect the circuit of Fig. 3.1.

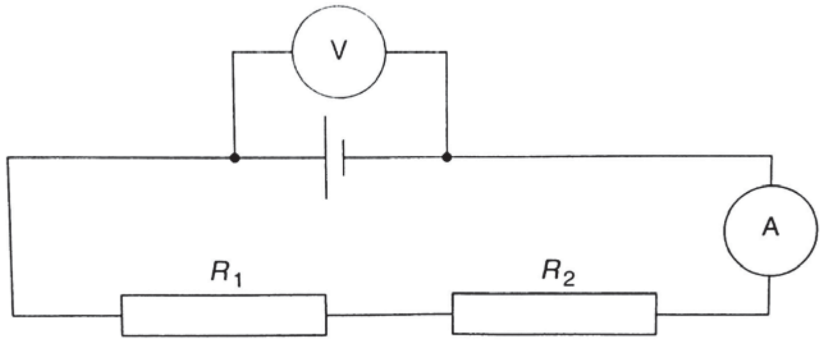


Fig. 3.1

(b) Record the voltmeter reading V_0 and the ammeter reading I_0.

V_0 = ……….…….… I_0 = …………………..…..[1]

(c) **(i)** Disconnect the voltmeter. Reconnect the voltmeter across the resistor of resistance R_1 only.

Measure and record the voltmeter reading V_1 and the ammeter reading I_1.

V_1 = ……….…….… I_1 = …………………..…..

(ii) Again disconnect the voltmeter. Reconnect the voltmeter across the resistor of resistance R_2 only.

Measure and record the voltmeter reading V_2 and the ammeter reading I_2.

V_2 = ……….…….… I_2 = …………………..…..[1]

(d) For a series circuit, it is suggested that

$$V_0 = V_1 + V_2 \quad \text{and} \quad I_0 = I_1 = I_2$$

Suggest why your results do not support these relationships.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(e) **(i)** Connect the circuit of Fig. 3.2.

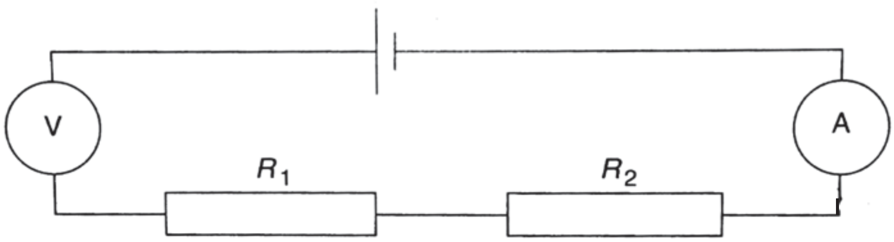


Fig. 3.2

(ii) Record the voltmeter reading V_3 and the ammeter reading I_3.

V_3 = ……………… I_3 = ………………..

(iii) Use your readings to determine the resistance R_v of the voltmeter and the resistance R_1.

(You may find the following relationships useful:

$R = \dfrac{V}{I}$, resistors in series $R_{total} = R_1 + R_2$)

[2]

R_v = ……………………….

R_1 = ……………………….

(iv) Justify the number of significant figures in your value of R_1.

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

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………..

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

(v) Suggest one change to the apparatus in the circuit of Fig. 3.1 to give a more accurate determination of R_1.

…………………………………………………………………………………………….

……………………………………………………………………………………………

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

[**Total: 8 marks**]

4 Under normal conditions, air is a poor conductor of electricity. However, when the electric field in the air reaches a certain ‘breakdown value’, electrons are stripped or ‘ionised’ from the air molecules. The ionised air allows the sudden and massive flow of electric current. The enormous amount of heat associated with this current may cause a spark to be generated.

Design an experiment to investigate how the minimum voltage needed to generate a spark across a fixed gap of air varies with the temperature of the air.

You may assume that the following equipment is available, together with any other apparatus which may be found in an A-level science laboratory:

Transparent thermally-insulated chamber

High voltage power supply

Metal plate electrodes

You should draw a diagram to show the arrangement of your apparatus. In your account, you should pay particular attention to

(a) how the temperature of the air can be varied,

(b) the procedure to be followed,

(c) the control of variables, and

(d) any precautions that would be taken to improve the accuracy and safety of the experiment.

[**Total**: **13 marks**]

Diagram

End of Paper

JC2 Preliminary Exam 2017 (H2 Physics)

Paper 1 Solutions

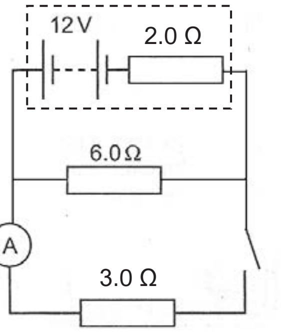
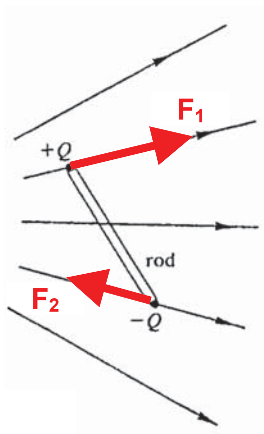
Qn	1	2	3	4	5	6	7	8	9	10
Ans	A	D	B	C	B	D	C	B	C	A

Qn	11	12	13	14	15	16	17	18	19	20
Ans	D	A	B	C	C	A	C	D	D	A

Qn	21	22	23	24	25	26	27	28	29	30
Ans	A	D	C	A	C	A	B	C	B	

Qn	Ans	Description
1	A	There are 9 oscillations counted by the student, whereas there are 10 oscillations in reality. Thus student's calculated period = 0.9 T, where T is the actual period. Percentage error in student's calculation = $\frac{0.9\,T-T}{T} \times 100\%$ = -10 % (hence 10% lower)
2	D	$B = \mu_o nI = \frac{F}{IL}$ $[\mu_o] = \left[\frac{F}{nI^2L}\right] = \frac{\text{kg m s}^{-2}}{\text{m}^{-1}\text{A}^2\text{m}} = \text{kg m s}^{-2}\text{A}^{-2}$
3	B	At max height, velocity of the projectile = horizontal component of initial velocity = v cos θ Therefore, KE at max height = ½ m(v cos θ)^2 = (½ mv^2)(cos^2 θ) = (cos^2 θ)(Initial KE)
4	C	Area under v-t graph is the displacement moved. Since total area is increasing from t = 0 to 2, and start to decrease from t = 2, hence answer is C.
5	B	F_L = Force exerted by the locomotive Considering the forces acting on the 6 trucks (take the 6 trucks to be one system), F_L – 6(4000) = ma, but a = 0 since it is constant speed. F_L = 24000 N When the coupling between trucks 2 and 3 snaps, considering only the forces acting on trucks 1 and 2 as a system, F_L – 2(4000) = ma F_L – 2(4000) = (2 x 6.0 x 10^4 + 24 x 10^4)a, where F_L = 24000 N Hence, a = 0.044 m s^{-2}
6	D	Taking the system as the boy and boat B, initial momentum = 0. Hence, when the boy jumps, taking leftward as positive, $mv_{boy} = Mv_B$

		Now, taking the system as the boy and boat A, Initial momentum = mv_{boy} (since before contact, the boy is moving while the boat A is stationary) Hence, Final momentum = $(m+M)v_A = mv_{boy}$ $(m+M)v_A = Mv_B$ $v_A / v_B = M / (m+M)$
7	C	For a smooth surface there is no friction, hence, the force at that point acting on the cube must be perpendicular to the surface. Option C is the answer instead of A because friction acts towards S_2 as it prevents the object from slipping downwards. The combination of friction and reaction makes Q tilt towards S_2.
8	B	Since $m / t = \rho V / t = (1000)(1.4) = 1400$ kg s^{-1} Since efficiency = 20%, power output $= (0.2)(GPE / t)$ $= (0.2)(mgh) / t$ $= (0.2)(m / t)(gh)$ $= (0.2)(1400)(9.81)(750)$ = 2.1 MW
9	C	The gradient of the energy-time graph is the force, thus, the answer is C. Had this been a potential-time graph, the gradient would have been the field or acceleration.
10	A	$g = \dfrac{GM}{R^2} = \dfrac{G\rho V}{R^2} = \dfrac{G\rho\frac{4}{3}\pi R^3}{R^2} = \dfrac{4}{3}G\rho\pi R$, hence, g is proportional to R.
11	D	$p = \frac{1}{3}\frac{m}{V} < c^2 >$ $1 \times 10^5 = 1/3(1.6/0.5)<c^2>$ $\sqrt{< C^2 >} = 306$ ms^{-1}
12	A	$p = \frac{1}{3}\frac{m}{V} < c^2 >$ $1 \times 10^5 = 1/3(1.6/0.5)<c^2>$ $\sqrt{< C^2 >} = 306$ ms^{-1}
13	B	max V = wA, $w = 1/10\times10^{-3} = 2\times 3.14 f$ f = 15.9 Hz.
14	C	
15	C	The time for 3 full waves = 13 ms, hence, the period is $\frac{0.013}{3}$ s. The frequency is $\frac{1}{\text{period}}$ = 230 Hz.
16	A	Drawing the next instance where the waveform is displaced to the left will show that the corresponding particles are in the corresponding upper or lower positions.

17	C	Total resistance in series with E_1 = 8.30 + 1.42 = 9.72 Ω. By pot divider principle, pd across whole pot wire XY = 8.30/9.72 x 9.00 = 7.69 V. At balance, emf E_2 = Pd across balance length l {no loss voltage across R} = 0.745/1.000 x 7.69 = 5.73 V.
18	D	The circuit can be redrawn in the following way.  Let the total external resistance be R. Thus 1/R = 1/3 + 1/6 R = 2 Ω $E = I(R+r)$ where I = *total current* $12 = I(2.0 + 2.0)$ $I = 3.0$ A Ammeter reading = current through 3.0 Ω. Thus, ammeter reading = 6 / 9 x 3.0 A = 2.0 A
19	D	For parallel plates, qE = ma qV/d = (9.11 x 10^{-31})a (1.6 x 10^{-19})(4500) / (1.5 x 10^{-3}) = (9.11 x 10^{-31})a a = 5.3 x 10^{17}
20	A	F_1 is larger than F_2 since the density of field at +Q is higher than at –Q. Hence, there is a resultant force. Taking moment at the C.G. of the rod, the forces will result in a net clockwise moment. 
21	A	The speed of magnet is lower at the beginning compared to the end, resulting in a higher magnitude and narrower time; and there is a reversal in the induced current.
22	D	Use left hand rule to check. The induced current will produce a force that is always opposing V. There is no current for option C.
23	C	Use right hand grip rule to check
24	A	mg = BIL (10/1000) x 9.81 = 0.4x 0.6 I I = 0.409, use left hand rule to produce an upward force. Current is from P to Q
25	C	The output voltage is 240/20 = 12 V, and output current is 12/5. Output power is 12x12/5, which is 0.95 of the input power. $\frac{12x12}{5} = 0.95\text{x } 240\ \text{I}$ I = 0.126 A
26	A	$I_{rms} = \sqrt{\frac{2A^2}{4}} = \frac{A}{\sqrt{2}}$

27	B	Using Einstein's Photoelectric Equation, $hf = \Phi + eV_s$ $3.5 \times 10^{-19} = \Phi + (1.6 \times 10^{-19})(0.25)$ $\Phi = 3.1 \times 10^{-19}$ J
28	C	Given that $E = \frac{1}{2} mv^2$, $mE = \frac{1}{2} m^2v^2$ $2mE = p^2$ $p = \sqrt{2mE}$ Using de Broglie's equation, $p = h / \lambda$ $\sqrt{2mE} = h / \lambda$ $\lambda = h / \sqrt{2mE}$ Therefore, given that h and m are constants, λ is proportional to $\frac{1}{\sqrt{E}}$
29	B	${}^{134+84}_{84}X \rightarrow {}^{132+82}_{82}Z + {}^{4}_{2}\alpha \rightarrow {}^{130+84}_{84}Y + 2\,{}^{0}_{-1}\beta$
30	C	Total rest masses of P and Q should be larger. Total momentum is constant. It is uncertain if BE per nucleon of X and Y are larger than P and Q.

End of solutions

Solution for 2017 SAJC Prelim Paper 2

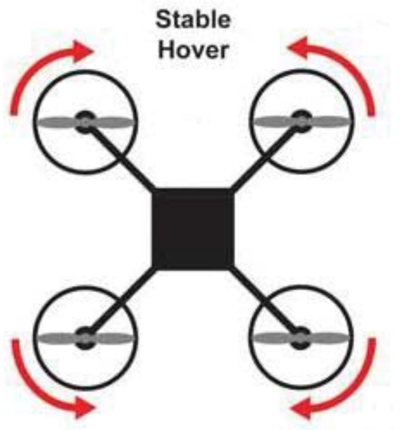
1 **(a)** **Torque of a couple:** The product of one of the forces of the couple and the perpendicular distance between the lines of action of the forces. [1]

A Couple is a pair of equal and opposite forces, whose lines of action do not coincide. (Hence it tends to produce rotation only) [1]

(b) Taking moment about the left string,
$T_R(2) = 1g(1) + 4.5g(1.5)$ [1]
$T_R = 38.0$ N [1]

$F_{net,y} = 0$
$T_L = (4.5+1)g - 38.0$
$T_L = 16.0$ N [1]

(c) **(i)**



[1]

(ii) The propellers produce a combined thrust / lift equal to the weight (of (0.330)(9.81) = 3.24 N)) [1]

(iii) Propellers 1 and 2 decrease speed equally (between 1 and 2) while propellers 3 and 4 increase speed equally (to tilt in order to have a component of force forward) [1]

After which, all four propellers should spin at the same speed that is faster than its original speed for hovering. [1]

2 **(a)** The direction of the object changes continuously and hence there is a change in velocity of the object. [1]

Based on Newton's first law, this means that there must be a force acting on the object. [1]

Since the speed remains unchanged, this force cannot have a component tangential to the circle. This implies that the force is perpendicular to the velocity/displacement of object (so towards centre of circle). [1]

(b) For the block to just make it through the top of the loop, the weight is just providing for the centripetal force.

$mg = mv_{top}^2 / R$
$(0.50)(9.81) = (0.50)(v_{top}^2) / 1.5$
$v_{top} = 3.836$ m s^{-2} [1, also award if student leave as KE = 3.68 J]

By PCOE,

$KE_i + EPE_i + GPE_i$ – work done by friction $= KE_f + EPE_f + GPE_f$
$0 + ½\, ke^2 + 0 – Fd = ½\, mv_{top}^2 + 0 + mg(2R)$ [1]
$½\,(78.4)(e^2) – (1.47)(2.5) = ½\,(0.50)(3.836^2) + 0.50(9.81)(2 \times 1.5)$

Solving, e = 0.750 m [1]

(c) At the top of the motion, only weight provides for the centripetal force.

$mg = mr_1\omega^2$
ω = sqrt [(9.81) / 0.13] = 8.687 rad s^{-1} [1]

Spring constant, k = 5 / (0.148 – 0.13) = 278 N m^{-1} [1]

(Since the mass is moving at constant angular velocity, at the bottom, ω is also 8.687 rad s^{-1}.)

Hence, at the bottom, tension – mg provides for centripetal force.

$T – mg = mr_2\omega^2$ (Note that $r_2 \neq r_1$)
$ke – mg = mr_2\omega^2$
$(277.8)(L – 0.13) – (5.0) = (5 / 9.81)(L)(8.687^2)$
[award 1 for substituting e = L – 0.13]

Solving, L = 0.172 = 17.2 cm [1]

3 **(a)** <u>k/m is a constant</u>, therefore a is proportional to x [1]
'-' sign showed that a is opposite to x [1]

(b) w^2= k/m
$(2\pi/T)^2$= k/m [1]
T = 1.57 s [1]

(max 1 mark for T = π/2)

(c) max KE = max EPE
½ mv^2 = ½ $mw^2x_o^2$ [1]
X_0 = 0.12 m [1]

(d) Energy proportional to $(\text{amplitude})^2$

$0.8 = \frac{x_0^2}{3^2}$ [1]
X_o = 0.0268 m [1]

(e) metal block experiences changing magnetic flux. Hence, by Faraday'EMF induced produces electric <u>(eddy) current</u>. [1]

<u>Heat</u> is generated in the metal block as a result of the flowing current. [1]

The energy of oscillation therefore decrease faster than without magnets.

OR

By Lenz's Law, there is an opposing magnetic force against the motion of oscillation. [1]

<u>Work is done</u> to overcome the opposing force, and hence the system decreases energy faster.

4 **(a)** Electric field strength at a point is defined as the electric force per unit (positive) charge acting on a **<u>small positive</u>** test charge placed at that point. [1]

(b) **(i)** Like charges. There are equipotential lines that encompasses both charges. [1]

Equal magnitude. The equipotential lines are symmetrical. [1]

(Award 1 mark for 2 out of 4 correct statements)

(ii) 90° [1]

<u>No work is done</u> when a (second) charge is moved along the same equipotential line since there is no change in potential. Hence, the direction of the electric force must be perpendicular to the displacement moved. [1]

(iii) Field lines drawn for like charges (repulsive) [1]

Field lines drawn should be roughly perpendicular to equipotential lines. [1]

(c) Potential at point M

= potential at point M due to q_1 + potential at point M due to q_2

$= (\frac{1}{4\pi\varepsilon_o})[\frac{35\times10^{-3}}{5} + \frac{-52\times10^{-3}}{4}]$

= $(8.99 \times 10^9)(-6 \times 10^{-3})$

= -54.0×10^6 V [1]

Potential at point N

= potential at point M due to q_1 + potential at point M due to q_2

$= (\frac{1}{4\pi\varepsilon_o})[\frac{35\times10^{-3}}{4} + \frac{-52\times10^{-3}}{5}]$

= $(8.99 \times 10^9)(-1.65\times 10^{-3})$

= -14.8×10^6 V [1]

Work Done to move the charge from point M to N

= $q\,\Delta V$

= $(4.5 \times 10^{-6})(-14.8 \times 10^6 + 54.0 \times 10^6)$

= 176 J

[1]

5 **(a)** Induced e.m.f. is proportional (equal) to the rate of change of magnetic flux (linkage) [1]

(b) **(i)** Flux linkage = NBA

= 85 x (πx 10^{-3}x 2.8)x (π x (1.6 x 10^{-2})^2)

= 6.00 x 10^{-4} Wb [1]

(ii) Flux change = 2 x 6.00 x 10^{-4} [1]

Induced e.m.f. = 0.004 V [1]

(iii) 0 v for t = 0 to 0.3, t = 0.6 to 1.0 and t > 1.6 t [1]

0.004 V for t = 0.3 to 0.6 s [1]

- 0.002 V for t = 1.0 to 1.6 s [1]

(iv) rms of input = 2.55/$\sqrt{2}$ = 1.80 [1]

85 / 15 = V / 1.80

V = 10.2 V [1]

(v) flux leakage /incomplete flux linkage from primary coil to secondary coil [1]

6 **(a)** **(i)** Ionisation energy = 10.4 eV = 1.66×10^{-18} J [1]

(ii) λ_3 is the longest wavelength emitted, corresponding to the lowest energy photon. [M1]

Therefore, transition is from E3 to E2, where the energy difference is the lowest. [A1]

(iii) When the current is passed through the gas, electron collides with the atom at ground state and pass energy equivalent to the difference of E_3 and ground state. [1]

The atom is excited up to a higher energy level at E3 (for about 10^{-8} seconds.) [1]

The atom will then de-excite to the lower energy state E2 by emitting a <u>photon</u> of energy with corresponding wavelength of λ_3. [1]

(b) **(i)** Stopping potential is the **<u>minimum negative</u>** potential required to stop the **<u>fastest</u>** electron from arriving at the collector plate. [1]

(ii) Number of photoelectrons emitted per second

$$= \frac{I}{q}$$

$$= \frac{0.34 \times 10^{-3}}{1.6 \times 10^{-19}}$$

$= 2.125 \times 10^{15}$ s^{-1} [1]

Number of incident photons per second

$$= \frac{P}{hf}$$

$$= \frac{P}{h\frac{c}{\lambda}}$$

$$= \frac{2.85 \times 10^{-3}}{(6.63 \times 10^{-34})(\frac{3.0 \times 10^{8}}{225 \times 10^{-9}})}$$

$= 3.224 \times 10^{15}$ s^{-1} [1]

Quantum yield

$$= \frac{2.125 \times 10^{15}}{3.224 \times 10^{15}}$$

= 0.659 [1]

7 **(a)** As temperature increases, amplitude of the vibration of lattice ions become greater. M1
Thus drift velocity of electrons is lower. A1

(b) **(i)** series B1
(ii) parallel B1

(c) **(i)** The movement of the coolant is driven by heat loss from panel / cooling by convection current in the air / cooling without power input B1
(ii) Active cooling could fail / active cooling needs energy input, increasing costs or decreasing system output / difficult to eliminate passive cooling. B1

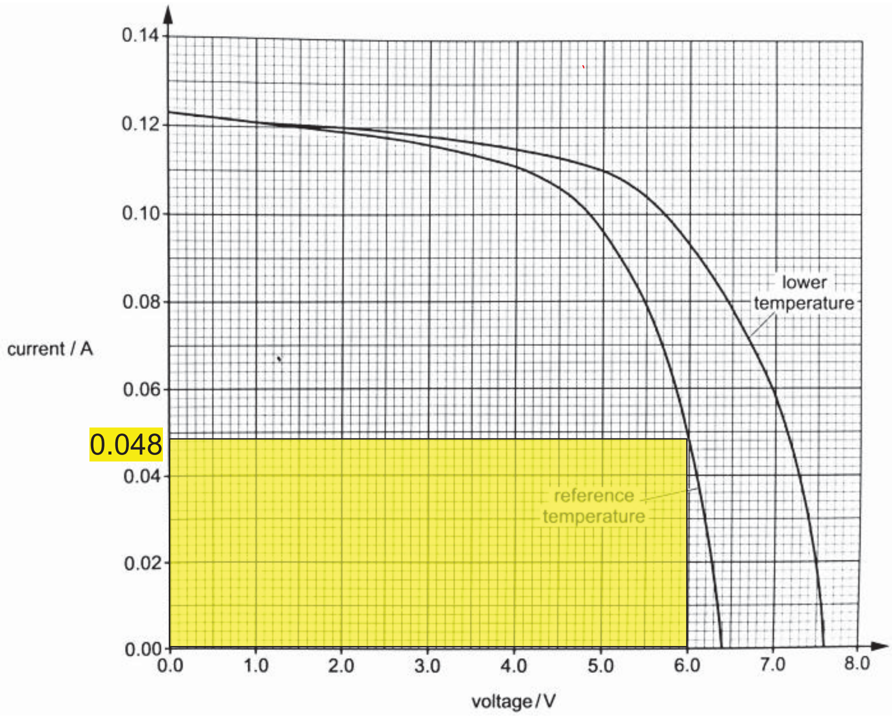
(d) Position panel so that there is an air gap around it
eg. mount panel a small distance above the roof / in open space / clear from obstructions / spaced out in a field. B1

(e) **(i)** V_R = 6.4 V, V = 7.6 V B1
(ii) At low voltages, there is little or no change to current with temperature. B1
At higher voltages, there is greater current at lower temperature. B1
(iii) best fit line drawn B1
(iv) μ = - gradient C1
μ = 0.12 V °C^{-1} (accept 0.11 V °C^{-1} to 0.13 V °C^{-1}) A1

When $T = T_R$, $V = V_R$ = 6.4 V
From graph, T_R = 25 °C (accept 24 °C to 26 °C) A1

(v) 7.6 = 0.12 (25 – T) + 6.4
T = 15 °C B1

(vi) rectangle drawn below line M1
correct area indicated (6.0V and 0.048 A) A1



(vii) Use of area of rectangle or $P = IV$ C1

$P = 0.5$ W A1

(f) **(i)** Better chance of capturing photons OR photons of a greater range of frequencies (contained within sunlight) can be captured B1

(ii) Electrical output power increases as angle of incidence on panel decreases. B1

OR

The larger the angle between the PV panel and the incident sunlight, the larger the electrical power output. B1

JC2 Preliminary Exam 2017 (H2 Physics)
Examiner's Report with answers for Paper 3

1 **(a)** $\Delta w = p\Delta V = 5.2 \times 10^5 \times (5 - 1.6) \times 10^{-4} = 176.8$ [1]

$\Delta U = 442 – 176.8 = 265$ J [1]

(b) No PE, decrease in U = decrease in KE. [1]
KE, (3/2 nRT), is proportional to T. So T decreases [1]

(c) $\Delta U = 313 – 265.2 = 47.8$
$\Delta W = (5 - 1.6) \times 10^{-4} \times (5.2 + 1) / 2 = 105.4$ J [1]

$\Delta Q = 47.8 – 105.4$
$\Delta Q = - 57.6$ J [1]

(d) $pV = nRT$
$5.2 \times 10^5 \times 1.6 \times 10^{-4} = n \times 8.31 \times (273.15 + 227)$ [1]

$n = 0.0200$
$N = 6.02 \times 10^{23}\ n = 1.2 \times 10^{22}$ [1]

(e) $\frac{1}{2} <c^2> = 3/2\ kT$
$\sqrt{< c^2 >}$ proportional to $\sqrt{T}$ or $\sqrt{V}$ when P is constant [1]

$$\frac{\sqrt{<c^2>}}{350} = \sqrt{\frac{5}{1.6}}$$

$\sqrt{< c^2 >} = 619$ m s^{-1} [1]

2 **(a)** **(i)** Waves must have the same frequency or wavelength [1]
Waves must have the same amplitude [1]
Waves must be antiphase/180º or π radians apart [1]

(ii) Noise of engine is of one frequency/pitch while speech/music varies in pitch and/or frequency. [1]

(b) **Diffraction** refers to the **spreading** [bending] **of waves when they pass through an opening [gap]**, or round an obstacle into the "shadow" region. [1]

(c) $n_{max} \le d/\lambda$ [1]

Since the diffraction grating produces up to only third order, $3 \le d / \lambda < 4$

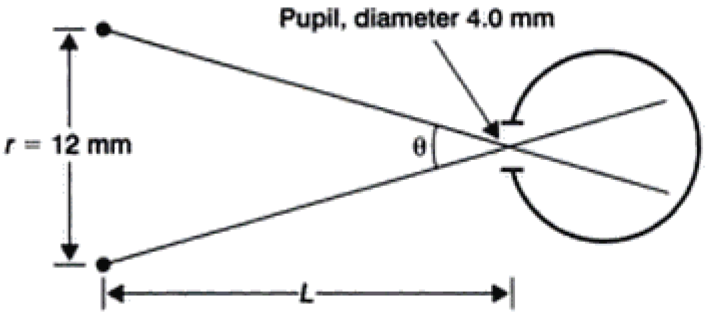
Thus, $3\lambda \le d < 4\lambda$ [1]

(d) Slit width (gap between ribs) too wide compared to x-ray wavelengths, diffraction effects will not be pronounced enough. [1]

OR

Slit separation (thickness of ribs) too wide compared to x-ray wavelengths, all maxima will be deflected by negligible angle. [1]

(e)



The maximum value of L is found for the minimum value of θ, when the two sources separated by a distance of $r = 12 \times 10^{-3}$ m can just about be resolved.

$$\theta \approx \frac{\lambda}{d} = \frac{0.60 \times 10^{-6}}{4.0 \times 10^{-3}} = 0.15 \times 10^{-3} \text{ rad}$$ [1]

For small values of θ, then

$$L = \frac{r}{\theta} = \frac{12 \times 10^{-3}}{0.15 \times 10^{-3}} = 80 \text{ m}$$ [1]

3 **(a)** **(i)** (V = 1.398 V, I = 0.31x10^{-3} A)
$R = V / I$ = **<u>4.5 x 10^3 Ω</u>** [2]

(ii) $R = \rho L/A$ [M1]
$\rightarrow \rho = RA/L$ = 4.5 x 10^3 x 0.800 x 0.210 / 0.900
= **<u>840 Ω m</u>** [A1, ECF]

(b) **(i)** <u>3 J of non-electrical energy is transformed into electrical energy for each coulomb of charge</u> that passes through the battery. [1]

(ii) <u>2 J of electrical energy is transformed into non-electrical energy for each coulomb of charge</u> that passes the resistor. [1]

(c) **(i)** emf = I ($R_1 + R_2$) = (200 x 10^{-6}) x(15 + 10) x 10^3 = **<u>5.0 V</u>** [1]

(ii) emf = I [$R_v R_1/(R_v + R_1) + R_2$]

correct expression of R_{eq} for 15 kΩ // with voltmeter R_v [1]

5.0 V = (250 x 10^{-6}) [15 R_v /(R_v+ 15) + 10]x 10^3

Solving R_v = **<u>30 kΩ</u>** [2, ECF]

4 **(a)** region of space where a moving charge/current carrying conductor experience a force [1]

(b) **(i)** out of the plane of the paper/page [1]

(ii) The force is perpendicular to the velocity [1]
No work done by the force, so KE does not increase [1]

(iii) Centripetal force provided by magnetic force
Bqv = mv^2/r [1]

d = 2r = 2mv/Bq [1]

(iv) T $= \frac{\pi d}{2v}$ [1]

$= \frac{\pi}{2v}\left(\frac{2mv}{Bq}\right)$

$= \frac{\pi m}{Bq}$, independent of v [1]

(v) Helical path out of the page [1]

(vi) E-field lines pointing from right from left. [1]

5 **(a)** **(i)** Smaller deviation (not zero deviation), acceptable path wrt position of N. [1]

(ii) The nucleus is small <u>in comparison</u> to the atom
OR
Atom is mostly empty space [1]

(iii) Deviation depends on charge of nucleus. [1]

Since nuclei of isotopes have same charge, there is no change in deviation.
(do not allow "isotopes have the same charge") [1]

(iv) β-particles have a range of energies **OR**
β-particles can be deviated by orbital electrons **OR**
β-particles have small masses [1]

(b) **(i)** 2 [1]

(ii) mass defect = 92(1.007u) + (235 - 92)(1.009u) – 235.123u = 1.808u [1]

binding energy = $1.808(1.66 \times 10^{-27})(3.00 \times 10^{8})^2 / (1.60 \times 10^{-19})$
= 1688 MeV [1]

binding energy per nucleon = 1688 / 235 = 7.18 MeV [1]

(iii) 8.09 MeV is the <u>average</u> energy required to completely separate each nucleon from molybdenum-95 nucleus. [1]

(iv) energy released = binding energy of products – binding energy of reactants + KE of reactants [1]
= 95(8.09) + 139(7.92) – 235(7.18) + 10.0
= 192 MeV [1]

(c) **(i)** $N = 1 \times 10^{-3} / (226 \times 1.66 \times 10^{-27}) = 2.666 \times 10^{21}$ [1]

$$A = \lambda N$$
$$= \frac{\ln 2}{t_{1/2}} N$$
$$= \frac{\ln 2}{1600 \times 365 \times 24 \times 60 \times 60}(2.666 \times 10^{21})$$

$= 3.7 \times 10^{10}$ Bq [1]

(ii) The parent nuclei that decay to form radium-226 have long half-life. [1]

(d) **(i)** fraction of the total no. of undecayed nuclei which will decay per unit time
OR
the probability of a nucleus decaying per unit time. [1]

(ii) $C = C_0 e^{-\lambda t}$
$228 = 538\, e^{-\lambda(8.0)}$ [1]
$\lambda = 0.107\ h^{-1}$

$t_{1/2} = \ln 2 / 0.107 = 6.5$ h [1]

(iii) random nature of decay
background radiation
daughter product is radioactive
(any 2 sensible suggestions, [1] each)

Section B

6 **(a)** **(i)** $s_y = u_y t + ½ a t^2$

$0 = 800 \sin 50° (t) + ½ (-9.81) (t^2)$ [1]

$t = 125$ s [1]

$s_x = u_x t = 800 \cos 50° (125) = 64.2$ km [1. ecf]

(ii) Angle = 40° [1]

(iii) Time of flight is shorter. [1]

(b) **(i)** To find the distance travelled while accelerating to max speed,

$v^2 = u^2 + 2as$

$(60000 / 3600)^2 = 0 + 2(1)(s)$

$s = 138.89$ [1]

To find time required to reach maximum speed,

$s = ut_1 + ½ at_1^2$

$138.89 = 0 + ½ (1)(t_1)^2$

$t_1 = 16.67$ s [1]

To find the time taken to travel remaining distance at top speed,

$s = ut_2$

$3000 – 138.89 = (60000 / 3600)(t_2)$

$t_2 = 171.67$ s [1]

Minimum time required = $t_1 + t_2 = 171.67 + 16.67 = 188.3$ s [1, ecf]

Alternatively,

To find time required to reach maximum speed,

$v = u + at_1$

$60000 / 3600 = 0 + (1)(t_1)$

$t_1 = 16.67$ s [1]

To find the distance travelled while accelerating to max speed,

s = ut + ½ at2

= 0 + ½ (1)(16.67)2

= 138.89 m [1]

To find the time taken to travel remaining distance at top speed,

$s = ut_2$

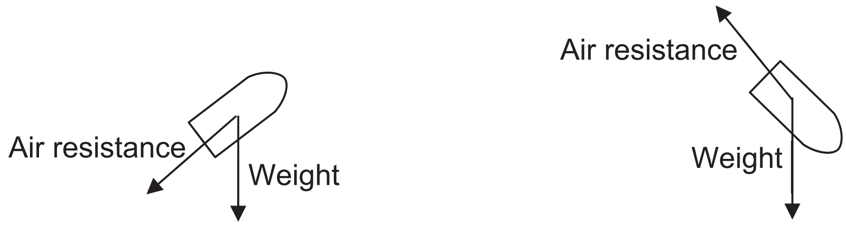
$3000 – 138.89 = (60000 / 3600)(t_2)$

$t_2 = 171.67$ s [1]

Minimum time required = $t_1 + t_2 = 171.67 + 16.67 = 188.3$ s [1, ecf]

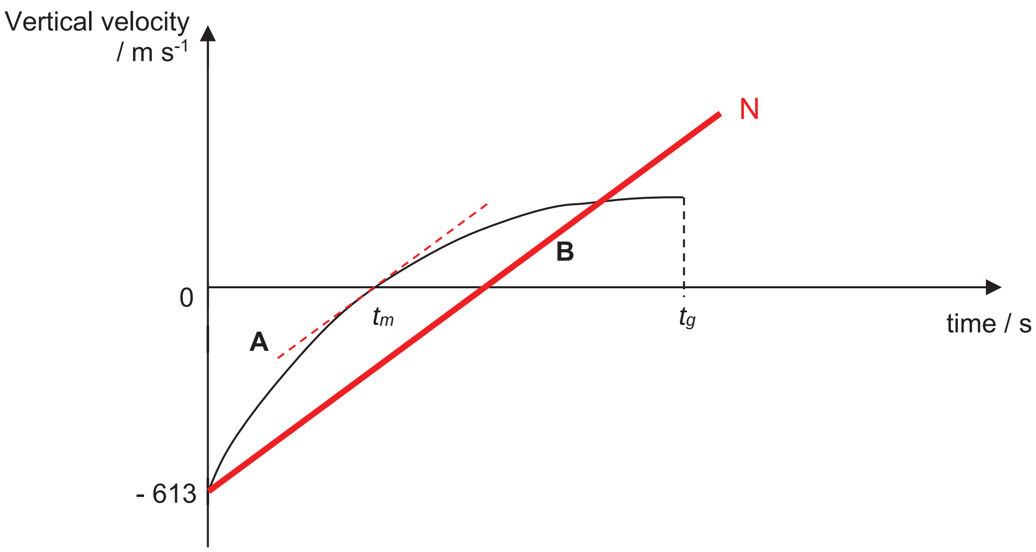
(ii) time required = 188.3 – 125 = 63.3 s [1, ecf]

(c) **(i)**



(Minus 1 mark for each missing vector or label.) [2]

(ii)



Correct shape and sign [1]
Larger initial velocity (lower final velocity) [1]
Approximately equal area before and after reach max height (A = B) [1]
(Not a marking pt, but good to know $t_m < t_g - t_m$)

(iii) Upward sloping straight line [1, ECF for sign]
Gradient of line N to be parallel to tangent at t_m for (ii) [1]

(iv) The net accelerating force (*W – air resistance*) (or net acceleration) when the projectile is moving downwards is always smaller than the retarding force (*W + air resistance*) (or deceleration) when it is moving upwards. [1]

Since the distance travelled upwards is the same as the distance travelled downwards, time taken for it to travel to the maximum height will be shorter than the time taken for the projectile to return to the ground. [1]

(d) **(i)** It cannot be applied as there is an external force acting on the system. [1]

The ground exerts an normal contact force on the gun / Weight is acting on the projectile etc [1]

7 **(a)** **(i)** rate of change of angular displacement with respect to time. [1]

(ii) One radian is defined as the angular displacement of an object in circular motion where the ratio of the arc length *s*, and the radius *r*, is equal to 1. [1]

(b) **(i)** velocity in m s^{-1} = $68 \times \left(\frac{1000}{3600}\right) = 18.89$ m s^{-1} [1]

Resultant force = centripetal force $= \frac{mv^2}{r}$

$= \frac{(900)(18.89)^2}{19.0}$ [1]

$= 16900$ N [1]

(ii) <u>Sideway</u> (or <u>lateral</u>) friction between (tyre and road). [1]

(iii) For the F1 car to maneuver at a higher speed, a larger centripetal force is required. [1]

This can be provided by the horizontal component of the normal reaction force that the road acts on the race car. [1]

(c) Properties:

- Orbits west to east over equator
- Maintains a fixed position relative to Earth's rotation
- Period is 24 hrs (1 day) or same as Earth's rotation

Advantages :

- Offers uninterrupted communication between transmitter and receiver
- Allow the satellite to monitor the same area at all time
- Satellite dish need not be steerable

(d) **(i)** $F = \frac{GMm}{r^2} = \frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})(2.5 \times 10^3)}{(1.6 \times 10^7)^2}$ [1]

$= 3910$ N [1]

(ii) $v_{orbit} = -\frac{GM}{r} = -\frac{(6.67 \times 10^{-11})(6.0 \times 10^{24})}{1.6 \times 10^7}$

$= -25$ MJ kg^{-1} [1]

Increase in potential $= -25 - (-63) = 38 \times 10^6$ J kg^{-1} [1]

Increase in potential energy $= m\Delta V = (2.5 \times 10^3)(38 \times 10^6)$

$= 9.5 \times 10^{10}$ J [1]

(e) $\omega = \dfrac{2\pi}{T} = \dfrac{2\pi}{7.15 \times 24 \times 3600} = 1.02 \times 10^{-5}$ rad s^{-1} [1]

Centripetal acceleration of Jupiter, $g = \omega^2 r = (1.02 \times 10^{-5})^2(1.07 \times 10^9)$
$= 0.111$ m s^{-2} [1]

Since $g = \dfrac{GM}{r^2}$, $M = \dfrac{gr^2}{G} = \dfrac{(0.111)(1.07 \times 10^9)^2}{6.67 \times 10^{-11}}$ [1]
$= 1.91 \times 10^{27}$ kg [1]

Apparatus List for Q1

1. Two springs
2. Two stands, bosses and clamps
3. Hacksaw blade
4. Two corks, with slits to grip to grip the hacksaw blade in retort clamps
5. Five 100 g slotted masses loaded onto a 100 g mass hanger
6. Small ring (eg keyring)
7. 30 cm rule with a millimetre scale
8. Protractor

The hacksaw blade, springs, ring and masses should be assembled as shown in Fig. 4.2

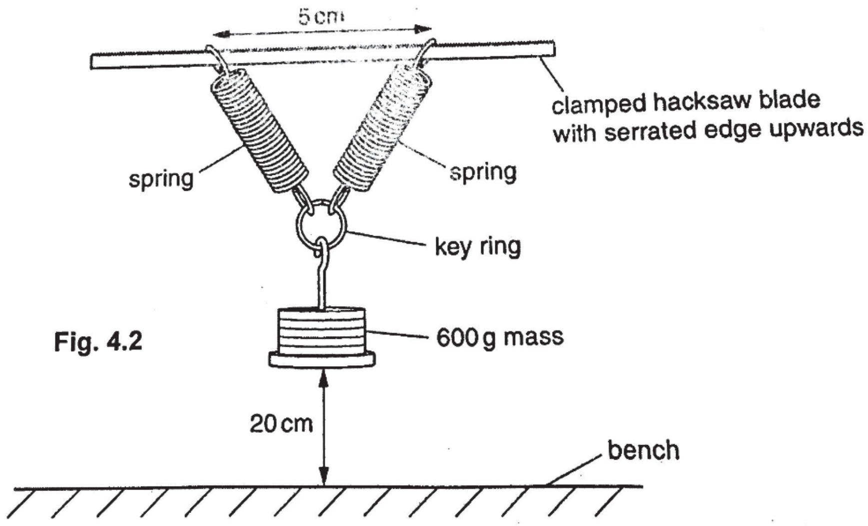


Fig. 4.2

Apparatus List for Q2

1. A ball of modelling clay (of mass 50 g)
2. A flat metal/wooden board
3. Vernier caliper
4. A stopwatch
5. Retort stand, clamp and boss-head
6. Rubber band
7. Nail
8. Sellotape & scissors

Apparatus List for Q3

1. 1.5 V dry cell with holder
2. A digital ammeter set to the 200 μA (dc) range
3. Six connecting leads
4. A 0 – 3 V dc analogue voltmeter
5. Two resistors one labelled ‘R_1’ and the other labelled ‘R_2’.
   Each of the resistors is securely placed in a component holder.

<u>Markscheme for Prelim Physics Practical: Q1</u>

(a) [1]

- Repeated readings of L_0 & average recorded to **nearest 0.001 m** (ie 0.1 cm)
- Acceptable **range:** 2.0 – 2.4 cm

(c) <u>Successful collection of **5 or more sets** of raw data</u> (ie of θ & L) where **$30^0 < \theta < 80^0$** without assistance **[2]**

{1 mark for 4 sets, zero mark for 3 or less sets.
Deduct up to 2 marks if student requires assistance}.

<u>Range of Data/Independent Variable</u>: **Range of $\theta \geq 35^0$** [1]

<u>Column Heading & Tabulation</u> [1]

- Each column heading must contain a **quantity and a unit**:
  $\theta/^0$, L/m , $\dfrac{1}{\cos(\frac{\theta}{2}/°)}$
- No split tables, ie readings of $\dfrac{1}{\cos(\theta/2)}$ tabulated with θ & L.

<u>Raw Data</u> (ie of θ & L): <u>Precision of Recording</u> [1]

- All values of θ **to nearest degree** &
- All values of L **to nearest 0.001 m {ie 0.1 cm}**

<u>Calculated Quantities</u>: <u>Precision & Consistency</u> [1]

All values of $\dfrac{1}{\cos(\theta/2)}$ **<u>consistently</u>** recorded to same number of **s.f.** as θ or, consistently 1 more sf.

<u>Calculated Quantities</u>: <u>Accuracy of Calculation</u> [1]

All values of $\dfrac{1}{\cos(\theta/2)}$ correctly calculated.

(d) Why minimum value of θ was restricted to 30^0: [1]

For $\theta < 30^0$, the lower ends of springs may come into **contact** with each other (which will introduce an error to the value of θ.)

(e) (i) <u>Graph: Scale, Size & Axes</u> [1]

- Sensible scales, no awkward scales (eg 3 units into 10 small squares)
- Plotted pts occupy at least ½ **the graph grid in both x & y directions**

- Axes labelled with the quantity & unit {ECF for wrong units in (c)}
- Successive scale markings: no more than 20 small squares apart.

Plotting of Points [1]

- ALL observations in table must be plotted
- accurate to within half a small square.
- **Thickness of plots** (ie the crosses, 'x') ≤ half a small square

Best fit line & Anomaly [1]

- **Minimum number of 4** non-anomalous pts.
- Line drawn with **approx. equal number** of points on either side of line (anomalous pts not considered).
- Line not be kinked/disjointed or thicker than half a small square
- Anomalous plot **clearly indicated** (eg by a circle or labelled.) Allow 1 anomalous plot only.

(e) (ii) Determination of Gradient [1]

- Recording of the **4 coordinates** accurate to **half a small square**
- Hypotenuse of triangle **> half length** of line drawn
- **No obscurity** of the 2 pts used for gradient calculation
- Gradient calculated correctly & number of sf follows the lowest no. of s.f. among the 4 coordinates {or one more}.
- Unit for gradient: $\mathbf{m^{-1}}$

(e) (iii) Determination of y-intercept [1]

- Vertical intercept calculated using a point on the line {not from the table} & value of gradient.
  {Allow reading off the y- intercept (to the correct number of decimal places which is determined by ½ small sq for y-axis}) if x-axis starts from zero & there is no 'bunching of plots' }
- Unit for y-intercept: **no unit**

(f) Linearisation of Eqn $\frac{1}{\cos(\theta/2)}$ = P L – Q { unnecessary for this question}

- Stated **explicitly**: *P* = gradient of graph [1]
- Stated explicitly:*Q* = y-intercept {Accept answer which omits this statement}

Q/P calculated correctly, recorded to **correct sf & unit** { metre }: [1]

(g) 2 Significant Sources of Error **[2]**

- **In the measurement of θ,** error arises as the **axes of the springs that define θ are imaginary**/not well-defined, (as well as parallax error), or

- **In the measurement of *L***, error arises due to the **unsteadiness of the hands** in holding the rule.

Markscheme for Prelim Physics Practical: Q2

(a) (ii) Repeated readings of *d* & average recorded to **precision denoted by Δd in (iii)** [1]

- Within specified range**:** 4 - 5 cm

(iii) Percentage uncertainty in *d* correctly calculated with **2 mm ≤ Δd < 8 mm** [1]

& recorded to **1 or 2 sf** (not 3 sf).

(c) (ii) Determination of *T* [1]

- **Repeated timings** to **nearest 0.1 s**
- Timings for oscillations must be such that **$nT \geq 10$** s, where ***n*, no. of oscillations is recorded**.
- Appropriate number of **sf** for *T*

(d) (iii) **Repeated readings** of *d* & **average** recorded to **nearest 1 mm** [1,ecf]

- Acceptable value**:** {must be > 6 cm as specified}

Determination of *T* [1,ecf]

- **Repeated timings** to **nearest 0.1 s**
- Timings for oscillations must be such that **$nT \geq 10$** s, where ***n***, **no. of oscillations** is recorded.
- Value of T > value in (c) (ii)
- Appropriate number of **sf** for *T.*

(e) (i) Calculation of 2 values of *k* [1]

- 2 values of *k* **calculated correctly** & recorded to **appropriate number of sf** [which is to the same no of sf as T or d {whichever is the smaller} , or 1 more]
- Unit of k : **$s^2\ m^{-3}$**

(ii) Justification of Conclusion: [1]

The criterion here is, whether or not,

$$\frac{\Delta k}{k_{ave}} \textbf{ x 100\% > a stated reasonable Percentage Error}$$

If yes, ⇒ results do not support suggested relationship.

(f) (i) Any 2 significant sources of error: **[2]**

- Uncertainty in measuring *d* due to the variation in diameter of the **irregularly-shaped** piece of clay, or,
due to the very soft clay, it is easily compressed when touched.

- Difficult to ensure that timing is stopped at the right instant ie when cylinder is at the same position as when timing began.
- Any other reasonable answer

(ii) Improvements: **[2]**

- Use a less malleable clay (ie less compressible clay), or ,
  use a circular mould
  Use a fiducial marker (ie a point of reference) placed at the centre of oscillation,
  or, use video camera with timer/frame by frame playback.
- Any other reasonable answer,

Markscheme for Prelim Physics Practical: Q3

(b) Recording of V_0 & I_0 [1]

- V_0 to the nearest 0.05 V
- I_0 to the nearest 0.1 μA
- Accurate values obtained: $V_0 \approx 1.50 \pm 0.20$ V, $I_0 \approx \{120.0 – 140.0\} \times 10^{-6}$ A

(c)(ii) Recording of V_2 & I_2 [1]

- V_2 to the nearest 0.05 V {ecf}
- I_2 to the nearest 0.1 μA {ecf}
- *Values of V_2 & I_2 *are very close to* V_1 & I_1 respectively *{since* $R_1 = R_2$*}*
- Accurate values obtained: $V_2 \approx 0.30 - 0.40$ V, $I_2 \approx 178.2$ μA

(d) **[2]**

- Resistance of voltmeter is not >> R_1 (or R_2)/Voltmeter resistance is not infinite
- Explained consequence of point above { eg, "When voltmeter is connected across R_1, effective resistance across resistor R_1 becomes less than value of R_1" .}

(e) (ii) $V_3 = 0.30$ V, $I_3 = 100.4 \times 10^{-6}$ A [0]

(e) (iii) (Assume internal resistances of cell & of ammeter are negligible, & since $R_1 \approx R_2$)
Thus emf = V_0 in Fig. 3.1)

- In Fig 3.2: $V_0 = V_3 + I_3\,[R_1 + R_2]$
  ie $1.50 = 0.30 + 100.4 \times 10^{-6}\,[2R_1]$ (eqn A)

  $\rightarrow$ **$R_1 = 6.00 \times 10^3\ \Omega$** [1]

- Since $V_3 = I_3 R_v$, R_v = *voltmeter resistance,* from Fig. 3.2:

  $\rightarrow$ Voltmeter resistance $R_v = (0.30\text{ V}) \div (100.4 \times 10^{-6}\text{ A}) =$ **$3.00 \times 10^3\ \Omega$** [1]

(e) (iv) From eqn (A), R_1 should have the same number of sf as V_3 (the quant with least no. of sf) or one more. Since V_3 has 2 sf, R_1 can have {2 or 3} sf. [1]

(e) (v) One Change to apparatus (in Fig. 3.1) to obtain more accurate value for R_1: [1]
Replace the analogue voltmeter with a voltmeter with a higher resistance, or a digital voltmeter or, a potentiometer.

Markscheme for Prelim Physics Practical: Q4 (Planning)

Written Account	Marks
A Clear Labelled Diagram of Layout of Essential Apparatus • Parallel connection of voltmeter/CRO across 2 electrodes {or the high voltage supply} connected to high voltage supply • Apparatus above placed within transparent thermally-insulated chamber. (Each electrode is held by retort stand & clamp arrangement.) {Power supply may be outside of chamber} *{Alternatively, these 2 marks may be credited at the written account.}*	1 1
B Identified Independent & Dependent Variables • Independent Variable: temperature of air in chamber • Dependent Variable: minimum pd across electrodes when spark is generated **C Control of Variables (ie stated how other variables that affect V_{min} are kept const):** • Distance between the electrodes is kept constant (by monitoring with vernier caliper), or, • Pressure within chamber using vacuum pump & pressure gauge	1 (both correct, '**minimum**' is essential) 1(for either)
D How Variables are Measured/Varied: • Voltage across electrodes: voltmeter or (calibrated) CRO • Temperature of air in chamber: measured by a **thermocouple**/ temperature sensor attached to data logger • Temperature is varied by the use of an electrical **heater**/heating element with a thermostat {Unacceptable: Bunsen burner, thermostat on its own}	1 1 1
E Basic Procedure 1. Set up the apparatus as shown in the diagram 2. Measure the temperature of the air in the chamber using a thermocouple (placed near the electrodes). 3. Use the high voltage power supply to **slowly increase** the voltage across the electrodes **from a low value** until a spark is generated. Measure this voltage (V_{min}). 4. Repeat steps 2 & 3 to get several sets of readings of T & V_{min}.	1 for stating both: • at a given T, V is measured & • several sets of these readings are obtained at different T

F Analysis • Assume the relationship is $V_{min} = k\,T^n$, where k & n are constants. • Plot a graph of lg V_{min} against lg T. • If a linear graph is obtained, my assumed relationship is valid, where n is the gradient and $k = 10^{y\text{-intercept}}$.	(1 for all 3 pts correct)
G Safety Precaution (Any 1) • Keep hands dry and wear gloves (to minimise risk of electrocution when handling high voltage supply.) • Monitor the pressure constantly to minimise risk of explosion/implosion • Use goggles to view spark {possible danger of uv radiation} • Any other reasonable safety precaution (eg 'don't touch plates')	Max of 1
H Good Experimental Features/ Details • Stated how the **minimum** voltage for sparking to occur was determined (by a '**slow increase** of the voltage **from a low value**") • Any 2 from: ✓ thermocouple is calibrated {ie thermocouple emf is first calibrated to temperature} ✓ sufficient time allowed for air in chamber to reach equilibrium before recording T ✓ lighting condition is low so that spark can be seen easily ✓ chamber must be properly sealed to ensure reliable pressure readings <u>Less significant ones</u>: ✓ repeat measurement of voltage and taking the average ✓ switch off circuit when not taking readings to prevent overheating of apparatus	Max of 3 1 2