NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/01**

Paper 1 Multiple Choice

Additional Materials: Multiple Choice Answer Sheet

13 Sep 2017
1 hour

READ THE INSTRUCTION FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name, Subject Class and index number on the Answer Sheet in the spaces provided unless this has been done for you.
DO **NOT** WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

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

This document consists of 13 printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^8\ ms^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ C$
the Planck constant	$h = 6.63 \times 10^{-34}\ Js$
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	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2,\ v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	$T/K = T/^\circ C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \dots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

1 Which of the following shows the base units of magnetic flux density?

A T **B** kg s^{-2} A^{-1} **C** kg m^{-1} s^{-1} **D** Wb m^{-2}

2 A projectile is launched at 45° to the horizontal with initial kinetic energy E.

Assuming air resistance to be negligible, what will be the kinetic energy of the projectile when it reaches its highest point?

A 0.50 E **B** 0.71 E **C** 0.87 E **D** E

3 A passenger on a bus moving forward at constant speed notices that a ball which has been at rest in the aisle suddenly starts to roll towards the front of the bus. What can be concluded about the motion of the bus from this observation?

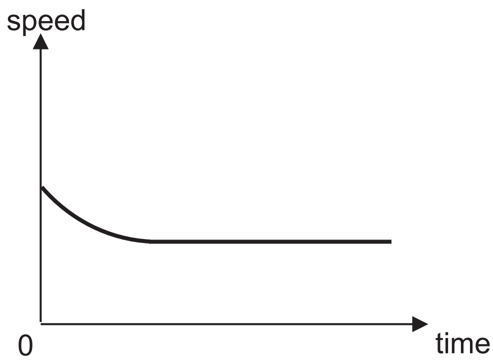
A The bus is moving at constant speed.
B The bus is decelerating.
C The bus is accelerating.
D The bus is making a turn.

4 A stream of water from a pipe travels horizontally at 10 m s^{-1}. The stream strikes a wall and splashes back horizontally at 5 m s^{-1}. What is the pressure exerted by the wall on the water? (density of water = 1000 kg m^{-3})

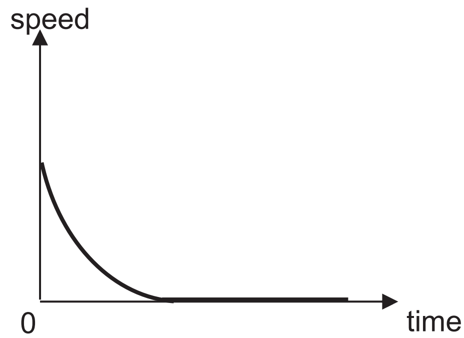
A 50 kPa **B** 100 kPa **C** 150 kPa **D** 200 kPa

5 A ball is dropped from a great height into the sea and enters the sea at high speed. The density of the ball is less than the density of sea water. If viscous force cannot be ignored, which of the following is the speed-time graph of the ball after it enters the sea?

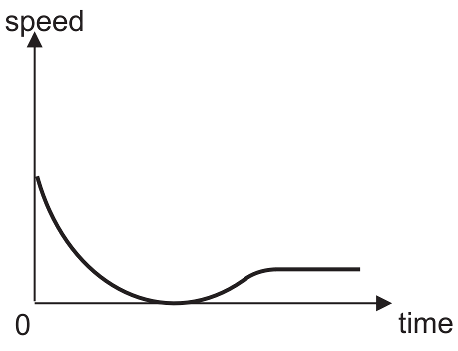
A



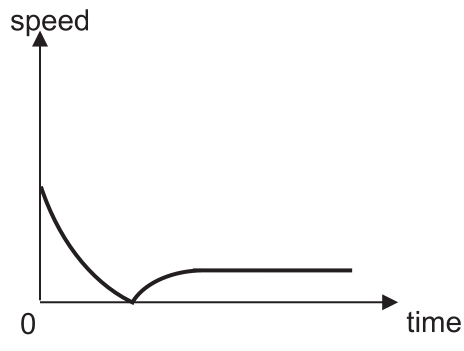
B



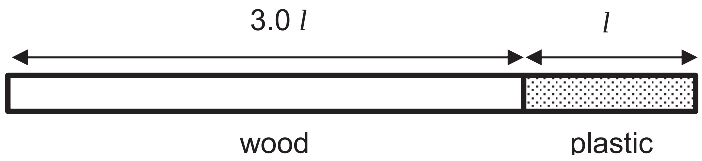
C



D



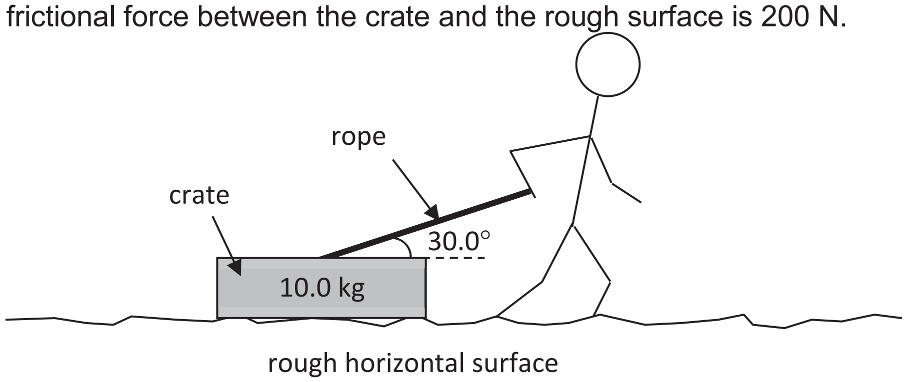
6 A rod consists of a uniform wood section and a uniform plastic section, as shown.



The length of the wooden section is 3.0 l and the length of the plastic section is l. The density of the wooden section is 600 kg m^{-3} and the density of the plastic section is 1000 kg m^{-3}. What is the distance of the centre of gravity of the entire rod from its left end?

A 1.1 l **B** 1.8 l **C** 2.2 l **D** 2.9 l

7 A man drags a crate of mass 10.0 kg across a rough horizontal surface at a constant speed of 0.800 m s^{-1}. The rope makes an angle of 30.0 ° with the horizontal. The average frictional force between the crate and the rough surface is 200 N.



What is the instantaneous power input by the man on the crate 2.00 seconds after he starts to accelerate the crate uniformly at 1.00 m s^{-2}? The angle which the rope makes with the crate remains unchanged.

A 0 W **B** 194 W **C** 588 W **D** 679 W

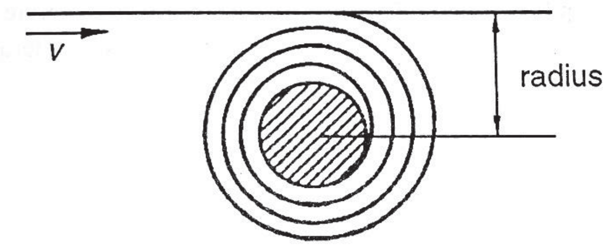
8 A body moves in a circle with increasing angular displacement. At time t, the angles θ swept out by the body are as follows:

t /s	θ /rad
2	11
4	19
6	27
8	35

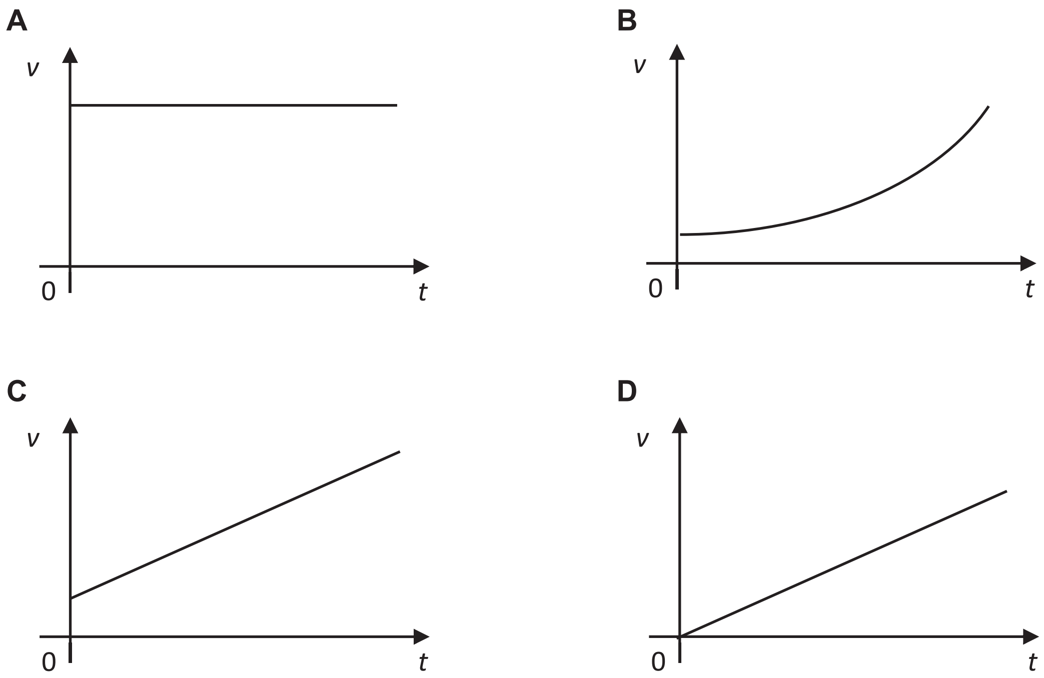
The angular velocity of the body

A gradually decreases and is 4.5 rad s^{-1} when t = 6 s.
B gradually increases and is 4.5 rad s^{-1} when t = 6 s.
C is constant at 4 rad s^{-1}.
D is constant at 8 rad s^{-1}.

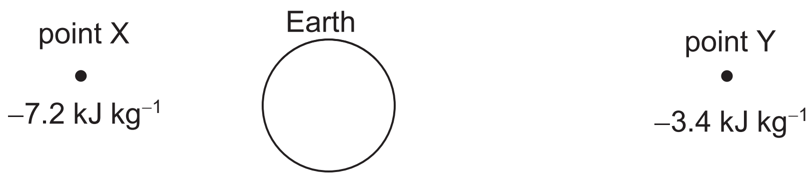
9 A straight length of tape winds on to a roll rotating about a fixed axis with constant angular velocity, the radius of the roll increasing at a steady rate.



Which one of the graphs below correctly shows how the speed v at which the tape moves towards the roll varies with time?



10 The gravitational potential at point X due to the Earth is -7.2 kJ kg^{-1}. At point Y, the gravitational potential is -3.4 kJ kg^{-1}.



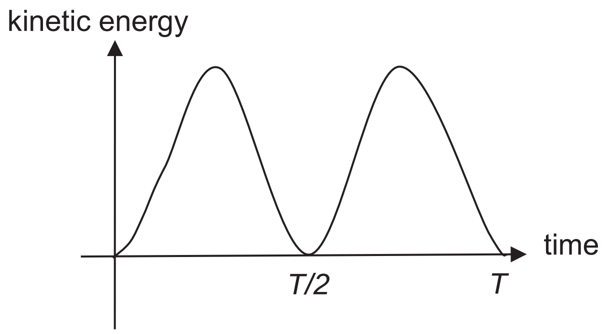
The change in gravitational potential energy of a 4.0 kg mass when it is moved from point X to point Y is

A $-$ 42.4 kJ **B** $-$ 15.2 kJ **C** +3.8 kJ **D** +15.2 kJ

11 Why does the Moon stay in its orbit at a constant distance from the Earth?

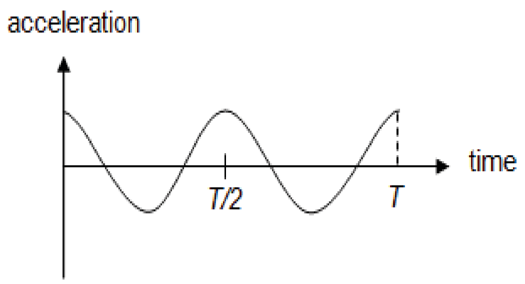
A The gravitational pull of the Earth on the Moon balances the gravitational pull of the Moon on the Earth.
B The gravitational pull of the Earth on the Moon is just sufficient to cause the centripetal acceleration of the Moon.
C The gravitational pull of the Moon on the Earth is negligible at this distance.
D The centripetal force the Earth exerts on the Moon balances the centripetal force the Moon exerts on the Earth.

12 A body moves with simple harmonic motion about a point P. The graph shows the variation with time of its kinetic energy.

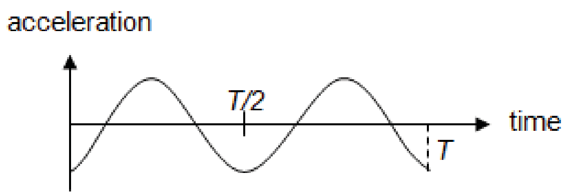


Which graph shows the variation with time of its acceleration?

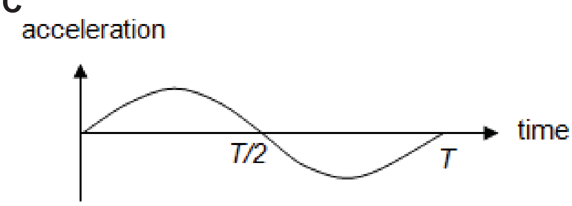
A



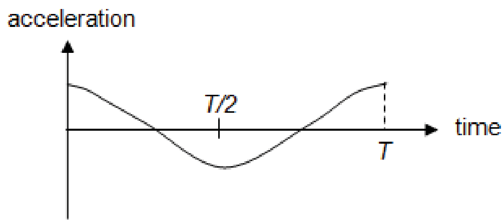
B



C



D



13 A fully loaded car's suspension system has a natural frequency of 1.20 Hz. When the car is driven over a series of equally spaced bumps at a speed of 5.0 m s^{-1}, the amplitude of vibration becomes much larger. What is the separation of the bumps?

A 1.1 m **B** 2.3 m **C** 4.2 m **D** 6.0 m

14 For an ideal gas at 300 °C, the mean kinetic energy of the gas molecules is 1.6×10^{-23} J. What are the values for the temperature of the gas and the mean kinetic energy of the gas molecules when its molecules are, on average, travelling at twice the root mean square speed?

	Temperature / °C	**Kinetic energy / J**
A	600	3.2×10^{-23}
B	1100	3.2×10^{-23}
C	2000	6.4×10^{-23}
D	2300	6.4×10^{-23}

15 An ideal monatomic gas has 1000 J of heat added to it and it does 500 J of work; its temperature changes by T_1. When twice the amount of heat is added to it and it does the same amount of work, its temperature changes by T_2. The ratio of T_1 / T_2 is

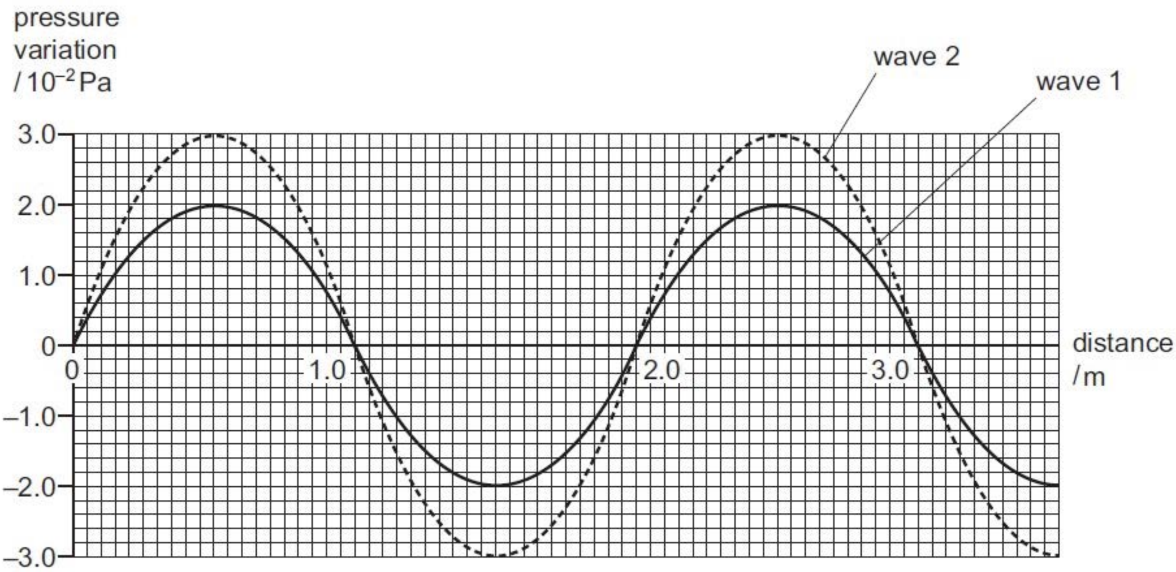
A $\frac{1}{5}$ **B** $\frac{1}{3}$ **C** $\frac{3}{5}$ **D** 1

16 Which statement describes a situation when polarisation could not occur?

A Light waves are reflected.
B Light waves are scattered.
C Microwaves pass through a metal grid.
D Sound waves pass through a filter paper.

17 A sound wave consists of a series of moving pressure variations from the normal, constant air pressure.

The graph shows these pressure variations for two waves at one instant in time.



Wave 1 has an intensity of 1.6×10^{-6} W m^{-2}.

What is the intensity of wave 2?

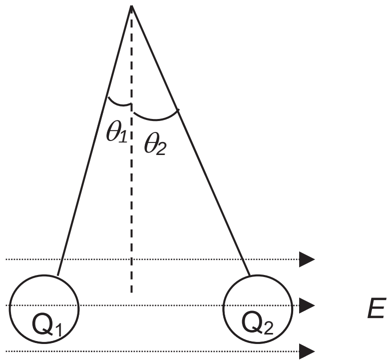
A 2.4×10^{-6} W m^{-2} **B** 3.0×10^{-6} W m^{-2} **C** 3.6×10^{-6} W m^{-2} **D** 4.5×10^{-6} W m^{-2}

18 Monochromatic light of wavelength 590 nm is incident normally on a diffraction grating. The angle between the two second-order diffracted beams is 43°.

What is the spacing of the lines on the grating?

A 0.87 μm **B** 1.6 μm **C** 1.7 μm **D** 3.2 μm

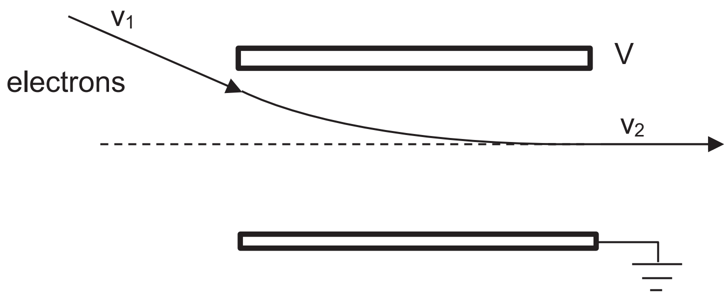
19 Two oppositely-charged spheres of the same mass are suspended by light strings. When placed in a region of uniform external electric field E, the spheres come to equilibrium as shown in the figure below, with $\theta_2 > \theta_1$.



Which statement is correct?

A Q_1 is positive and $|Q_1| > |Q_2|$.
B Q_1 is positive and $|Q_1| < |Q_2|$.
C Q_1 is negative and $|Q_1| > |Q_2|$.
D Q_1 is negative and $|Q_1| < |Q_2|$.

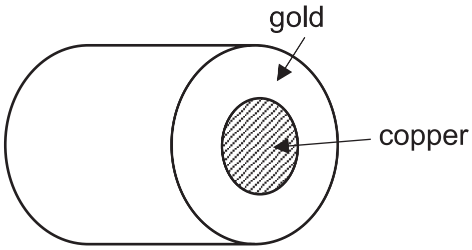
20 A beam of electrons move through two horizontal plates in which the electric potential of the upper plate is V. The initial speed of the electrons before entering the plates is v_1. The final velocity of the particles after leaving the plates is v_2.



Which statement is correct?

A V is positive and $v_1 > v_2$
B V is positive and $v_1 < v_2$
C V is negative and $v_1 > v_2$
D V is negative and $v_1 < v_2$

21 A composite wire of diameter 4.0 mm consists of a copper core of diameter 2.0 mm surrounded by layer of gold as shown in the figure.



The resistivity of copper is $1.7 \times 10^{-8}\ \Omega$ m and the resistivity of gold is $2.4 \times 10^{-8}\ \Omega$ m.
What is the resistance of 1.0 m of the composite wire?

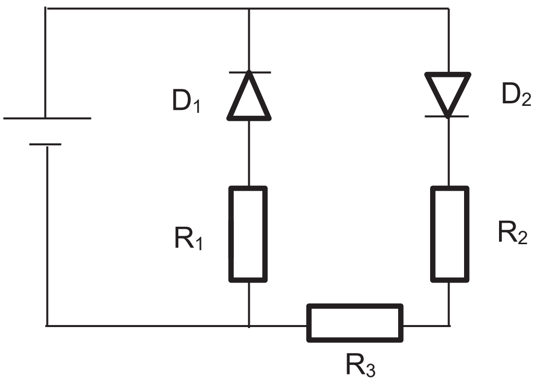
A $4.3 \times 10^{-4}\ \Omega$ **B** $1.7 \times 10^{-3}\ \Omega$ **C** $3.2 \times 10^{-3}\ \Omega$ **D** $8.0 \times 10^{-3}\ \Omega$

22 The drift velocity of the electrons through a cylindrical metal conductor is *v* when the current flowing through the conductor is *I*.

What is the new drift velocity of the electrons if the diameter of the cylindrical conductor is doubled and the current flowing through is also doubled?

A v/2 **B** v **C** **2**v **D** **4**v

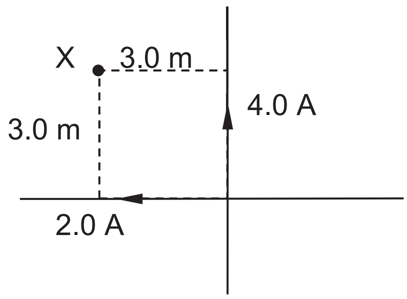
23 A circuit consisting of diodes and resistors is shown below.



Which of the following options correctly show the relative magnitude of the potential differences across the components D_1, R_1 and R_2?

	Greatest to smallest potential difference		
A	D_1	R_1	R_2
B	D_1	R_2	R_1
C	R_1	R_2	D_1
D	R_2	R_1	D_1

24 Two long current carrying conductors are placed perpendicular to each other. The current flowing through one of the wires is 4.0 A upwards, while the current through the other wire is 2.0 A towards the left.



What is the magnitude and direction of the resultant magnetic field at a point X, which is 3.0 m perpendicularly away from both wires? Ignore the Earth's magnetic field.

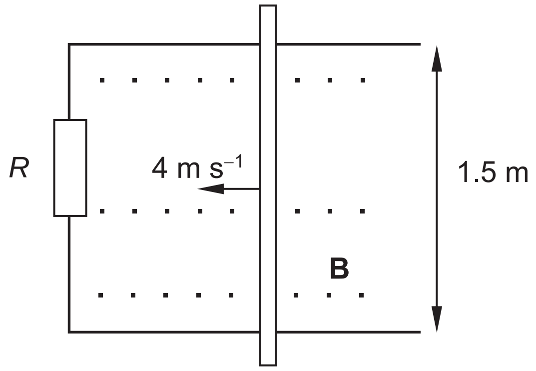
A 1.33×10^{-7} T out of the plane of the page

B 1.33×10^{-7} T into the plane of the page

C 4.00×10^{-7} T out of the plane of the page

D 4.00×10^{-7} T into the plane of the page

25 A metallic rod of length 2.5 m slides along a frictionless wire frame of width 1.5 m with a constant speed of 4.0 m s^{-1} across a magnetic flux density of 5.0 T pointing out of the plane of the frame as shown.



What is the direction of the induced current and the power dissipated by the resistor R of resistance 12 Ω?

	Direction of induced current	Power dissipated
A	Clockwise	208 W
B	Anti clockwise	208 W
C	Clockwise	75 W
D	Anti clockwise	75 W

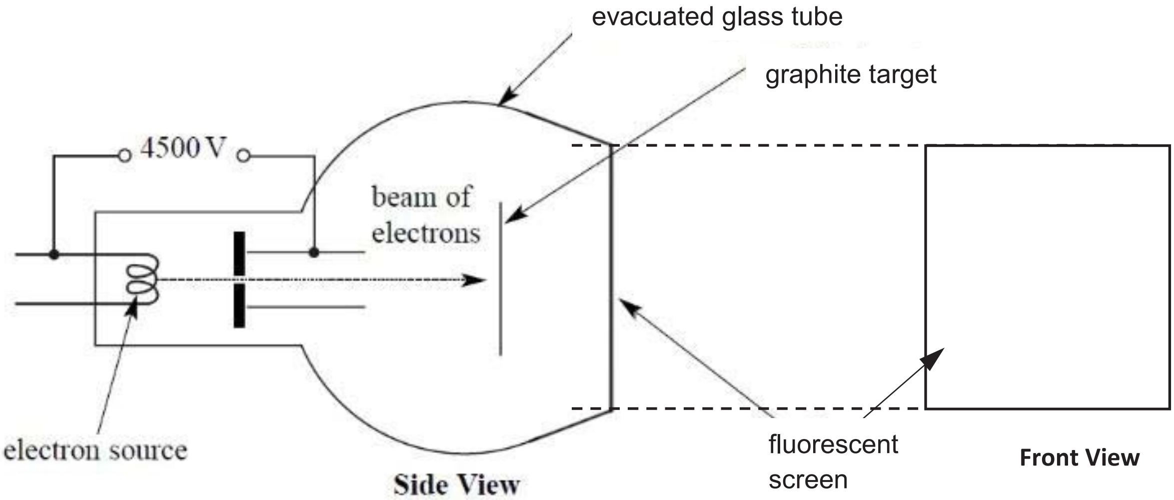
26 When a steady current I flows in a resistance R, the power dissipated is P. If an alternating current of *r.m.s.* value $I/2$ flows in a resistance $R/2$, what is the power dissipated?

A P **B** $P/2$ **C** $P/4$ **D** $P/8$

27 In a series of photoelectric emission experiments, metals of different work function ϕ were illuminated with monochromatic light of different frequencies f and intensities I. It was found that, for each experiment, the emitted electrons emerged with a spread of kinetic energies up to a certain maximum value. This maximum kinetic energy depends on

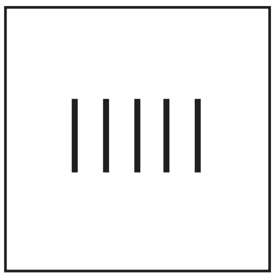
A ϕ but not on f, or I.
B ϕ and I but not on f.
C ϕ and f but not on I.
D ϕ, f, and I.

28 Electrons being fired at a polycrystalline graphite target in a vacuum as shown. The inside surface on the far side of the chamber is coated with fluorescent material that emits light when the electrons release their energy to it.



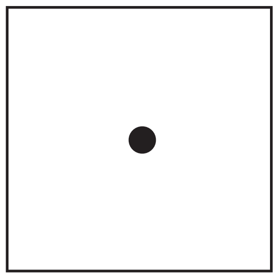
Which of the following shows the correct image seen on the fluorescent screen?

A



Front View

B

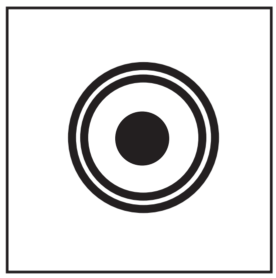


Front View

C

Front View

D



Front View

29 Which of the following statements concerning nuclear reactions, the mass differences and energies released is true?

A The greater the binding energy of a nucleus, the more stable it is.

B If the total mass of the products of a reaction is greater, this reaction is impossible.

C Although the half-life of a radioactive substance is unaffected by changes in pressure, temperature and other external factors, we can still change the half-life by allowing the substance to react chemically to produce a new radioactive compound.

D When a stationary nucleus decays to produce a daughter nucleus and a γ-photon, the products always move off in opposite directions so as to conserve linear momentum.

30 The half-life of a certain radioactive element is such that 7/8 of a given quantity decays in 12 days. What fraction remains undecayed after 24 days?

A 1/128 **B** 1/64 **C** 1/32 **D** 1/16

-END-

NJC P1 Answer Key

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

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

9749/02

Paper 2 Structured Questions

25 Aug 2017
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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

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

Answers **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	/ 10
2	/ 10
3	/ 10
4	/ 10
5	/ 10
6	/ 10
7	/ 20
Total (80m)	

This document consists of 16 printed pages.

Data

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permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ C$
the Planck constant	$h = 6.63 \times 10^{-34}\ Js$
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	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall	$g = 9.81\ ms^{-2}$

Formulae

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hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t\ \ and\ \ v = \pm\omega\sqrt{x_0^{\ 2} - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

1 **(a)** **(i)** Define the *speed* of an object.

____

____ [1]

(ii) Distinguish between *speed* and *velocity*.

____

____

____ [2]

(b) A car is travelling along a straight road at constant speed v. A hazard suddenly appears in front of the car. In the time interval between the hazard appearing and the brakes on the car coming into operation, the car moves forward a distance of 29.3 m. With the brakes applied, the front wheels of the car leave skid marks on the road that are 12.8 m long, as illustrated in Fig. 1.1.

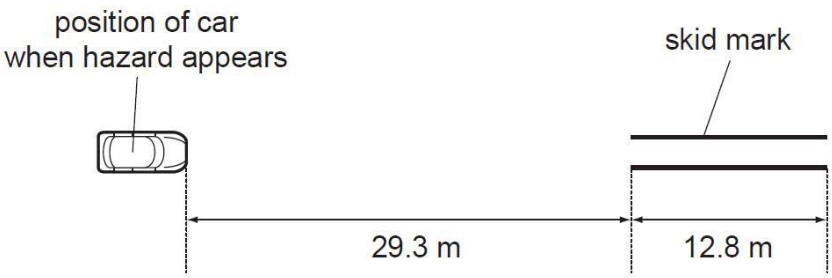


Fig. 1.1

It is estimated that, during the skid, the magnitude of the deceleration of the car is 0.85 g, where g is the acceleration of free fall.

(i) **(1)** Show that the speed v of the car before the brakes are applied is 14.6 m s^{-1}.

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

(2) Determine the time interval between the hazard appearing and the brakes being applied.

time = ___________ s [2]

1 **(b)** **(ii)** The legal speed limit on the road is 60 km h^{-1}. Use **both** of your answers in **(b)(i)** to comment on the driver's standard of driving.

____

____

____

____ [3]

2 **(a)** A uniform metal rod AB of mass 1.5 kg and length 0.50 m is freely pivoted at A as shown in Fig. 2.1.

The end B is suspended by a light spring. The other end of the spring is supported at X. When the rod is in equilibrium, it makes an angle of 30° with the horizontal and the angle between the rod and the spring is 90°.

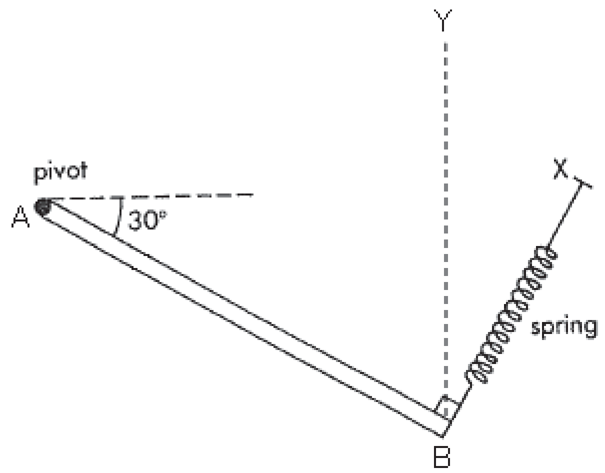


Fig. 2.1

(i) On Fig. 2.1, draw and label the forces acting on the metal rod AB. [2]

(ii) Show that the tension in the spring is 6.4 N.

[2]

2 **(a)** **(iii)** Calculate the magnitude and direction of the reaction force at pivot A.

magnitude = ________ N [4]
direction = ____________

(b) Explain if there will be any change in the tension of the spring if the spring is aligned vertically along YB instead, so that the angle between the lever and the spring is no longer 90°.

____

____

____ [2]

3 On one particular ride in an amusement park, passengers 'loop-the-loop' in a vertical circle, as illustrated in Fig. 3.1.

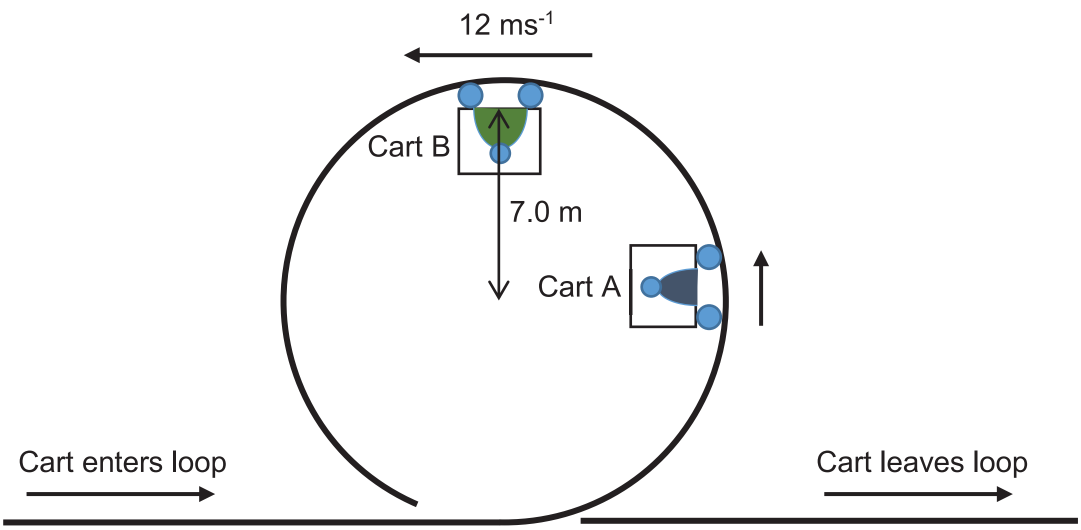
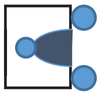
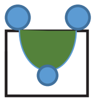


Fig. 3.1

3 **(a)** **(i)** On the diagrams below, draw and label the forces acting on the passenger in Cart A and Cart B.

Cart A 

Cart B 

[2]

(b) The loop has a radius of 7.0 m and a passenger of mass 60 kg in cart B is travelling at 12 ms^{-1} at the highest point of the loop. Assume that frictional forces may be neglected,

(i) Calculate, for this passenger, at the highest point,

(1) his centripetal acceleration,

centripetal acceleration = ________ m s^{-2} [1]

(2) the force exerted by the seat on him.

force = __________ N [2]

(ii) The passenger in Cart B now moves round and descends to the bottom of the loop. Determine the speed of this passenger on leaving the loop.

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

3 **(c)** Upon seeing that the cart is moving at such a fast speed of 12 m s^{-1}, another passenger at the platform of the ride requests the operator to slow the speed of the cart down. The operator refused the request due to safety reasons. Explain in the context of this question, a reason for this.

____

____

____

____ [3]

4 A small straight tunnel is dug through the centre of the Earth as shown in Fig 4.1.

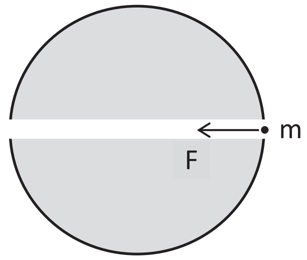


Fig 4.1

A small mass, m, released at one end of the tunnel, travels through it and emerges at the other end. Assuming that the mass does not rub against the sides of the tunnel and that air resistance is negligible, it can be shown that the gravitational force F acting on m is given by:

$$F = -\frac{4}{3}\pi G\rho x m$$

where G is the gravitational constant, ρ is the density of Earth, which is assumed to be uniform and x is the displacement of the mass from the centre of the Earth.

(a) Explain why the motion of the mass is *simple harmonic*.

____

____

____

____ [2]

4 **(b)** The density of Earth is 5460 kg m^{-3} and the radius of Earth is 6.4×10^6 m.

(i) Show that the period of oscillation of the mass is 5100 s.

[2]

(ii) Calculate the maximum speed of the mass.

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

(c) Given that m = 1.0 kg. Show that the maximum change in gravitational potential energy of the oscillating mass is 3.1×10^7 J.

[2]

(d) The gravitational potential energy, E_p, of a 1.0 kg mass at Earth's surface, calculated using the formula $E_p = -\frac{GMm}{r}$, is numerically equal to 6.2×10^7 J. Explain why the value calculated in **(c)** is exactly half of this value.

____

____

____

____ [2]

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

[1]

(b) Two charged spheres are placed with their centres 12.0 cm apart. Fig. 5.1 shows the resultant electric field strength between the centres of the charged spheres A and B.

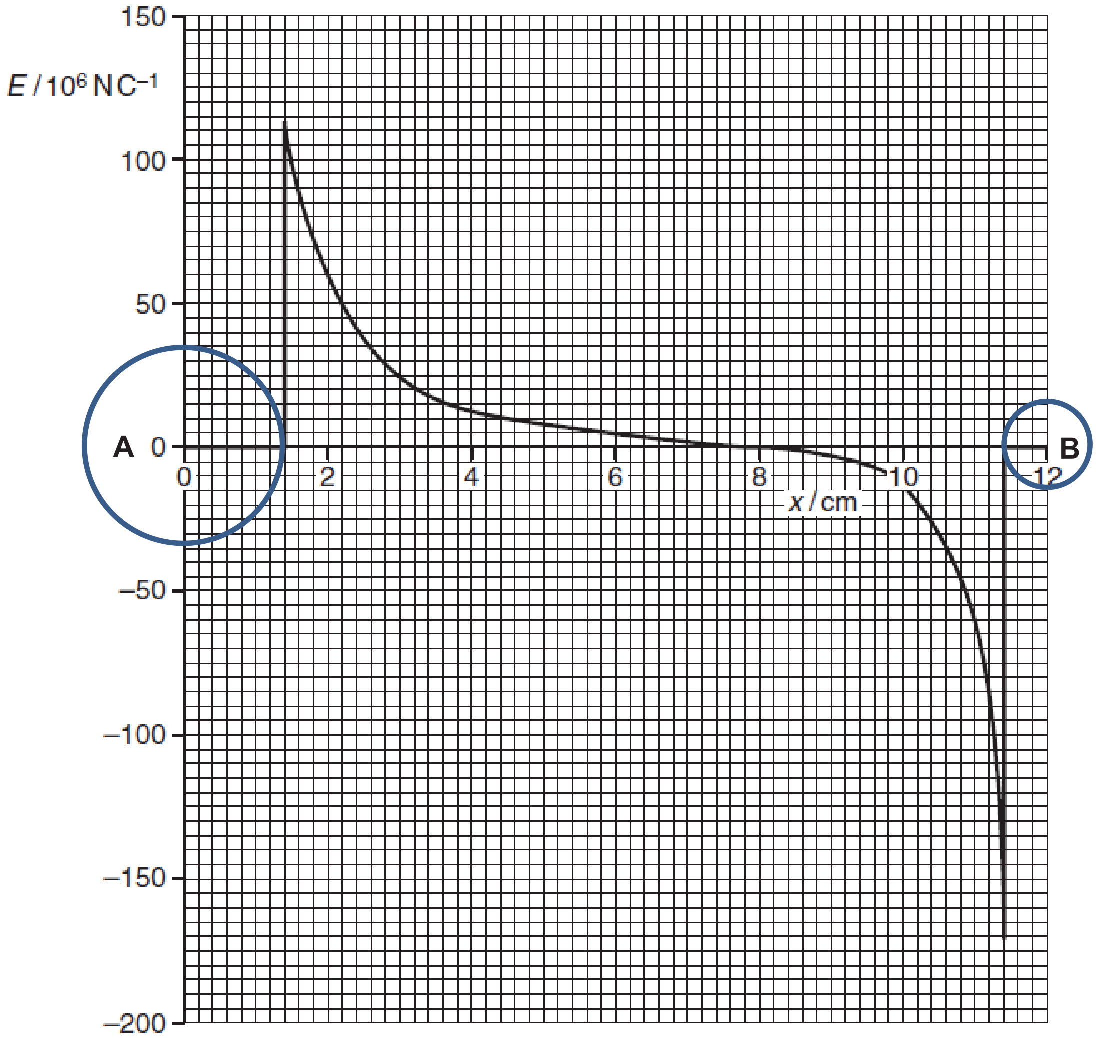


Fig. 5.1

(i) Using Fig. 5.1, state and explain the potential difference between the points x = 0.0 cm and x = 1.4 cm.

[2]

5 **(b)** **(ii)** Calculate the ratio of the charge of sphere A to that of sphere B.

ratio = ___________ [2]

(c) **(i)** A proton is moved from the point x = 8.0 cm to the surface of point B. Explain what happens to the electric potential energy of the proton.

____

____

____ [2]

(ii) Estimate the change in electric potential energy of the proton when it is moved from the point x = 8.0 cm to the surface of sphere B.

change in electric potential energy = ____________ J [2]

(iii) The proton is now released from rest at the point x = 6.0 cm. Describe the subsequent motion of the proton.

____

____ [1]

6 **(a)** The spectrum of electromagnetic waves is divided into a number of regions such as radio waves, visible light and gamma radiation.

(i) State two distinct features of electromagnetic waves that are common to all regions of the electromagnetic spectrum.

1. ______________________________

2. ______________________________ [2]

(ii) State a typical wavelength for x-rays.

______________________________ [1]

(b) A string is stretched between two fixed points. It is plucked at its centre and the string vibrates, forming a stationary wave as illustrated in Fig. 6.1.

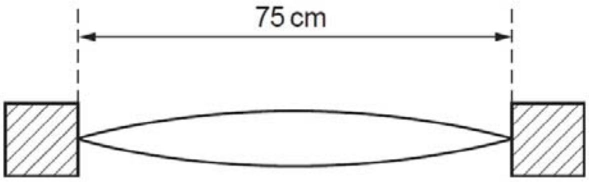


Fig. 6.1

The length of the string is 75 cm.

(i) The frequency of vibration of the string is 360 Hz. Calculate the speed of the wave on the string.

speed = ________ ms^{-1} [2]

(ii) By reference to the formation of the stationary wave on the string, explain what is meant by the speed calculated in **(b)(i)**.

____

____

____

____

______________________________ [3]

6 **(c)** The setup in **(b)** is brought near a tube of water which is filled up to the brim as shown in Fig. 6.2. A tap at the bottom of the tube may be used to release the water in the tube. Determine the length of the air column when the first loud sound is heard. (Speed of sound in air = 330 m s^{-1})

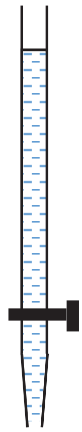


Fig. 6.2

length of air column = ________ m [2]

7 Read the following passage and then answer the questions which follow it. (Numbers near to the right-hand margin of the passage indicate the line numbers.)

Lithium solid-state batteries

Lithium solid-state batteries represent a new concept in battery technology. Solid-state means that the liquids and pastes present in ordinary battery systems are replaced by a solid plastic film which cannot leak. This plastic film separates a lithium anode (positive electrode) from a composite cathode (negative electrode) which is in contact with aluminium foil. (See Fig. 7.1) The resultant cell can be constructed so that it has a large electrode area but is less than 0.2 mm thick. It is in many ways similar to a sheet of paper and can be cut and formed into almost any shape. Lithium solid-state cells such as this are rechargeable and can be incorporated into the cases of equipment or into such items as credit cards.

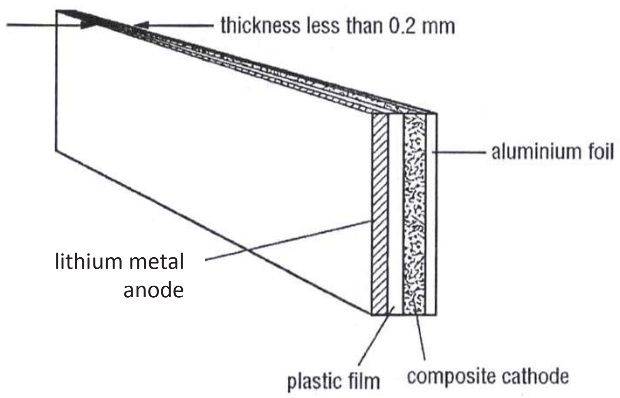


Fig. 7.1

The initial e.m.f. of the cell at full charge is 3.4 V but it rapidly falls to about 2.8 V on load and thereafter falls as shown in Fig. 7.2. The cell needs to be recharged when the e.m.f. reaches 2.0 V. In practice, its average e.m.f. is 2.5 V.

The current density, energy density and charge capacity all have to be considered for a particular application.

The recommended maximum value of discharge current density is 0.15 milliamperes per square centimetre of electrode area, the charge capacity is 3.6 coulombs per square centimetre of electrode area, and the energy density is 120 watt-hours per kilogram of cell mass.

Charging one of these cells should be carried out with a constant applied voltage of 3.4 V and with a current density limited to 2.5 mA cm^{-2}. A typical charging current against time graph is shown in Fig. 7.3 for a cell of electrode area 50 cm^2.

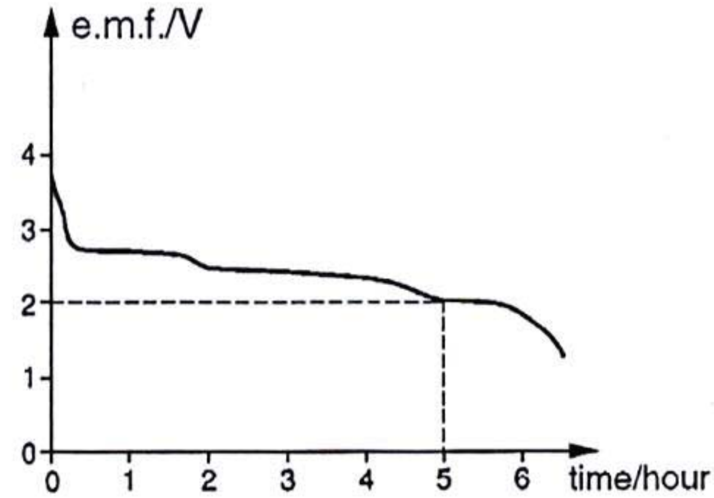


Fig. 7.2

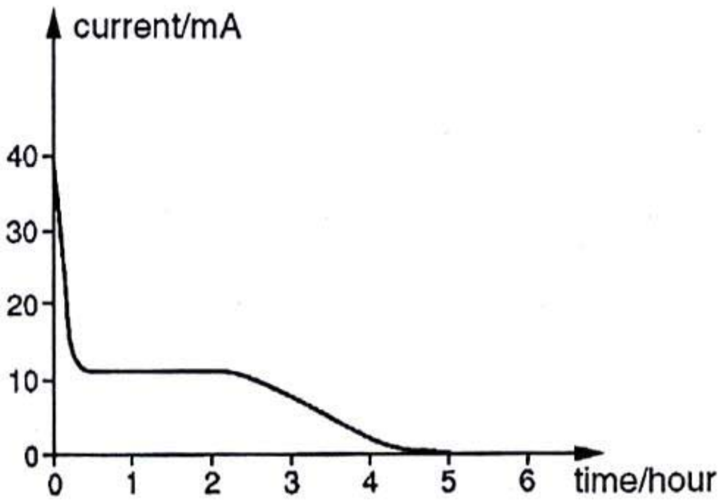


Fig. 7.3

For safety it is vital that 26

(1) cells should not be short circuited. (A fuse should be incorporated in any circuit with a cell of charge-storage capacity greater than 3600 coulombs.)

(2) cells should not be used in environments with a temperature above 140 °C.

(3) water or water vapour is kept away from lithium cells. 33

7 **(a)** Give **one** possible use of a lithium solid-state cell.

____ [1]

7 **(b)** Deduce from the units, and then write down, the meaning of the terms *current density* and *energy density*. (lines 10-25)

____

____

____

____ [2]

(c) By reference to lines 10-25 of the passage, answer the following questions for a cell of electrode area 50 cm^2.

(i) Calculate the charge-storage capacity of this cell.

Charge storage capacity = ________ C [1]

(ii) Calculate the recommended maximum value of the discharge current.

Maximum discharge current = ________ mA [1]

(iii) Calculate how long this cell can supply this maximum current.

Time maximum current can be supplied = ___________ s [2]

(iv) Calculate the energy it supplies in this time, assuming that the e.m.f. has a constant value of 2.5 V.

Energy supplied = __________ J [2]

(v) Estimate the mass of the cell.

Mass = _________ g [1]

7 **(d)** Fig. 7.3 shows the charging graph for a cell of the same electrode area as in **(c)**.

(i) From the graph, estimate the average charging current over the 5-hour charging time.

Average charging current = __________ mA [2]

(ii) Calculate the energy used in charging the cell.

Energy used in charging the cell = __________ J [2]

(e) Using your answers to **c(iv)** and **d(ii)**, deduce the electrical efficiency of the charge/discharge cycle.

Electrical efficiency = ____________ [2]

(f) Suggest reasons for **two** of the safety considerations. (lines 26-33)

1. ____

____

2. ____

____ [2]

(g) Draw a diagram, using circuit symbols, to illustrate how you would connect a battery of cells which could produce a current up to 300 mA at a voltage of approximately 10 V. In your answer specify the electrode area of the individual cells.

[2]

End of Paper

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS

9749/03

Paper 3 Longer Structured Questions **(Section A)**

29 Aug 2017
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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

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

Section A
Answers **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	**/ 6**
2	**/ 10**
3	**/ 10**
4	**/ 9**
5	**/ 8**
6	**/ 8**
7	**/ 9**
Total	**/ 60**

This document consists of 14 printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ C$
the Planck constant	$h = 6.63 \times 10^{-34}\ Js$
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	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}$
acceleration of free fall	$g = 9.81\ ms^{-2}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$, $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -GM/r$
temperature	$T/K = T/°C + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.	$v = v_0 \cos \omega t$ and $v = \pm\omega\sqrt{x_0^2 - x^2}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \cdots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_0 nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \frac{ln2}{t_{\frac{1}{2}}}$

Section A (60 marks)

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

1 (a) When a solid is heated, the thermal energy required is given by the expression

gain in thermal energy = c × mass × temperature rise, where c is a constant.

(i) Name the quantities in the expression that are SI base quantities.

.... [1]

(ii) Express, in terms of SI base units, the unit of c.

unit of c = ... [2]

(b) In an experiment to determine the specific heat capacity of a liquid by an electrical method, a student obtained the following results.

Mass of liquid heated = 1.5 ± 0.1 kg
Initial liquid temperature = 27.0 ± 0.5 °C
Final liquid temperature = 84.0 ± 0.5 °C
Electrical power of heater = 1000 ± 10 W
Time of heating = 180 ± 5 s

Calculate the specific heat capacity of the liquid together with its uncertainty. Show the method you used to determine the uncertainty.

specific heat capacity = ... ± .... [3]

2 **(a)** Two balls X and Y, of the same mass 160 g, experience a head-on collision as shown in Fig. 2.1. Ball X is moving at 10 m s^{-1} and ball Y is moving at 5 m s^{-1}.

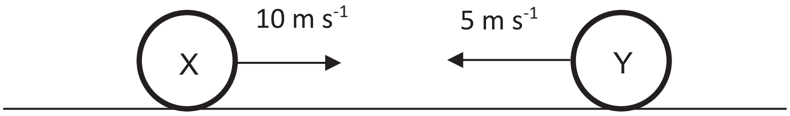


Fig. 2.1

Fig. 2.2 shows the force of ball Y on ball X during the collision.

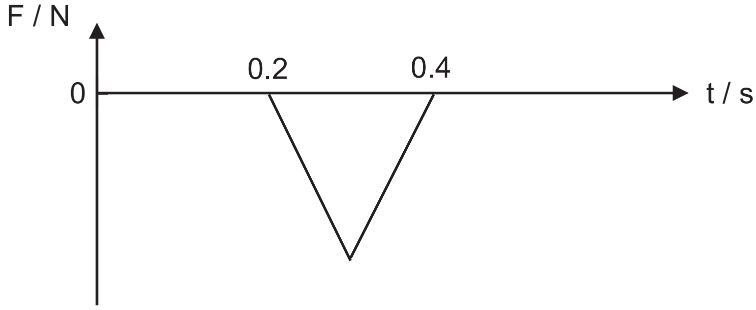


Fig. 2.2

(i) Calculate the maximum force acting on ball X if the impulse on ball X during the collision is 2.0 kg m s^{-1}.

maximum force = ……………………….. N [1]

(ii) Calculate the velocities of ball X and ball Y after the collision. State the direction of the velocities.

velocity of ball X = ……………………….. m s^{-1}

velocity of ball Y = ……………………….. m s^{-1}

[3]

2 (a) (iii) State and explain whether the collision is elastic or inelastic.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(iv) Sketch the momentum-time graph for ball Y on Fig. 2.3. Include appropriate values.

[2]

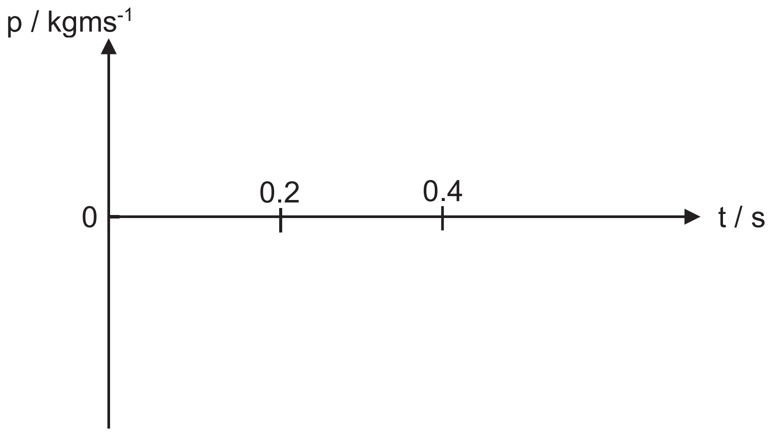


Fig. 2.3

(v) Explain whether it is possible for the kinetic energy of the balls to be fully converted to other forms of energy during the collision.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

3 In a distant galaxy, the planet Odyssey is orbited by two small moons Scylla and Charybdis, labelled **O**, **S**, **C** respectively in Fig. 3.1 below. The distances of the moons from the centre of the planet are 5*R* and 4*R*, where *R* is the radius of the planet.

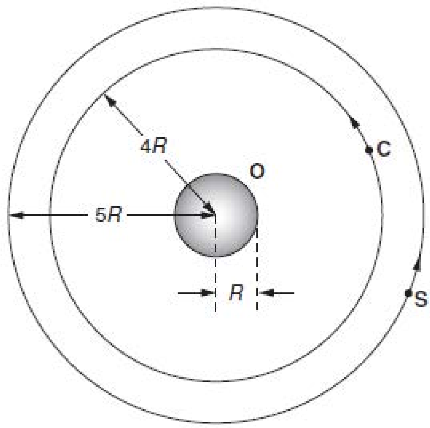


Fig. 3.1

(a) Define *gravitational field strength*.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

(b) Draw a gravitational field line of planet **O** passing through moon **S**. [1]

(c) The radius R of planet O is 2.0 x 10^7 m. The gravitational field strength *g* at its surface is 40 N kg^{-1}. Determine the mass of **O** assuming that the gravitational field strength due to the two moons is negligible compared to that of **O**.

mass of **O** = ……………………….. kg [2]

(d) Calculate the increase in gravitational potential energy of a small spacecraft of mass 3000 kg when it moves from the orbit of C to the orbit of S.

increase in gravitational potential energy = ……………………….. J [2]

3 **(e)** Calculate the orbital period of **S**.

orbital period of **S** = ……………………….. s [2]

(f) The orbits of the two moons shown in Fig. 3.1 are perfect circles. If the gravitational force exerted by **C** on **S** is significant, state and explain how the shape of the orbital path of **S** will change.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

4 **(a)** A circuit consists of four resistors, R_1, R_2, R_3 and R_4 of the same resistance R and two ammeters, A_1 and A_2, as shown in Fig. 4.1.

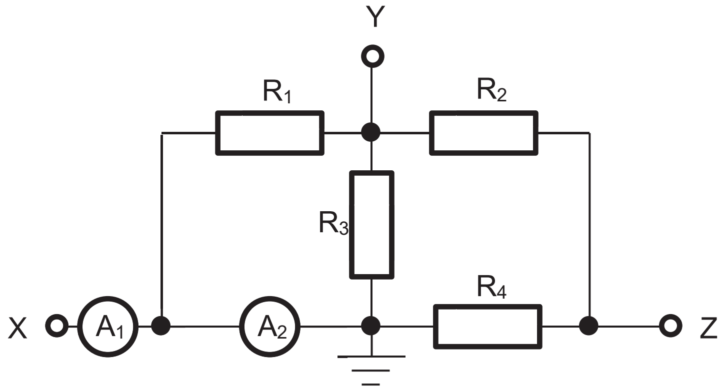


Fig. 4.1

The resistance measured between terminals X and Y is 2.4 Ω.

Show that the value of resistance R is 6.0 Ω

[1]

(b) **(i)** A cell of e.m.f. 1.5 V and internal resistance 0.60 Ω is connected across the terminals X and Y. Calculate the current reading in ammeter A_1.

current reading in A_1 = ……………………….. A [1]

(ii) Calculate the current reading in ammeter A_2.

current reading in A_2 = ……………………….. A [2]

(iii) The positive terminal of the cell is connected to X. Determine the electric potential at terminal Z.

electric potential at Z = ……………………….. V [2]

4 (b) (iv) An additional circuit consisting of a similar cell of e.m.f 1.5 V and internal resistance 0.60 Ω, a resistor S and a sensitive galvanometer A_3, as shown in Fig 4.2 , is now connected to the terminals X and Z.

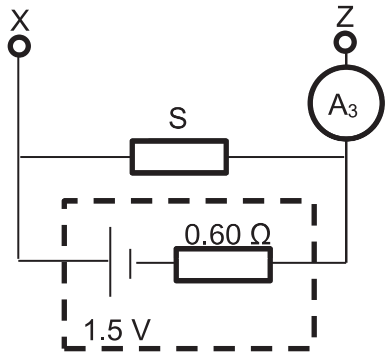


Fig. 4.2

1. The reading on galvanometer A_3 is zero. Determine the resistance of S.

Resistance of S = ……………………….. Ω [2]

2. Explain what will happen to the reading on galvanometer A_3 when the resistance of S is increased.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

5 (a) The diagram below shows the **full scale** diagram of a circuit. Part of the circuit QRST is placed in a region of uniform field *B* of 0.530 T that is directed in the positive x-direction. The battery supplies a current *I* of 2.50 A. The wire experiences a force as a result.

The region of the magnetic field is represented by the shaded region.

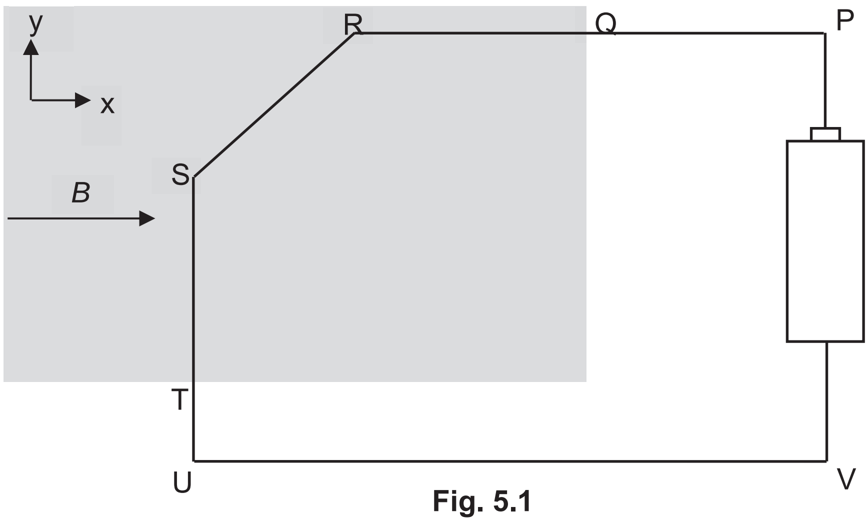


Fig. 5.1

(i) Define *tesla.*

………………………………………………………………………………………

……………………………………………………………………………………… [1]

5 (a) (ii) Calculate the resultant magnetic force acting on the wire.

resultant magnetic force = ……………………….. N [2]

(iii) It is possible that there is no resultant force acting on the wire if the field points in one particular direction. Draw the field in this direction in the Fig. 5.1 and label it **P**. [1]

5 (b) Fig. 5.2 shows the top view of a current balance where the rectangular wire loop PQRS pivoted at AB is in equilibrium. It is connected in series with a battery of 300 g and an e.m.f. of 2.0 V. Part of the wire loop is placed inside a solenoid. The mass of the loop can be taken to be negligible.

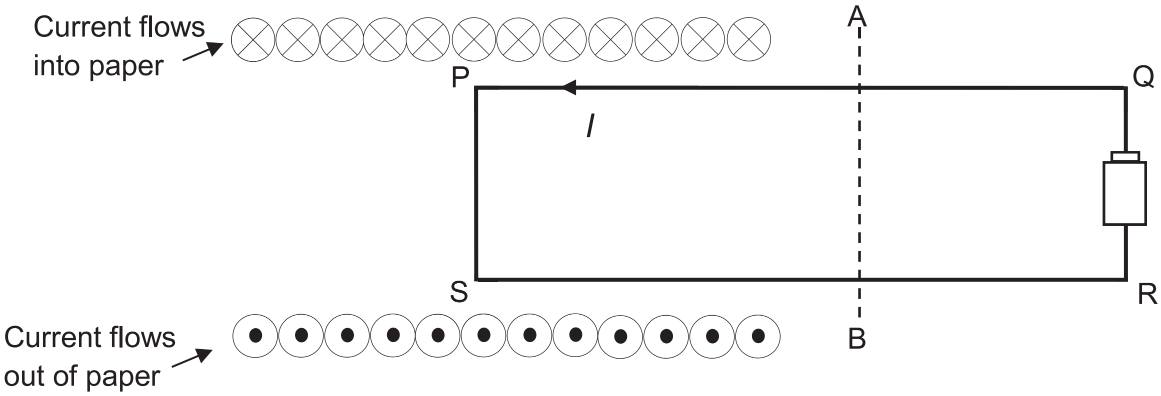


Fig. 5.2

(i) Draw the magnetic field lines in the solenoid. [1]

(ii) The length of the side PS is 6.0 cm and SB = 0.6SR. Given that the magnetic flux density in the solenoid is 0.40 T and the wire has resistance 2.0 mΩ, calculate the internal resistance of the battery.

internal resistance = ……………………….. Ω [3]

6 **(a)** Fig. 6.1 shows the front view of a large flat circular coil connected to a sinusoidal alternating voltage supply and a small flat circular coil placed at the centre of the large coil such that the planes of the two coils are coincident. The smaller coil is connected to a cathode-ray oscilloscope (c.r.o).

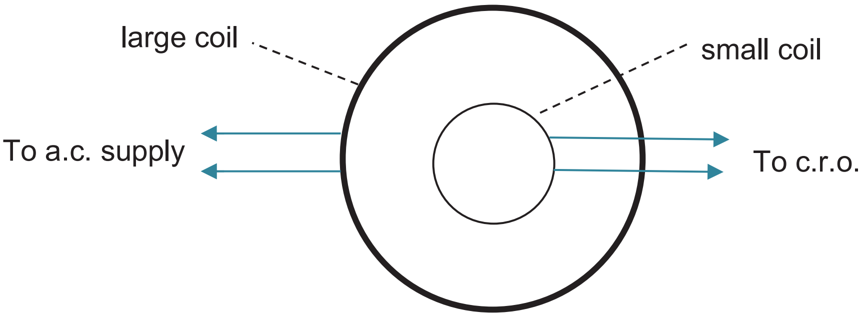


Fig. 6.1

If the variation of the sinusoidal alternating current to the large coil is as shown in Fig. 6.2, draw sketch graphs, one in each case, to show the variation with time of

(i) the magnetic flux through the small coil and [1]

(ii) the induced e.m.f. in the small coil as displayed on the c.r.o.. [1]

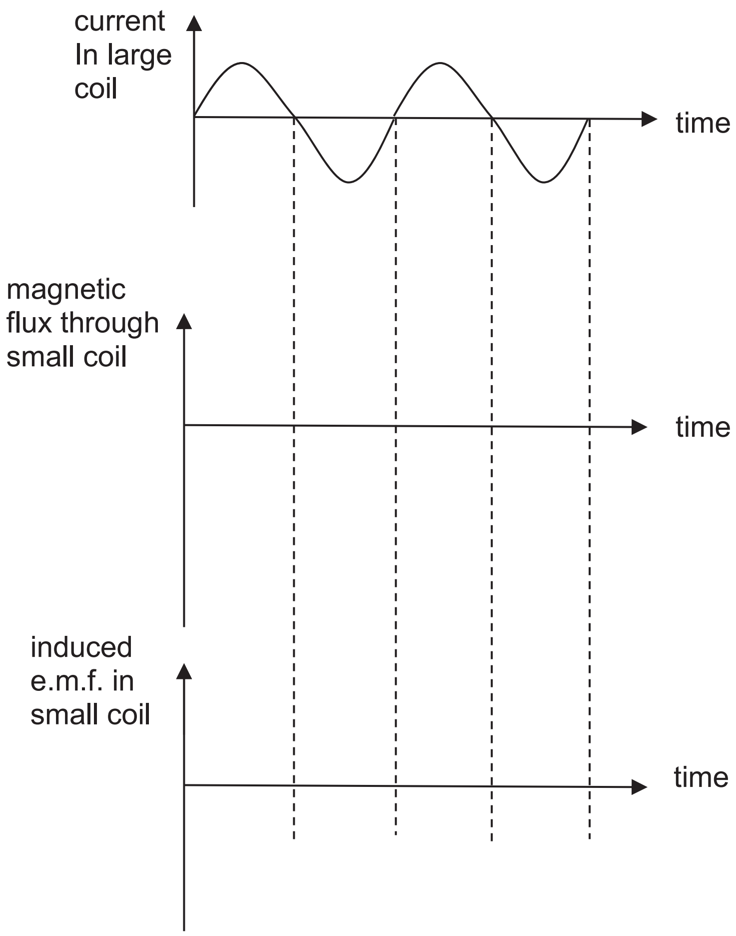


Fig. 6.2

(b) Justify the shape of your sketches in **(a)**.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

(c) State and explain how the trace on the screen of the c.r.o. would be affected if the following changes are made independently

(i) the small coil is rotated such that the angle between the planes of the two coils is now 90°, whilst maintaining a constant alternating current in the large coil.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

(ii) the frequency of the alternating current in the large coil is increased, whilst maintaining the same amplitude.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

7 Experiments are conducted to investigate the photoelectric effect. It is found that if the metal surface is exposed to light, electrons are either emitted immediately or they are not emitted at all.

(a) Suggest why this observation does not support the wave theory of light.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………[2]

7 (b) Data for the wavelength λ of the radiation incident on the metal surface and the maximum kinetic energy E_K of the emitted electrons are shown in Fig. 7.1.

λ /nm	E_K /10^{-19} J
650	–
240	4.44

Fig. 7.1

(i) Without any calculation, suggest why no value is given for E_K for radiation of wavelength 650 nm.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[2]

(ii) Use data from Fig. 7.1 to determine the work function energy of the metal surface.

work function energy = ……………………….. J [2]

(c) Radiation of wavelength 240 nm gives rise to a maximum photoelectric current I. The intensity of the incident radiation is maintained constant and the wavelength is now reduced.

State and explain the effect of this change on

(i) the maximum kinetic energy of the photoelectrons,

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[1]

(ii) the maximum photoelectric current I.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[2]

END OF SECTION A

NATIONAL JUNIOR COLLEGE

SENIOR HIGH 2 PRELIMINARY EXAMINATIONS

Higher 2

CANDIDATE NAME

SUBJECT CLASS

REGISTRATION NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions **(Section B)**

29 Aug 2017
2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

For Examiner's Use	
8	**/ 20**
9	**/ 20**
Total	**/ 20**

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

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

Section B
Answer any **one** question.

You are advised to spend half an hour on Section B.

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

This document consists of 10 printed pages.

Data

speed of light in free space	$c = 3.00 \times 10^{8}\ ms^{-1}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\ Hm^{-1}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\ Fm^{-1} = (1/(36\pi)) \times 10^{-9}\ F\ m^{-1}$
elementary charge	$e = 1.60 \times 10^{-19}\ C$
the Planck constant	$h = 6.63 \times 10^{-34}\ Js$
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	$R = 8.31\ JK^{-1}mol^{-1}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^{2}kg^{-2}$
acceleration of free fall	$g = 9.81\ ms^{-2}$

Formulae

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

Section B (20 marks)

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

8 (a) A small immersion electrical heater, operating at a constant power, was used to heat 64 g of water in a thin plastic cup. The mass of the cup was negligible. The temperature of the water was recorded at regular intervals for 30 minutes and a graph of temperature against time is drawn as shown in Fig. 8.1 below.

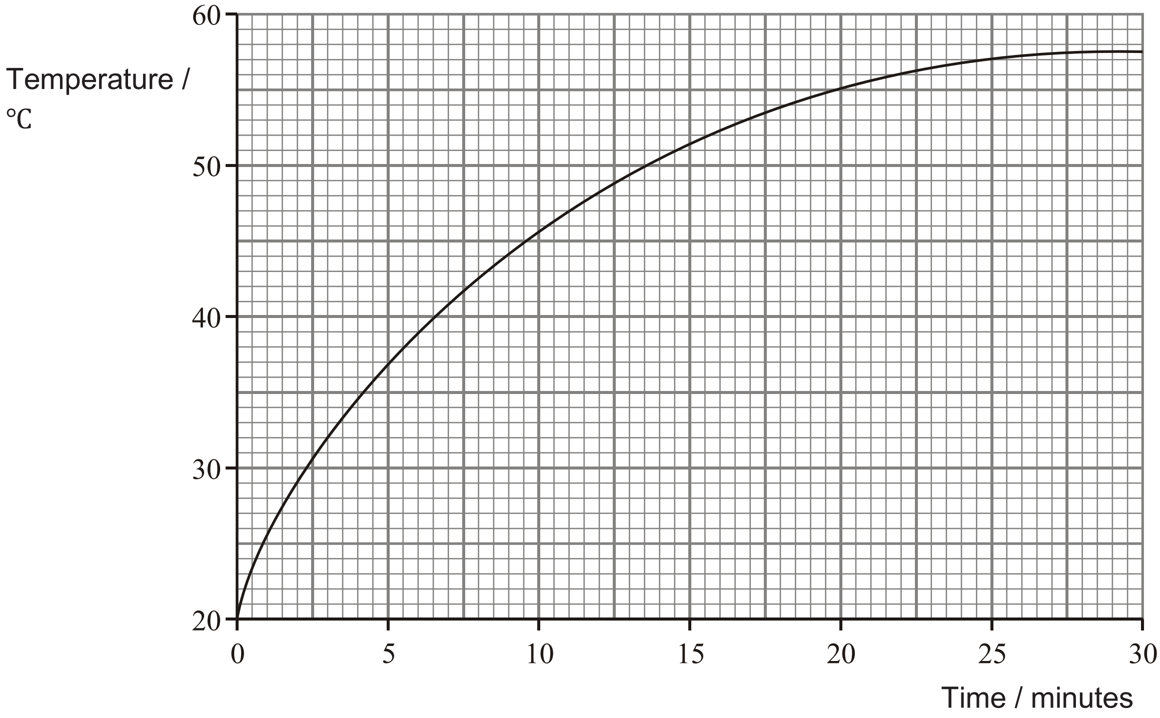


Fig. 8.1

(i) **1.** Use the graph to determine the initial rate of temperature rise of the water.

initial rate of temperature rise = ……………………….. ℃ min^{-1} [2]

2. The specific heat capacity of water is 4200 J kg^{-1} K^{-1}. Determine the rate at which energy was supplied to the water by the heater.

rate of energy supply = ……………………….. J min^{-1} [2]

8 **(a)** **(ii)** After 26 minutes the rate of temperature rise became very small. Explain why.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………[1]

(iii) The experiment was repeated using the same mass of water in a thick ceramic mug. The initial temperature of the water was the same and the water was heated for the same length of time.

1. On Fig 8.1, sketch a possible graph of temperature against time for the water in the thick ceramic mug. [1]

2. Explain your reasoning for your graph.

………………………………………………………………………………………

………………………………………………………………………………………[1]

(b) The pressure p exerted by an ideal gas is given by the equation

$$p = \frac{1}{3}\rho\langle c^2\rangle$$

(i) What does the symbol $\langle c^2\rangle$ represent?

………………………………………………………………………………………[1]

(ii) Use the equation given above to derive an expression for the total internal energy of the molecules of an ideal gas of volume V and pressure p. [2]

(iii) Calculate the internal energy of an ideal gas of volume 3.4×10^{-4} m^3 when its pressure is 100 kPa.

internal energy = ……………………….. J [1]

8 **(c)** An ideal gas in a cylinder can be considered to undergo a cycle of changes of pressure, volume and temperature as shown on Fig. 8.2.

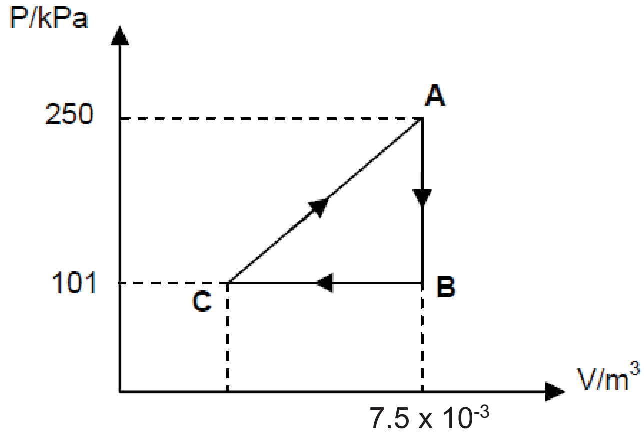


Fig. 8.2

The temperature of the gas at A and C are 623 K and 50 K respectively.

(i) Calculate the number of gas molecules in the cylinder.

no. of gas molecules = ……………………….. [1]

(ii) Calculate the volume of gas at C.

volume of gas at C = ……………………….. m^3 [1]

(iii) Calculate the change in internal energy of the gas for the process B $\rightarrow$ C.

change in internal energy = ……………………….. J [1]

8 **(c)** **(iv)** Calculate the net work done by the gas for the whole cycle.

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

(v) Explain whether thermal energy is taken in or given out for the process $C \rightarrow A$.

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

……………………………………………………………………………………[2]

(vi) State with a reason, the change in internal energy and the heat supplied to gas when it completes a cycle.

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

……………………………………………………………………………………[2]

9 Nuclear reactors make use of the fission of heavy nuclides such as Uranium 235 or Plutonium 239 to produce energy. Nuclear fission takes place when a Uranium 235 or a Plutonium 239 nuclide absorbs a slow neutron and split into two fragments of roughly equal masses together with two to three neutrons and the release of vast amount of energy. A typical reaction involving Uranium 235 is represented by the equation below:

$$ {}^{1}_{0}n + {}^{235}_{92}U \rightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}^{1}_{0}n + energy $$

The rest masses of the nuclides involved are as follows:

Nuclide	Rest mass
Uranium 235	235.0439299 u
Barium 141	140.9144119 u
Krypton 92	91.9261561 u
Neutron	1.0086649 u

Fig. 9.1

(a) Determine the energy released (in units of MeV) when a single Uranium 235 nucleus undergoes fission.

energy released = ……………………….. MeV [3]

(b) Besides Uranium 235, the fuel rod in the nuclear reactor also contains Uranium 238. When a Uranium 238 nucleus is exposed to free neutrons, it can absorb a free neutron to form ${}^{239}_{92}U$ which then decays to ${}^{239}_{93}Np$ (first decay) and then to ${}^{239}_{94}Pu$ (second decay).

(i) Complete the following nuclear equation for the first decay. [1]

$$ {}^{239}_{92}U \rightarrow {}^{239}_{93}Np + \_\_\_\_\_\_\_\_ + \overline{\upsilon} $$

(ii) Suggest what does the symbol $\overline{\upsilon}$ represent.

……………………………………………………………………………………[1]

9 (b) (iii) In the fuel rod, ${}^{239}_{93}Np$ nuclei are produced at a constant rate of 1.80 x 10^7 s^{-1}. On Fig. 9.2, draw a graph to show how **the number of ${}^{239}_{93}Np$ produced**, varies with time. Label this graph **X**. Assume that initially, there are no ${}^{239}_{93}Np$ nuclei present. [1]

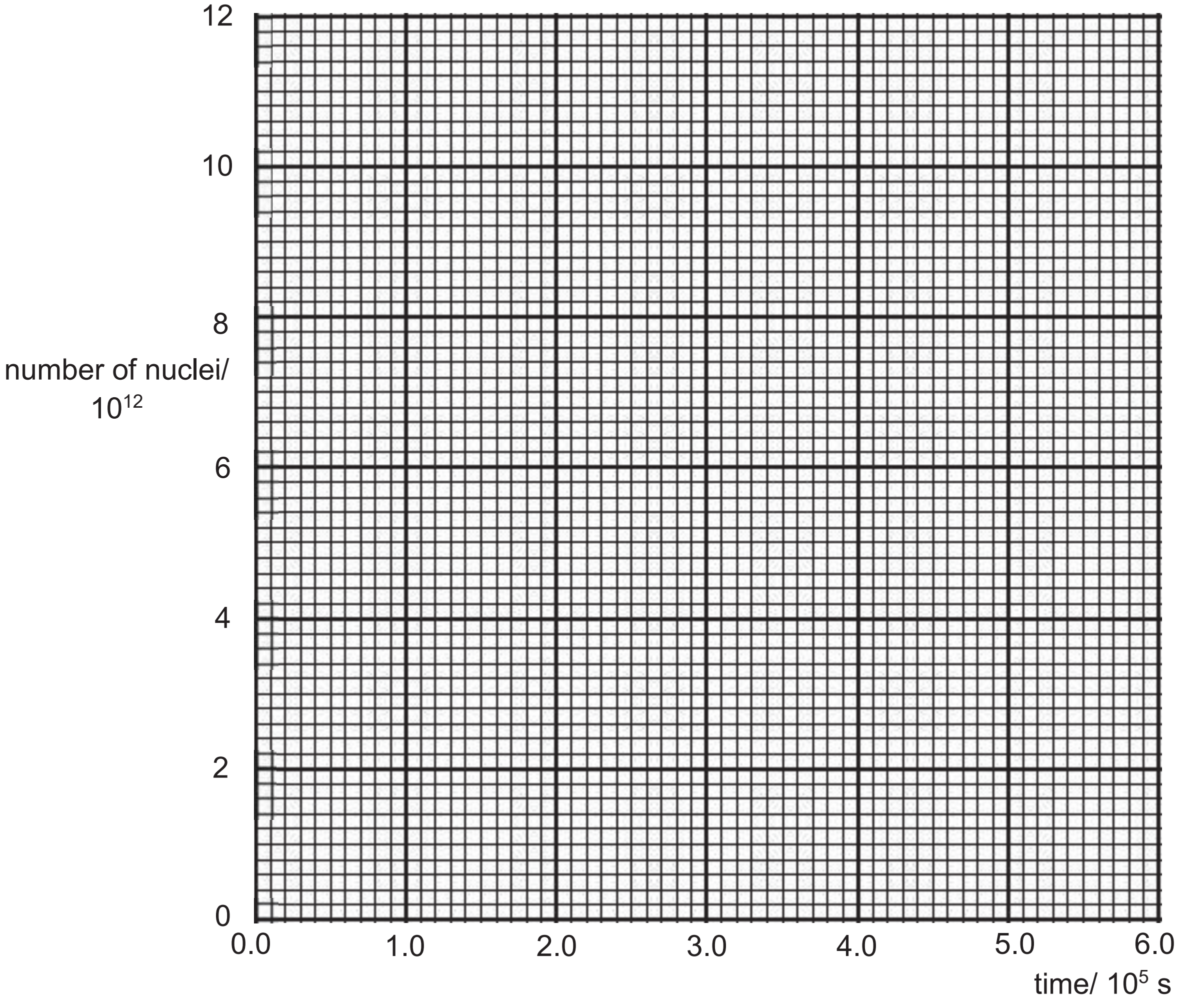


Fig. 9.2

(iv) State and explain, without calculation, how the rate of decay of ${}^{239}_{93}Np$ nuclei varies with time.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(v) Explain why the number of ${}^{239}_{93}Np$ nuclei present eventually becomes constant.

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

9 (b) (vi) Calculate this constant number of ${}^{239}_{93}Np$ nuclei given that the half-life of ${}^{239}_{93}Np$ is 2.04×10^5 s.

constant no. of ${}^{239}_{93}Np$ nuclei = ……………………….. [3]

(vii) On Fig. 9.2, sketch a graph to show how the number of ${}^{239}_{93}Np$ nuclei present varies with time. Label this graph **Y**. [1]

(viii) Assuming that ${}^{239}_{94}Pu$ is stable, determine the rate of production of ${}^{239}_{94}Pu$ when the number of ${}^{239}_{93}Np$ nuclei reaches a constant value.

rate of production of ${}^{239}_{94}Pu$ = ……………………….. s^{-1} [1]

(ix) On Fig. 9.2, sketch a graph to show how the number of ${}^{239}_{94}Pu$ varies with time assuming that ${}^{239}_{94}Pu$ is stable. Label this graph **Z**. [1]

(x) ${}^{239}_{94}Pu$ is in fact radioactive with a half-life of 7.58×10^{11} s. Determine, with a suitable calculation, whether this instability has any significant effect on the shape of graph **Z** in **(ix)**.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

9 **(b)** **(xi)** A stationary $^{239}_{94}Pu$ nucleus undergoes radioactive decay to give an alpha particle and a $^{235}_{92}U$ nucleus. The energy released in the decay is 5.16 MeV. Determine the velocity of the alpha particle immediately after the decay.

velocity of α particle = ……………………….. m s^{-1} [3]

END OF PAPER

H

NATIONAL JUNIOR COLLEGE
Preliminary Practical Examination
Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/04**
Paper 4 Practical Test **15 August 2017**
Candidate answers on the Question Paper. **2.5 hours**

No Additional Materials are required.

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

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

For Examiner's Use	
1	**/ 15**
2	**/ 8**
3	**/ 20**
4	**/ 12**
Total (55m)	

This document contains 13 printed pages, including this cover page.

1 When an object falls in air, it experiences a drag force which opposes the motion of the object. Larger objects experience greater drag forces. In this experiment, you will investigate how the terminal velocity of a paper cone falling in air depends on the diameter of the cone.

(a) Cut a sector out of a piece of filter paper as shown in Fig. 1.1.

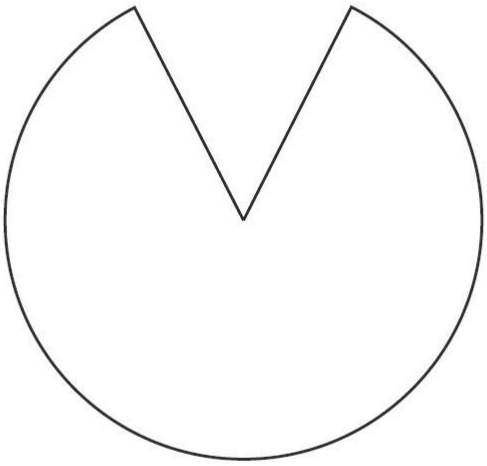


Fig 1.1

(b) (i) Tape the straight edges of the paper together to produce a cone, as shown in Fig. 1.2.

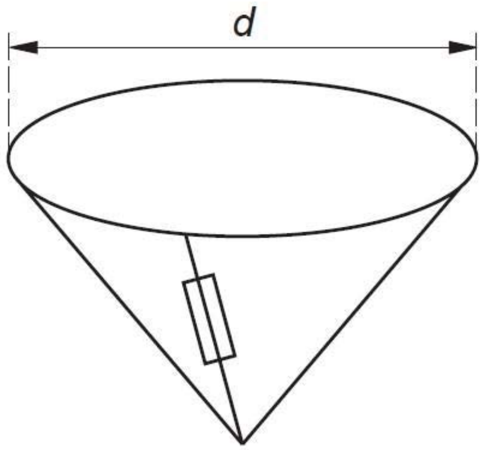


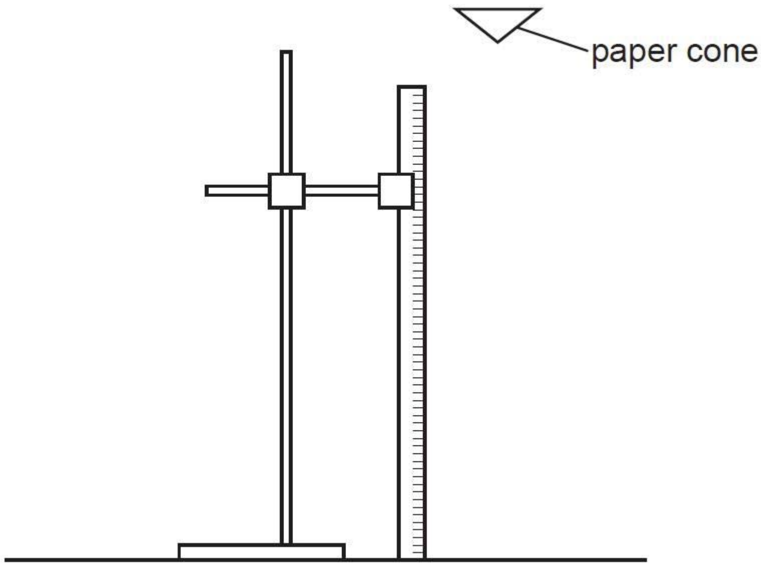
Fig. 1.2

(ii) Measure and record the diameter *d* of the cone.

d = ...[1]

(c) **(i)** Mount a metre rule vertically using a stand, boss and clamp.

(ii) Release the cone from a short distance above the top of the metre rule, as shown in Fig. 2.3.



Make and record measurements to determine the time t for the cone to fall through a distance h from the top of the metre rule.

h = ...

t = ...
[2]

(d) Estimate the percentage uncertainty in t, showing your working.

percentage uncertainty in t = ...[2]

(e) Calculate the terminal velocity v of the cone.

v = ...[2]

(f) **(i)** Remove the tape from the paper and cut away a larger sector as shown in Fig. 1.4.

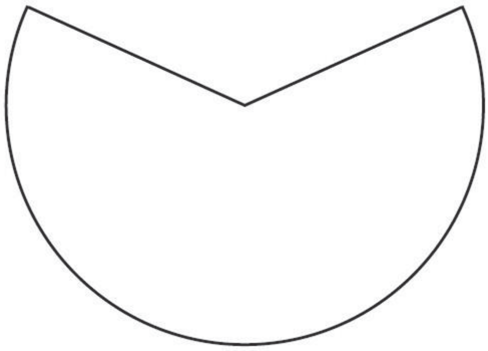


Fig. 1.4

(ii) Repeat **(b)**, **(c)(ii)** and **(e)**, recording your results below.

d = ...

h = ...

t = ...

v = ...

[2]

(g) It is suggested that v is inversely proportional to d. Do the results of your experiment support this suggestion? State and explain your reasoning clearly.

....

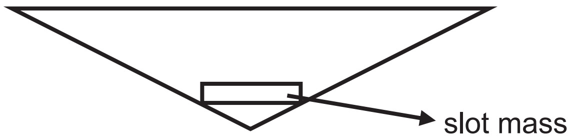
....

....

....

[4]

(h) In parachute making, it is also necessary to take into account the mass of the parachutist. Suggest changes to the paper cone experiment described above to study how a mass can affect the terminal velocity of the paper cone.



....

....

....

....

....

....

[2]

[Total: 15 marks]

2 This investigation considers the amount of charge flowing through a resistor.

(a) **(i)** Set up the circuit shown in Fig. 2.1, taking care to connect component Y the right way round.

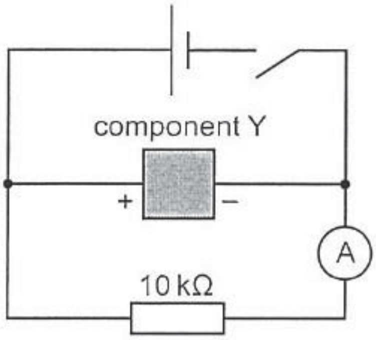


Fig. 2.1

(ii) Close the switch and wait about 10 s . Record the reading I on the ammeter.

I = ... [1]

(b) When the switch is opened, the current in the resistor gradually decreases to zero.

(i) Open the switch and start the stopwatch.

(ii) While the current is decreasing, record at least five readings of I and the time elapsed t up to a value of t = 50 s. You may need several attempts before you have a satisfactory set of results. You will need this set of readings to plot a graph in 2(c).

[2]

(iii) State two problems that arose in taking the readings.

1 ....

....

2 ....

.... [2]

(c) Plot your values from **(b)(ii)** on Fig. 2.2. The graph obtained should be a curve.

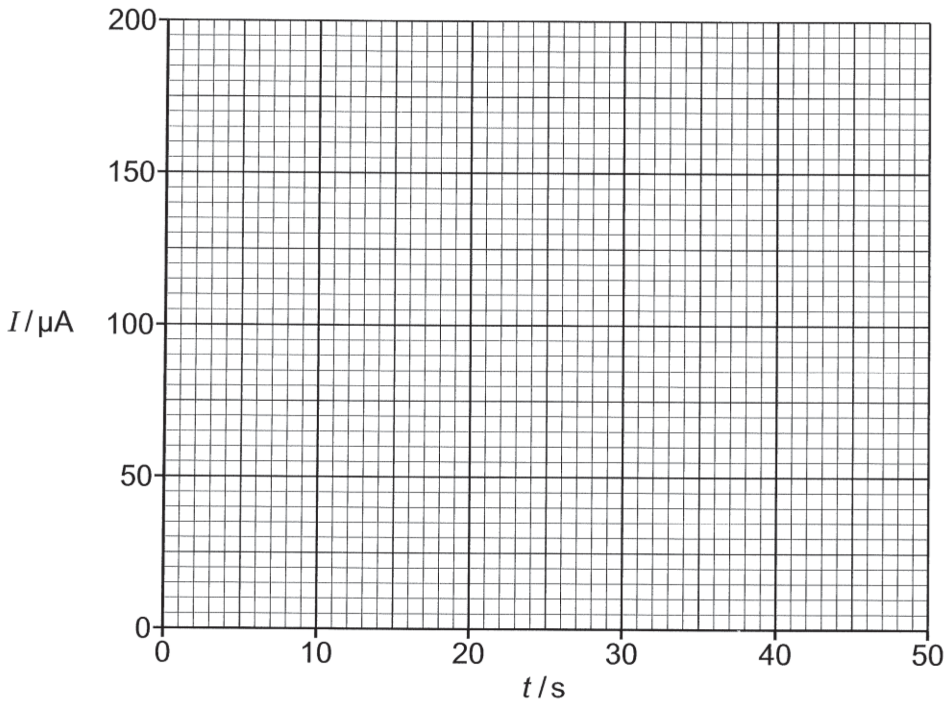


Fig. 2.2

[2]

(d) The area under the graph represents the charge Q that has flowed through the resistor during the 50 s. Estimate this charge.

Q = ... [1]

[Total: 8 marks]

3 In this experiment, you will investigate the motion of a system of masses.

(a) Set up the apparatus as shown in Fig. 1.1, with the shorter length of string above the central loop and the longer length of string below the central loop.
Place four slotted masses in the bottom loop and four slotted masses in the central loop.

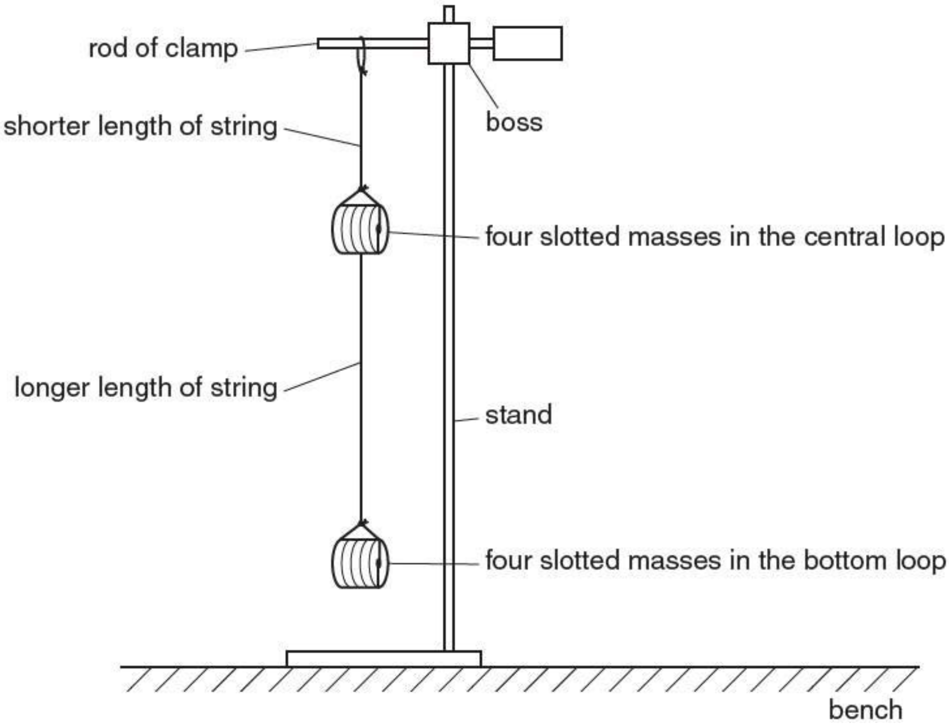


Fig 3.1

(b) Move the slotted masses in the bottom loop to the left.
Release the slotted masses and watch the movement.
The slotted masses will move to the right and then to the left again, completing a swing as shown in Fig. 3.2.

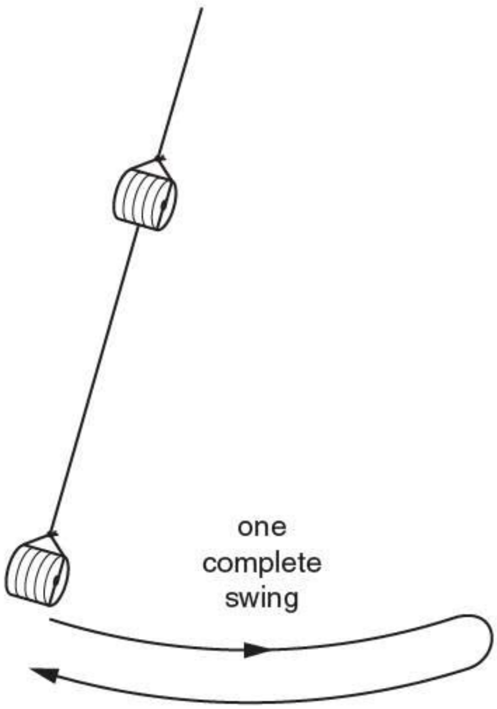


Fig 3.2

(c) Make and record measurements so that the period T of these oscillations may be determined.

T = ... [2]

(d) Change the number of slotted masses in each loop. Use **all** the eight slotted masses.

(i) Count and record the number B of slotted masses in the bottom loop.

B = ...

(ii) Count and record the number C of slotted masses in the central loop.

C = ...

(iii) Repeat **(b)**.

T = ...

(e) Repeat **(d)** until you have six sets of values of *B*, *C* and *T*. Include your results from **(c)** and **(d)**.

For each set of values, use all eight slotted masses.

[7]

(f) The quantities *T*, *B* and *C* are related by the equation

$$\frac{T^2}{B} = \frac{FC}{B} + G$$

where *F* and *G* are constants.

By plotting a suitable graph, determine the values of *F* and *G.*

F = ...

G = ...
[4]

[3]

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

………

………

………**[1]**

(h) **(i)** State two significant error or limitation of the procedure in the experiment.

………

………

………

………

………**[2]**

(ii) Suggest an improvement that could be made to the experiment to address the error/limitation in **h**(**i**). You may suggest the use of other apparatus or different procedures.

………

………

………**[1]**

[Total: 20]

4 A hot air balloon is tied to the ground using a rope. As the wind blows with speed v, the rope makes an angle θ to the horizontal, as shown in Fig 4.1.

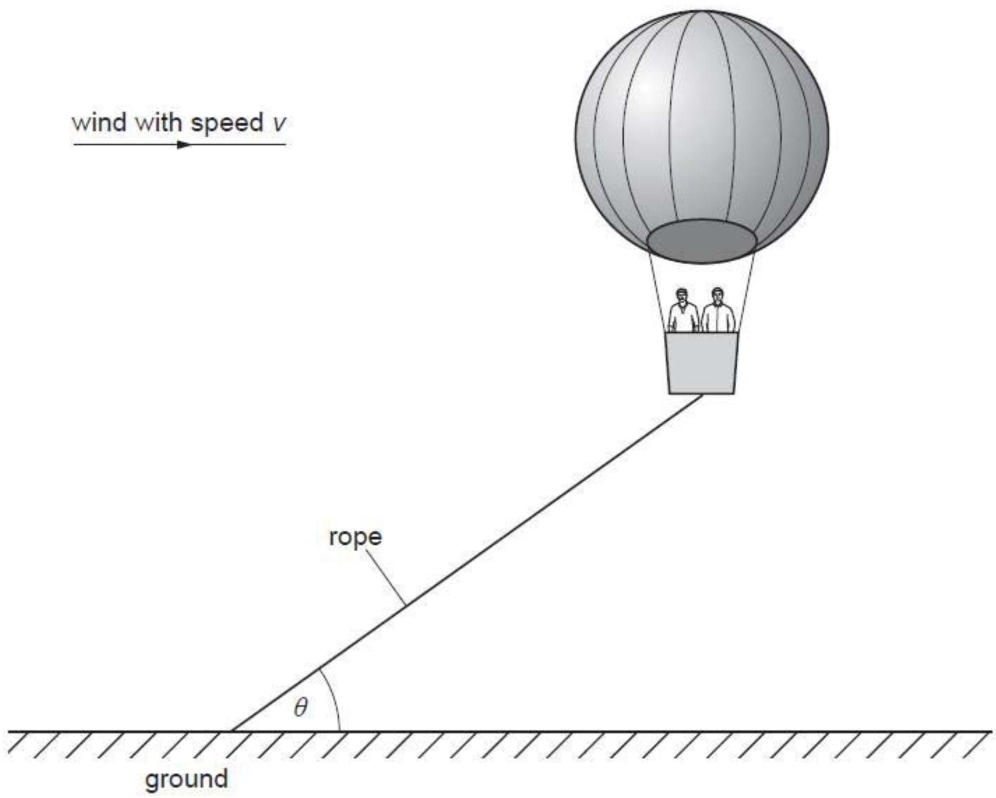


Fig 4.1

It is suggested that

$$\tan\theta = \frac{k}{v^2}$$

where k is a constant.

To model the hot air balloon in the laboratory, a balloon filled with helium is used. You may also use any of the other equipment usually found in a physics laboratory.

Design a laboratory experiment using a small helium-filled balloon to test the relationship between θ and v, and to determine a value for k.

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

(a) the equipment you would use,
(b) the procedure to be followed,
(b) how the speed of the wind and angle are measured,
(c) the control of variables,
(d) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

…… [12]

Apparatus List (Student)

Q1

1 Retort Stand with boss and clamp

2 Metre rule

3 Circular piece of filter paper

4 Scissors

5 Stopwatch

6 Sellotape

Q2

1 1.5 V dry cell in holder

2 Component Y

3 10 kΩ resistor

4 Six connecting leads

5 Stopwatch

6 Digital Multimeter

7 Switch

Q3

1 Retort Stand with boss and clamp

2 Metre rule

3 String (see diagram)

4 Eight 10 g slotted mass

5 Stopwatch

Apparatus List

Q1

1 Retort Stand with boss and clamp

2 Metre rule

3 Circular piece of filter paper

4 Scissors

5 Stopwatch

6 Sellotape

Q2

1 1.5 V dry cell in a holder.

2 1000 μF capacitor. The capacitor should be covered in masking tape so that candidates cannot see any details printed on it. It should be labelled "**component Y**" and the polarity of the connections should be indicated with a "**+**" and a "**–**".

3 10 kΩ resistor.

4 Six connecting leads.

5 Stopwatch reading to 0.1 s or better.

6 Digital multimeter set on the 200 μA range.

7 Switch.

Q3

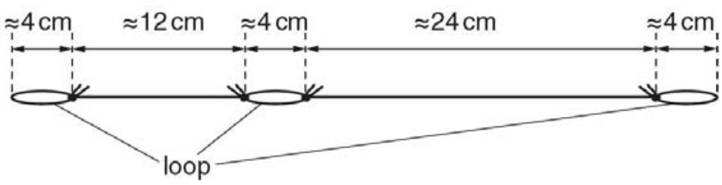
1 Retort Stand with boss and clamp

2 Metre rule

3 String (see diagram)

4 Eight 10 g slotted mass

5 Stopwatch



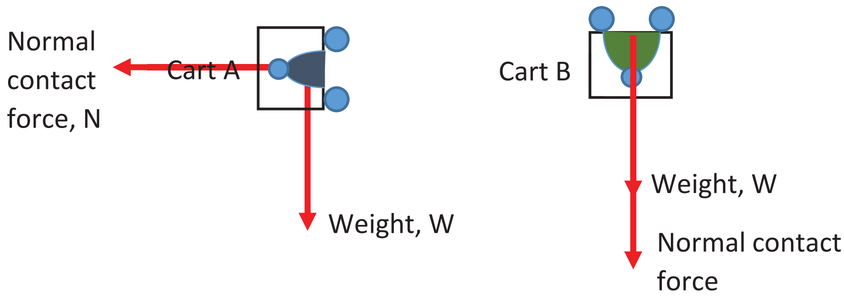
Each loop should be big enough to accommodate the eight slotted masses.

2017 NJC H2Phy Prelim Paper 1 Answer Key

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

2017 NJC H2Phy Prelim Paper 2 Mark Scheme

1	a)	i)		Speed is the rate of change of distance travelled of an object with time.	1
		ii)		Speed is a scalar and it is only the magnitude of velocity. Velocity is a vector and it has magnitude and a stated direction.	1 1
	b)	i)	1)	$v^2 = u^2 + 2as$ $0 = u^2 + 2 \times (-0.85 \times 9.81) \times 12.8$ $v = 14.6$ m s^{-1}	2
			2)	s = ut 29.3 = 14.6 t t = 2.01 s	 1 1
		ii)		60 km h^{-1} = 16.7 m s^{-1} or 14.6 m s^{-1} = 53 km h^{-1} Thus he is driving within speed limit. The driver's reaction time is too slow as compared to average human reaction time about 0.2 - 0.4 s.	1 1 1
2	a)	i)		- Weight, tension, reaction force - All 3 forces intersecting	2
		ii)		Using the principle of moments and choosing A as the pivot, Anticlockwise moment of tension = clockwise moment of weight of rod $T \times 0.50 = W cos30° \times 0.25$ $T \times 0.50 = 1.5 \times 9.81 \times cos30° \times 0.25$ $T = 6.4\ N$	2
		iii)		Resultant force is zero hence horizontal component of reaction force is equal to horizontal component of tension. Horizontal component of reaction force = $6.4\ sin30° = 3.2\ N$ to the left Resultant force is zero hence Vertical component of reaction force + vertical component of tension = weight Vertical component of reaction force = $1.5 \times 9.81 - 6.4\ cos30° = 9.17N$ upwards Reaction force = $\sqrt{3.2^2 + 9.17^2} = 9.7N$ $tan\theta = \frac{9.17}{3.2} \rightarrow \theta = 71°$ Direction: 71° clockwise above the horizontal	1 1 1 1
	b)			The clockwise moment provided by weight remains unchanged.	1

				For the rod to be in equilibrium, the net moment must zero. Since the perpendicular distance between tension and the pivot A is reduced when the tension is along YB, the tension must increase.	 1
3	a)	i)			1 1
	b)	i)	1)	$a_c = v^2 / r$ $= 12^2 / 7 = 20.6$ m s^{-2}	 1
			2)	$F_{net} = ma$ W + N = ma 60(9.81) + N = 60(20.6) N = 646 N	 1 1
		ii)		(KE + GPE) at top = KE at bottom ½ m $(12)^2$ + mg(14) = ½ m v^2 v = 20.5 m s^{-1}	1 1
	c)			If the velocity decreases, the required centripetal force decreases as well. This would reduce the normal contact force at the top since weight cannot be reduced. The passenger would fall off the cart if contact force is reduced to zero.	1 1 1
4	(a)			The acceleration, a, of the mass is given by $a = \frac{F}{m} = -\frac{4}{3}\pi G\rho x$. Since $\frac{4}{3}\pi G\rho$ is a constant, the acceleration of the mass is directly proportional to its displacement, *x* and the negative sign shows that the acceleration is directed in the opposite direction to displacement *x*. Therefore, the motion of the mass is simple harmonic.	2
	(b)	(i)		Comparing $a = -\frac{4}{3}\pi G\rho x$ with $a = -\omega^2 x$, $\omega^2 = \frac{4}{3}\pi G\rho = \frac{4}{3}\pi \times 6.67 \times 10^{-11} \times 5460 = 1.53 \times 10^{-6}$ $T = \frac{2\pi}{\omega} = 5085 \approx 5100$ s (shown)	2
		(ii)		Maximum speed, $v = \omega x_0 = \left(\frac{2\pi}{5100}\right) \times 6.4 \times 10^6 = 7900$ ms^{-1}	2
	(c)			Maximum change in gravitational potential energy = maximum change in kinetic energy of the oscillating mass	2

			$= \frac{1}{2}mv_{max}^2 - 0 = \frac{1}{2}(1)(7900)^2 = 3.1 \times 10^7$ J (shown)	
	(d)		The average gravitational force acting on the oscillating mass is half that of the gravitational force acting on the mass at the surface of the Earth. Since the change in gravitational potential energy is equal to the work done by gravitational force on the mass, the work done is exactly half that of the gravitational potential energy at the surface.	2
5	a)		The electric field strength at a point in an electric field is the electric force per unit positive charge acting on a small positive test charge placed at that point.	1
	b)	i)	Potential difference is zero because $E = \frac{\Delta V}{x}$ and E is zero between $x = 0$ and $x = 1.4\ cm$, hence ΔV must be zero in this region.	2
		ii)	Neutral point is at x = 8 cm $\frac{Q_A}{4\pi\varepsilon_0(8)^2} = \frac{Q_B}{4\pi\varepsilon_0(12-8)^2}$ $\frac{Q_A}{Q_B} = 2^2 = 4$	2
	c)	i)	Both A and B are positively charged. The electric potential increases from 8.0 cm to the surface of sphere B. Hence, electric potential energy increases for the proton.	1 1
		ii)	Potential difference = area under the graph About 75 small squares (each small square is $5 \times 10^6 \times 0.2 \times 10^{-2} = 10\ kV$) Potential difference = 750 kV Change in potential energy = $qV = 1.6 \times 10^{-19} \times 750\ kV = 1.2 \times 10^{16} J$	 1 1
		iii)	The proton will move back and forth around x = 8.0 cm.	1
6	a)	i)	speed of wave, transverse, can be polarized, does not require a medium to propagate,…	1
		ii)	0.01 nm to 10 nm	1
	b)	i)	wavelength = 2 x 75 cm = 150 cm v = f□ = 360 x 1.50 = 540 m s^{-1}	1 1
		ii)	When the string is plucked, it sent a wave traveling in the string. This wave hits the fixed end, gets reflected, and superpose with itself to form the stationary wave. This wave mentioned, travels at a speed that was calculated in (b)(i).	1 1 1

	c)			v = fλ 330 = 360 x λ λ = 0.92 m since it is the fundamental mode, the length of the air column = ¼ λ = 0.23 m	1 1
7	a)			Cell-phone battery, chips on credit cards, portable charger (small, thin objects which is not use in a moist/ wet environment)	1
	b)			Current density is the current the lithium cell can provide per unit area of the lithium cell. Energy density is the total energy stored in the lithium cell per unit mass of the lithium cell.	1 1
	c)	i)		$3.6 \times 50 = 180\ C$	1
		ii)		$0.15 \times 50 = 7.5\ mA$	1
		iii)		$I = \frac{Q}{t}$ $t = \frac{Q}{I} = \frac{180}{7.5 \times 10^{-3}}$ $= 24000\ s$ [1]	 1 1
		iv)		$P = IV = 2.5 \times 7.5 \times 10^{-3} = 0.01875W$ $E = Pt = 0.01875 \times 24000 = 450J$	1 1
		v)		$m = \frac{450}{120 \times 60 \times 60} \times 1 = 1.04g$	1
	d)	i)		Average current = area / total time = (7.5+20+12.5)/5=8 mA (highly overestimate, more than 10 mA or underestimate, less than 6 mA will have marks deducted)	1 1
		ii)		$P = IV = 8 \times 10^{-3} \times 3.4 = 0.0272W$ $E = Pt = 0.0272 \times 5 \times 60 \times 60 = 490\ J$	1 1
	e)			Efficiency $= \frac{energy\ during\ charging}{energy\ during\ discharing} \times 100\%$ $= \frac{450}{490} \times 100\% = 92\%$ (ratio is also accepted)	1 1
	f)			Short circuit will lead to a large current which will cause the cell to overheat and it might spoil or even catch fire At high temperatures, the plastic film might melt and as a result charges can flow between the electrodes causing a large current which is dangerous. Water might short circuit the cell. Water is usually not pure water and so can act as a conductor. (Any 2 reasonable answers)	 2
	g)			Show 4 cells in series. Each cell will produce 2.5 V so total is 10 V. State area is 2000 cm^2 to get 300 mA.	1 1

2017 NJC H2Phy Prelim Paper 3 Mark Scheme

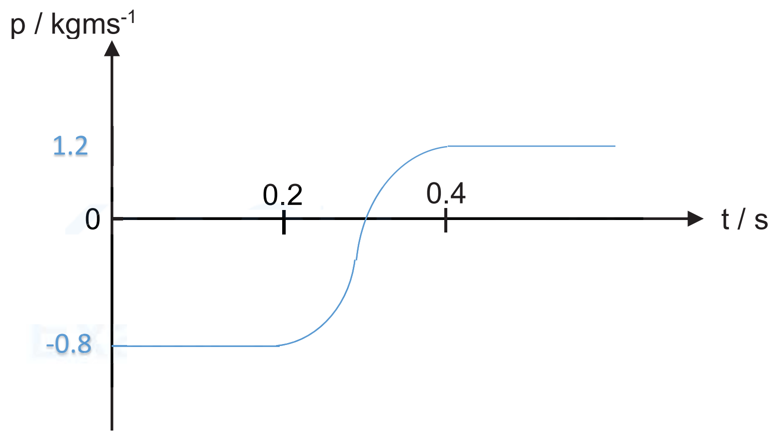
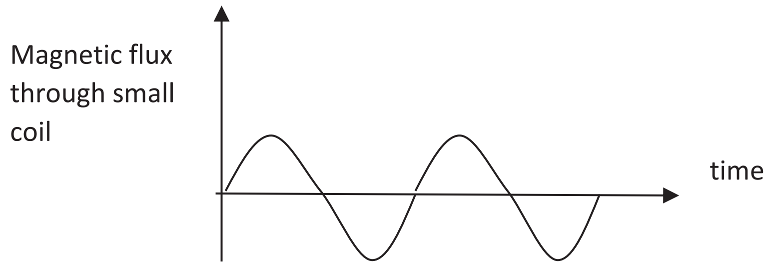
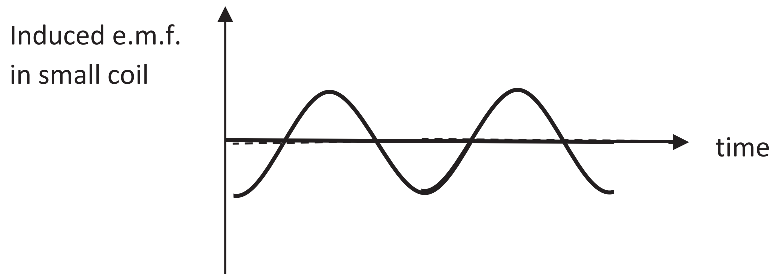
1	a)	i)		Mass and temperature	1
		ii)		Base units of the constant c $= \dfrac{\text{base units of energy}}{\text{(units of mass)(units of temperature)}}$ $= \dfrac{\text{kg m}^2\text{ s}^{-2}}{\text{(Kg) (K)}}$ $= \text{m}^2\text{ s}^{-2}\text{ K}^{-1}$	1 1
	b)			$Q=mc(\theta_f-\theta_i)$ $Pt=mc(\theta_f-\theta_i)$ $c=\dfrac{(1000)(180)}{(1.5)(84.0-27.0)}=2105$ $(\theta_f-\theta_i)=57\text{K}$, $\Delta\theta=0.5+0.5=1\text{K}$ $\Delta c=(\dfrac{10}{1000}+\dfrac{5}{180}+\dfrac{0.1}{1.5}+\dfrac{1}{57})(2105)=256.7=300$ C = 2100±300 $\text{m}^2\text{ s}^{-2}\text{ K}^{-1}$	1 1 1
2	a)	i)		The area under the force-time graph gives impulse $\frac{1}{2}(0.4-0.2)F_{max}=2 \rightarrow 20\ N$	1
		ii)		Final momentum of ball X = initial momentum + impulse [1] $= 0.16\times 10-2=-0.4\ kgms^{-1}$ Velocity of ball X = $-\frac{0.4}{0.16}=-2.5\ ms^{-1}$ (to the left) either correct sign or direction given Final momentum of ball Y = initial momentum + impulse $= 0.16\times(-5)+2=1.2kgms^{-1}$ Velocity of ball Y = $\frac{1.2}{0.16}=7.5ms^{-1}$ (to the right)	1 1
		iii)		The initial total kinetic energy of the balls is 10 J while the final total kinetic energy of the balls is 5J. Hence <u>there is a loss of kinetic energy</u>. The collision is inelastic.	2
		iv)		 	2

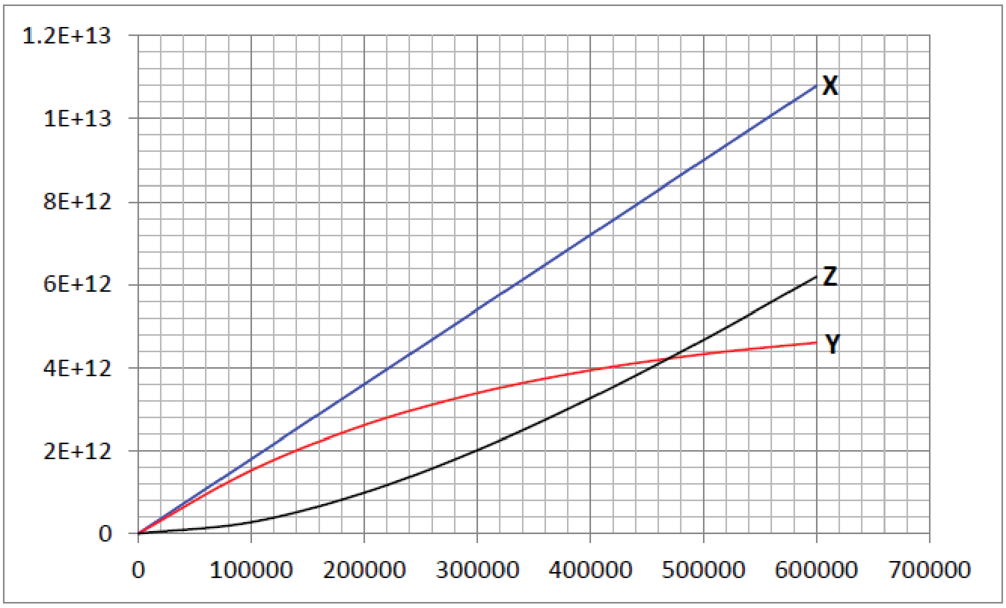
				Fig. 2.3 Before and after collision – straight line and correct values [1] Correct curve during collision, show that force/gradient reaches a maximum value in the center [1]	
		v)		If the kinetic energy is fully converted, the total kinetic energy is zero which implies both balls are stationary at the same time. [1] The initial total momentum of the balls is non zero (0.8 $kgms^{-1}$) [1] By the principle of conservation of linear momentum, it is not possible for both balls to be stationary as the total momentum would be zero and linear momentum would not be conserved. [1]	3
3	a)			Gravitational force per unit mass acting on a point mass placed at a point in the gravitational field.	1
	b)			Arrow pointing towards the centre of the planet	1
	c)			$\frac{GM}{(2.0 \times 10^7)^2} = 40$ M = 2.40 x 10^{26} kg	1 1
	d)			$-\frac{GMm}{5R} - \left(-\frac{GMm}{4R}\right) = \frac{GMm}{R}\left(\frac{1}{4} - \frac{1}{5}\right)$ = 40 x 2 x 10^7 x 3000 x 0.05 = 1.2 x 10^{11} J	1 1
	e)			Gravitation force provides the centripetal force $F_G = F_C$ $\frac{GMm}{(5R)^2} = m(5R)\omega^2$ $\omega = \sqrt{\frac{GM}{(5R)^3}}$ = 1.265 x 10^{-4} T = 49,700 s	1 1
	f)			The orbit of S will be elliptical because the (resultant) gravitational force acting on S from C and O, will not be equal to the centripetal force acting on S. The resultant force will points in the direction towards a non-fixed point along the line joining C and O	1 1
4	a)			Between X and Y, you have R_1, R_3 and (R_2 +R_4) in parallel. The effective resistance is $(\frac{1}{R} + \frac{1}{R} + \frac{1}{2R})^{-1} = 0.4R$ $R = \frac{2.4}{0.4} = 6.0\Omega$	1
	b)	i)		Total resistance = $2.4 + 0.6 = 3.0\Omega$ Current in A_1 = $\frac{E}{R} = \frac{1.5}{3.0} = 0.50A$	1
		ii)		Potential difference between X and Y = $\frac{2.4}{3.0} \times 1.5 = 1.2V$ Current through resistor R_1= $\frac{V}{R} = \frac{1.2}{6.0} = 0.20A$ Using Kirchoff's current law, current in A_2 = $0.50 - 0.20 = 0.30\ A$	1 1

		iii)		Potential difference across R_4 = $\frac{6.0}{6.0+6.0} \times 1.2 = 0.6V$ Potential at Z = $0 - 0.6 = -0.6V$	1 1
		iv)	1.	As reading is zero, the potential difference across S is 0.6 V. The potential difference across S = $\frac{S}{S+0.60} \times 1.5 = 0.6$ V Hence S = 0.4 Ω	1 1
			2.	The potential difference across S will be higher. As this potential difference is larger than that of the potential difference across X and Y, a (negative) reading will be registered on the galvanometer.	1
5	a)	i)		Tesla is the unit of magnetic flux density. One tesla is the magnetic flux density if a force of 1 N acts on a wire of length 1 m, carrying a current of 1 A placed perpendicular to the magnetic field.	1
		ii)		Resultant force = BIL = (0.530)(2.50)(0.046) =0.06095 = 6.10×10^{-2} N	 1 1
	b)	i)		Draw a magnetic field line parallel to line SR.	1
		ii)		Using the Principle of Moments and taking moments about AB, $Clockwise\ \ Moments = Anticlockwise\ \ Moments$ $F_B(L_{SB}) = W(L_{BR})$ $(BIL_{PS})(L_{SB}) = mgL_{BR}$ $(0.40)(I)(0.060)(0.6SR) = (0.300)(9.81)(0.4SR)$ $I = 81.75A$ $E = IR_T$ $2.0 = (81.75)(r + 0.002)$ $r = 0.0225\Omega$	1 1 1

6	a)				1 1
	b)			Magnetic flux through the small coil is proportional to the magnetic flux density generated by the large coil which is proportional to the alternating current in the large coil. Hence the magnetic flux-time graph through the small coil has the same shape as that of the current-time graph for the large coil. Induced e.m.f. in the small coil is directly proportional to the rate of change of magnetic flux linkage which is obtained from the negative of the slope of the magnetic flux- time graph.	1 1
	c)	i)		When the planes of the two coils are at 90° to each other, the magnetic field due to the current in the large coil is parallel to the plane of the small coil. Hence there is no magnetic flux linkage with the small coil and no e.m.f. will be induced in the small coil. The trace on the c.r.o. will show the amplitude of the induced e.m.f. reduced to zero. A horizontal line will be seen on the screen.	1 1
		ii)		When the frequency of the alternating current in the large coil is increased, the frequency of the alternating emf in small coil will also increase and hence the period will reduce. The rate of change of flux linkage in the small coil is faster now and hence the induced emf in the small coil will increase. The trace on the c.r.o. will show number of cycles increased and induced emf with larger amplitude.	1 1
7	a)			Wave theory suggest that it will take a while for electron to gather enough energy to be liberated; but this observation shows that electrons are emitted immediately.	1

				This also mean that once the electron gather enough energy, it will definitely be liberated; but this observation shows that sometime, photoelectron is not emitted at all.	1
	b)	i)		The larger the wavelength, the lower the frequency, thus the lower the energy, since E=hf . If the energy of the photon (650 nm) with frequency smaller than the threshold frequency, no photoelectron will be emitted. Therefore no value recorded for max KE.	1 1
		ii)		$hc / \lambda = \varphi + E_{MAX}$ $(6.63 \times 10^{-34} \times 3.0 \times 10^{8}) / (240 \times 10^{-9}) = \varphi + 4.44 \times 10^{-19}$ $\varphi = 3.8 \times 10^{-19}$ J	1 1
	c)	i)		Wavelength of the radiation is reduced, so the frequency is increased, thus the photon's energy, that is total energy, increases. Work function being constant, this will result in higher KE.	1 1
		ii)		Total energy per photon increase, but for intensity remain constant, number of photon per unit time must have decreased. This will result in less photoelectron per unit time, thus current decreased.	1 1
8	(a)	(i)	1.	Initial rate of temperature rise = gradient of the tangent to t = 0. Acceptable values: 8 to 16 °C min^{-1}	
			2.	From Q = Pt = mc$\Delta\theta$ $P = mc\frac{\Delta\theta}{t} = 64 \times 10^{-3} \times 4200 \times 8 = 2150$ J min^{-1}	
		(ii)	Rate of thermal energy supplied to the water by the heater is equal to rate of thermal energy lost to the environment.		
		(iii)	1.	Curve with the same initial gradient as the original one but lies above the original one.	
			2.	Thick ceramic cup is a better thermal insulator, hence reducing the rate of thermal energy lost to the environment resulting in the temperature of the water rising at a faster rate.	
	(b)	(i)	Mean square speed of the gas molecules.		
		(ii)	From $p = \frac{1}{3}\rho\langle c^2\rangle$ = $p = \frac{1}{3}\left(\frac{M}{V}\right)\langle c^2\rangle$ where M is the total mass of the gas & V is the volume occupied by the gas. $M\langle c^2\rangle = 3pV$		

			Since internal energy U of an ideal gas is equal to the total random kinetic energy of the gas molecules which is $= \frac{1}{2}M\langle c^2\rangle$, we have $U = \frac{1}{2}M\langle c^2\rangle = \frac{3}{2}pV$	
		(iii)	$U = \frac{3}{2}(100 \times 10^3)(3.4 \times 10^{-4}) = 51$ J	
	(c)	(i)	From $pV = NkT$, $N = \frac{pV}{kT} = \frac{250\times10^3\times7.5\times10^{-3}}{1.38\times10^{-23}\times623} = 2.18 \times 10^{23}$	
		(ii)	From $pV = NkT$, V$= \frac{NkT}{p} = \frac{2.18\times10^{23}\times1.38\times10^{-23}\times50}{101\times10^3} = 1.49 \times 10^{-3}$ m^3	
		(iii)	$\Delta U = \frac{3}{2}p_cV_c - \frac{3}{2}p_BV_B = -911$ J	
		(iv)	Net work done $= \frac{1}{2}(7.5 - 1.49) \times 10^{-3} \times (250 - 101) \times 10^3 = 448$ J	
		(v)	Gas gains internal energy since the temperature increases and negative work is done on the gas since the volume increases. From the first law of thermodynamics, thermal energy must be taken in by the gas.	
		(vi)	No change in internal energy since the change in internal energy is state dependent and the gas returns to its initial state after one cycle. Since net work done on the gas is negative, q must be positive meaning there is net thermal energy supplied to the gas.	
9	(a)	Rest energy of the reactants = $(235.0439299 + 1.0086649)uc^2$ = $3.526\ 626 \times 10^{-8}$ J Rest mass energy of products = $(140.9144119 + 91.9261561 + 3 \times 1.0086649)uc^2$ = $3.523\ 846 \times 10^{-8}$ J Energy released = $3.526\ 626 \times 10^{-8} - 3.523\ 846 \times 10^{-8}$ = 2.78×10^{-11} J = 174 MeV			
	(b)	(i)	Decay 1: $^{239}_{92}U \rightarrow {}^{239}_{93}Np + {}^{0}_{-1}e + \overline{\upsilon}$	
		(ii)	Anti-neutrino (accept neutrino)	
		(iii), (vii) & (ix)		



		(iv)	The rate of decay increases with time because the rate of decay is proportional to the number of ${}^{239}_{93}Np$ nuclei present.	
		(v)	The number of ${}^{239}_{93}Np$ becomes constant because the rate of formation of ${}^{239}_{93}Np$ is equal to the rate of decay.	
		(vi)	Rate of decay = λN $= \left(\frac{ln2}{2.04\times10^5}\right)N$ $\left(\frac{ln2}{2.04\times10^5}\right)N = 1.80\times10^7$ N = 5.3 x 10^{12}	
		(vii)	Students are expected to be able to deduce that the number of ${}^{239}_{93}Np$ increases from zero until it reaches a steady value of 5.3 x 10^{12}	
		(viii)	Rate of production of ${}^{239}_{94}Pu$ = rate of decay of ${}^{239}_{93}Np = 1.80 \times 10^7$ s^{-1}	
		(ix)	Students are expected to deduce that the number of ${}^{239}_{94}Pu$ nuclei at any instant is equal to X minus Y.	
		(x)	Maximum rate of decay of ${}^{239}_{94}Pu \approx \frac{\ln 2}{7.58\times10^{11}}\left((10.8-5.3)\times10^{12}\right)$ = 5 s^{-1} Maximum number of nuclei decayed after 6 x 10^5s = 3 x 10^6 This number is insignificant compared to the number of ${}^{239}_{94}Pu$ present which is of the order of 10^{12} nuclei, hence insignificant effect on the shape of Z. Or fraction of ${}^{239}_{94}Pu$ nuclei remaining after t = 6 x 10^5 sec =	

			$e^{\frac{-ln2}{7.58\times10^{11}}\times6\times10^{5}}$ = 0.999,999. Hence the ${}^{239}_{94}Pu$ nuclei are approximately stable within the time frame of 6 x 10^5 seconds (since this duration is much smaller than the half life of ${}^{239}_{94}Pu$), hence no significant effect on the shape of Z.	
		(xi)	k.e. of $\alpha = \frac{235}{239} \times 5.16 \times 10^6 \times 1.6 \times 10^{-19} = 8.118 \times 10^{-13}$ velocity of $\alpha = \sqrt{\frac{2\times8.118\times10^{-13}}{4u}}$ = 1.56 x 10^7 ms^{-1}	

NATIONAL JUNIOR COLLEGE
Preliminary Practical Examination
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

PHYSICS **9749/04**
Paper 4 Practical Test **15 August 2017**
Candidate answers on the Question Paper. **2.5 hours**

No Additional Materials are required.

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

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

For Examiner's Use	
1	**/ 15**
2	**/ 8**
3	**/ 20**
4	**/ 12**
Total (55m)	

This document contains 13 printed pages, including this cover page.

1 When an object falls in air, it experiences a drag force which opposes the motion of the object. Larger objects experience greater drag forces. In this experiment, you will investigate how the terminal velocity of a paper cone falling in air depends on the diameter of the cone.

(a) Cut a sector out of a piece of filter paper as shown in Fig. 1.1.

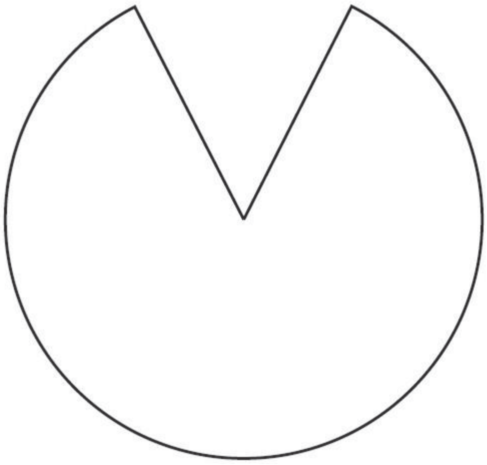


Fig 1.1

(b) **(i)** Tape the straight edges of the paper together to produce a cone, as shown in Fig. 1.2.

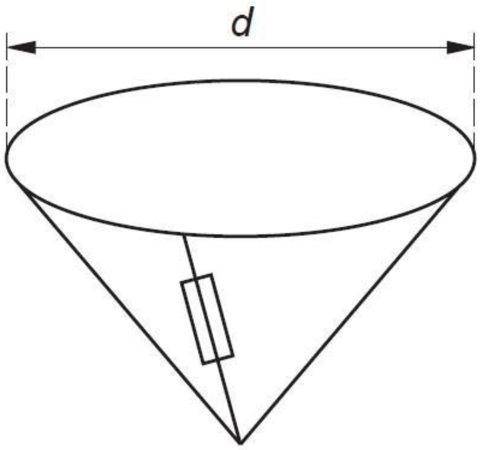


Fig. 1.2

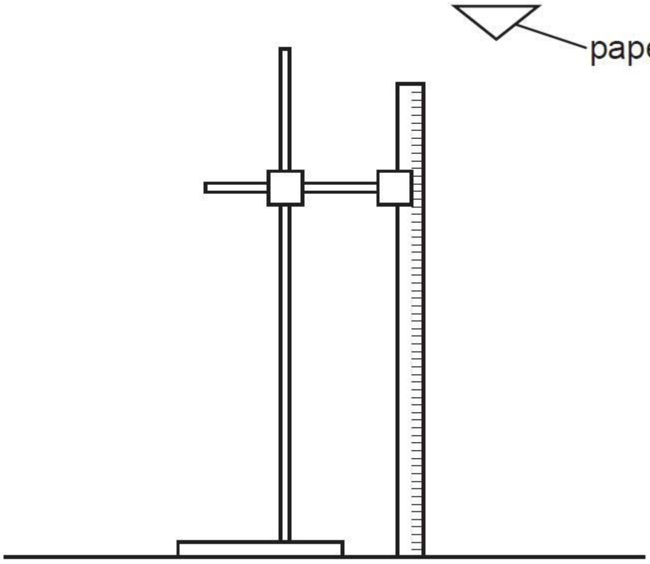
(ii) Measure and record the diameter *d* of the cone.

d = 11.0 cm ....[1]

[1m: d.p. + unit]

(c) **(i)** Mount a metre rule vertically using a stand, boss and clamp.

(ii) Release the cone from a short distance above the top of the metre rule, as shown in Fig. 2.3.



Make and record measurements to determine the time *t* for the cone to fall through a distance *h* from the top of the metre rule.

t_1 = 1.0 s
t_2 = 0.9 s
t_{ave} = 1.0 s

[1m: repeat readings]
[1m: d.p. + unit + 0.700 m ≤ h ≤ 1.000m]

h = 1.000 m

t = 1.0 s

[2]

(d) Estimate the percentage uncertainty in *t*, showing your working.

0.5/1.0 x 100% = 50 %

[1m: Δt 0.3 to 0.7 s]
[1m: 2 s.f. + unit]

percentage uncertainty in *t* = 50 % [2]

(e) Calculate the terminal velocity *v* of the cone.

$$v = \frac{h}{t} = \frac{1.000}{1.0} = 1.0 \text{ ms}^{-1}$$

[1m: correct calculation]
[1m: s.f. + unit]

v = 1.0 ms^{-1} [2]

(f) **(i)** Remove the tape from the paper and cut away a larger sector as shown in Fig. 1.4.

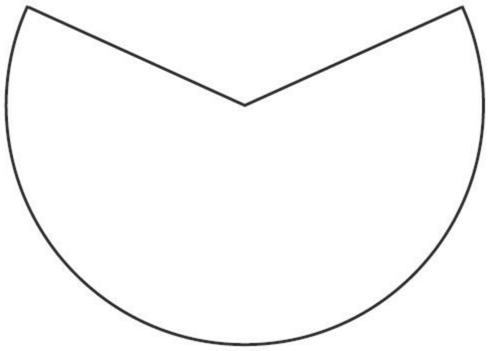


Fig. 1.4

(ii) Repeat **(b)**, **(c)(ii)** and **(e)**, recording your results below.

t_1 = 0.6 s
t_2 = 0.7 s
t_{ave} = 0.7 s

$$v = \frac{h}{t} = \frac{1.000}{0.7} = 1.4 \text{ ms}^{-1}$$

d = 9.0 cm

h = 1.000 m

t = 0.7 s

v = 1.4 ms^{-1}

[2]

[1m: correct calculation]
[1m: s.f./d.p. + unit + repeat reading]

(g) It is suggested that *v* is inversely proportional to *d*. Do the results of your experiment support this suggestion? State and explain your reasoning clearly.

If the relationship is valid, then
$v = kd^{-1}$

Thus, $k = vd$

$k_1 = (1.0)(11.0) = 11\ m^2\ s^{-1}$
$k_2 = (1.4)(9.0) = 13\ m^2\ s^{-1}$

$k_{ave} = (11 + 13)/2 = 12\ m^2\ s^{-1}$
$\Delta k = 2\ m^2\ s^{-1}$

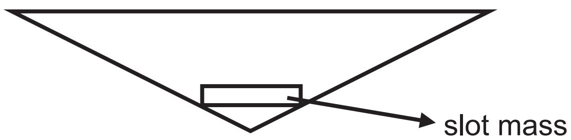
Percentage uncertainty = Δk / k_{ave} x 100% = 2/12 x 100% = 17% (2 s.f.)

[1m: correct relationship stated/used]
[1m: calculation of the proportionality constants]
[1m: percentage uncertainty.]
[1m: test against a stated criterion.]

Since the percentage error is 17%, which is less than 20%. Thus the suggested relationship is valid within the experimental error.

[4]

(h) In parachute making, it is also necessary to take into account the mass of the parachutist. Suggest changes to the paper cone experiment described above to study how a mass can affect the terminal velocity of the paper cone.



small slot mass can be added to the inverted paper cone. By varying the number of slot mass, the relationship between the attached mass and terminal velocity can be determine. It should be noted that the diameter of the cone should be kept constant.

[2]

[1m: workable experiment]
[1m: diameter should be kept constant.]

[Total: 15 marks]

2

This investigation considers the amount of charge flowing through a resistor.

(a) **(i)** Set up the circuit shown in Fig. 2.1, taking care to connect component Y the right way round.

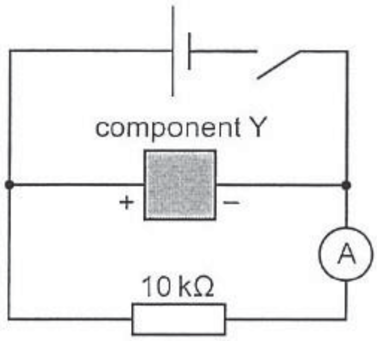


Fig. 2.1

(ii) Close the switch and wait about 10 s . Record the reading I on the ammeter.

[1m: value + unit]

I = 147.4 μA [1]

(b) When the switch is opened, the current in the resistor gradually decreases to zero.

(i) Open the switch and start the stopwatch.

(ii) While the current is decreasing, record at least five readings of I and the time elapsed t up to a value of t = 50 s. You may need several attempts before you have a satisfactory set of results. You will need this set of readings to plot a graph in 2(c).

t /s	I_1 /μA	I_2 /μA	I_{ave} /μA
10	75.1	78.5	76.8
20	44.9	46.0	45.5
30	27.4	28.0	27.7
40	16.7	17.1	16.9
50	10.2	10.7	10.5

[1m: 5 or 6 readings showing correct trend]
[1m: I to 0.1 μA and t to 0.01 s, 0.1 s or 1 s]

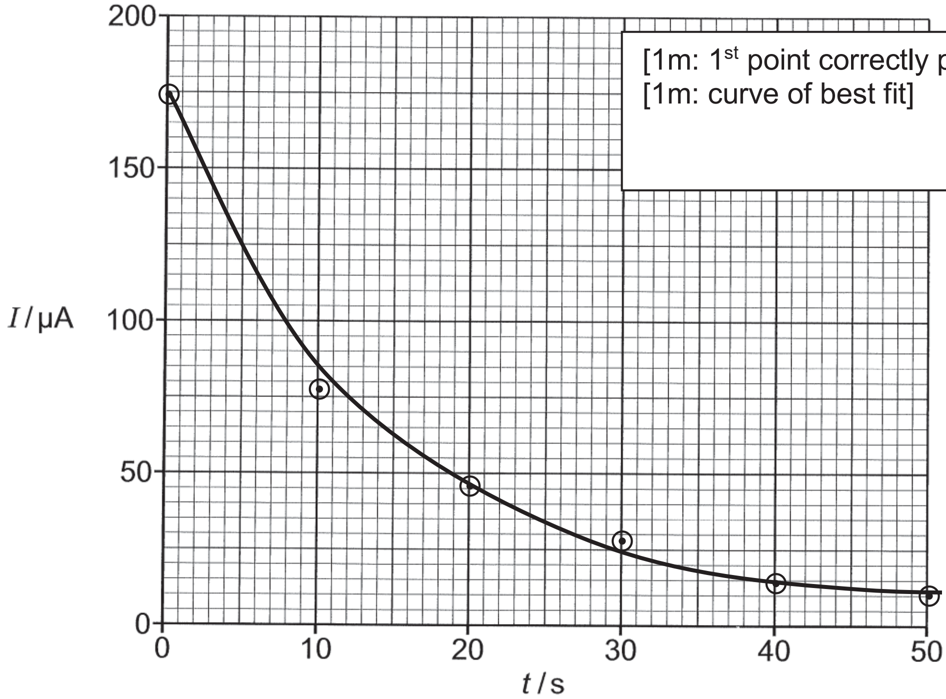
[2]

(iii) State two problems that arose in taking the readings.

1. decay is too quick.
2. difficulties in reading two instruments simultaneously.
3. when taking repeated set of readings, the initial reading of the current varies.

[2]

(c) Plot your values from **(b)(ii)** on Fig. 2.2. The graph obtained should be a curve.



[1m: 1st point correctly plotted]
[1m: curve of best fit]

Fig. 2.2

[2]

(d) The area under the graph represents the charge Q that has flowed through the resistor during the 50 s. Estimate this charge.

[1m: estimate of charge from area under the graph + unit]

Q = 2.78×10^{-3} C [1]

[Total: 8 marks]

area under graph

$$= \frac{1}{2}(175\times10^{-6}+85\times10^{-6})10 + \frac{1}{2}(85\times10^{-6}+25\times10^{-6})20 + \frac{1}{2}(25\times10^{-6}+12.5\times10^{-6})20$$

$= 2.78 \times 10^{-3}$ C

3 In this experiment, you will investigate the motion of a system of masses.

(a) Set up the apparatus as shown in Fig. 1.1, with the shorter length of string above the central loop and the longer length of string below the central loop.
Place four slotted masses in the bottom loop and four slotted masses in the central loop.

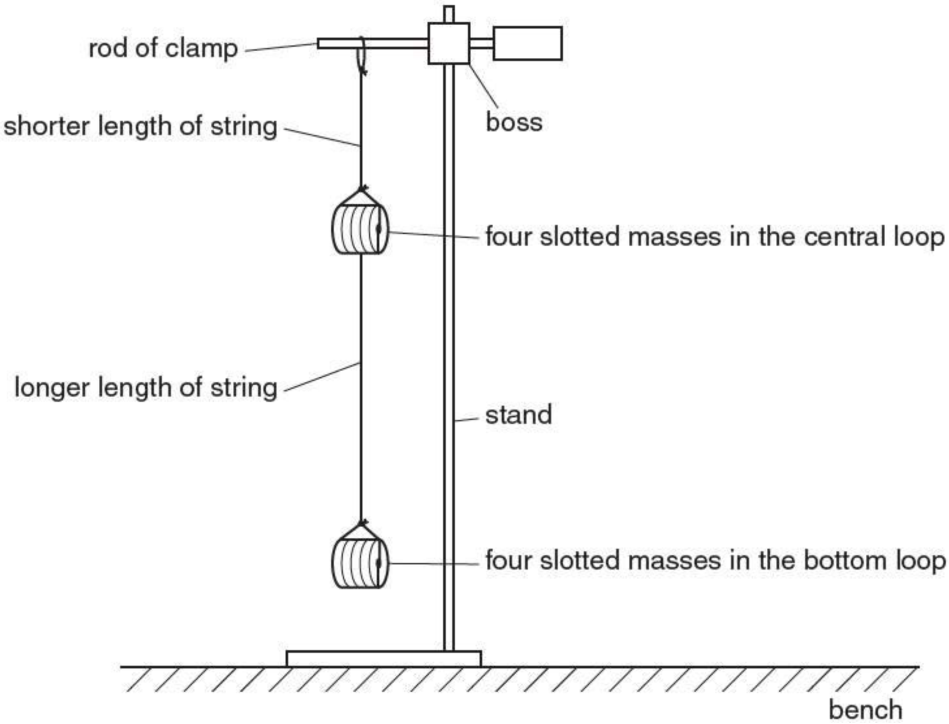


Fig 3.1

(b) Move the slotted masses in the bottom loop to the left.
Release the slotted masses and watch the movement.
The slotted masses will move to the right and then to the left again, completing a swing as shown in Fig. 3.2.

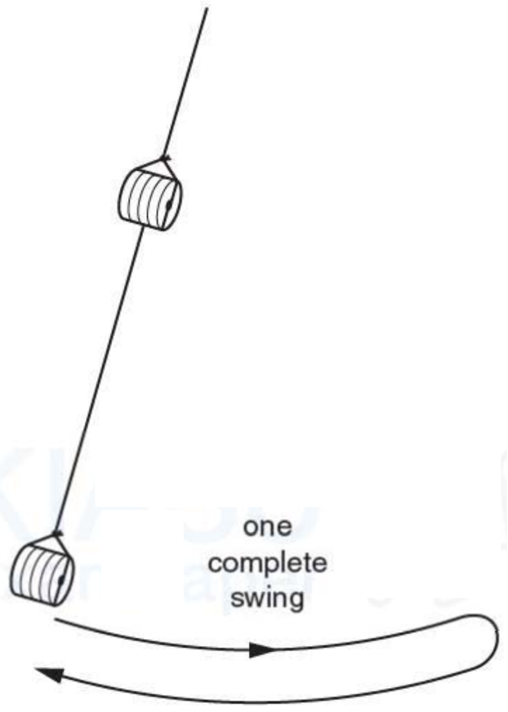


Fig 3.2

(c) Make and record measurements so that the period T of these oscillations may be determined.

t_1 = 11.9 s
t_2 = 12.0 s
t_{ave} = 12.0 s

N = 10
T = 1.20 s

[1m: repeated readings]
[1m: correct calculation + unit. Do not allow total time taken.]

T = 1.20 s [2]

(d) Change the number of slotted masses in each loop. Use **all** the eight slotted masses.

(i) Count and record the number *B* of slotted masses in the bottom loop.

B = 5

(ii) Count and record the number *C* of slotted masses in the central loop.

C = 3

(iii) Repeat **(b)**.

t_1 = 12.3 s
t_2 = 12.2 s
t_{ave} = 12.3 s

N = 10
T = 1.23 s

T = 1.23 s

(e) Repeat **(d)** until you have six sets of values of *B*, *C* and *T*. Include your results from **(c)** and **(d)**.

For each set of values, use all eight slotted masses.

N	B	C	t_1 /s	t_2 /s	t_{ave} /s	T /s	T^2 /s^2	C/B	T^2/B /s^2
10	6	2	12.4	12.5	12.5	1.25	1.55	0.33	0.258
10	5	3	12.3	12.2	12.3	1.23	1.50	0.60	0.300
10	4	4	11.9	12.0	12.0	1.20	1.43	1.0	0.357
10	3	5	11.4	11.4	11.4	1.14	1.30	1.7	0.433
10	2	6	11.1	11.0	11.1	1.10	1.22	3.0	0.611
10	1	7	10.6	10.5	10.6	1.06	1.11	7.0	1.11

2m – 6 data points w/o help
- **– 1m if 4 data points w/o help**
- **– 0m if 3 or less data points w/o help**
- **– deduct 1m if help required**
- **– deduct 2m if help required extensively**
- **– deduct 1m if wrong trend**
- **– min is zero mark**

1m – total t more than 10 s

1m – column headings

1m – raw data correct precision. 1 or 2 d.p. for t.

1m – calculated values to same s.f. as raw data or 1 more

1m – all data calculated correctly

[7]

(f) The quantities *T*, *B* and *C* are related by the equation

$$\frac{T^2}{B} = \frac{FC}{B} + G$$

where *F* and *G* are constants.

By plotting a suitable graph, determine the values of *F* and *G.*

By plotting a graph of **T^2/B against C/B**, **a straight line should be obtained** with F as the gradient and G the y-intercept. **[1 - linearize eqn]**

Using (6.40, 1.030) and (0.80 ,0.330)

From the graph, gradient = (1.030 – 0.330) / (6.40 – 0.80) **[1 - gradient]**
= 0.700 / 5.60
= 0.125

Thus F = 0.125 s^2

Using the equation form y = mx + c, gradient = 0.125, **(6.40, 1.030)**

1.030 = 0.125 (6.40) + c **[1 – y-intercept]**
c = 1.030 – 0.8 = 0.2

Thus, G = 0.2 s^2 **[1 – F and G with correct units]**

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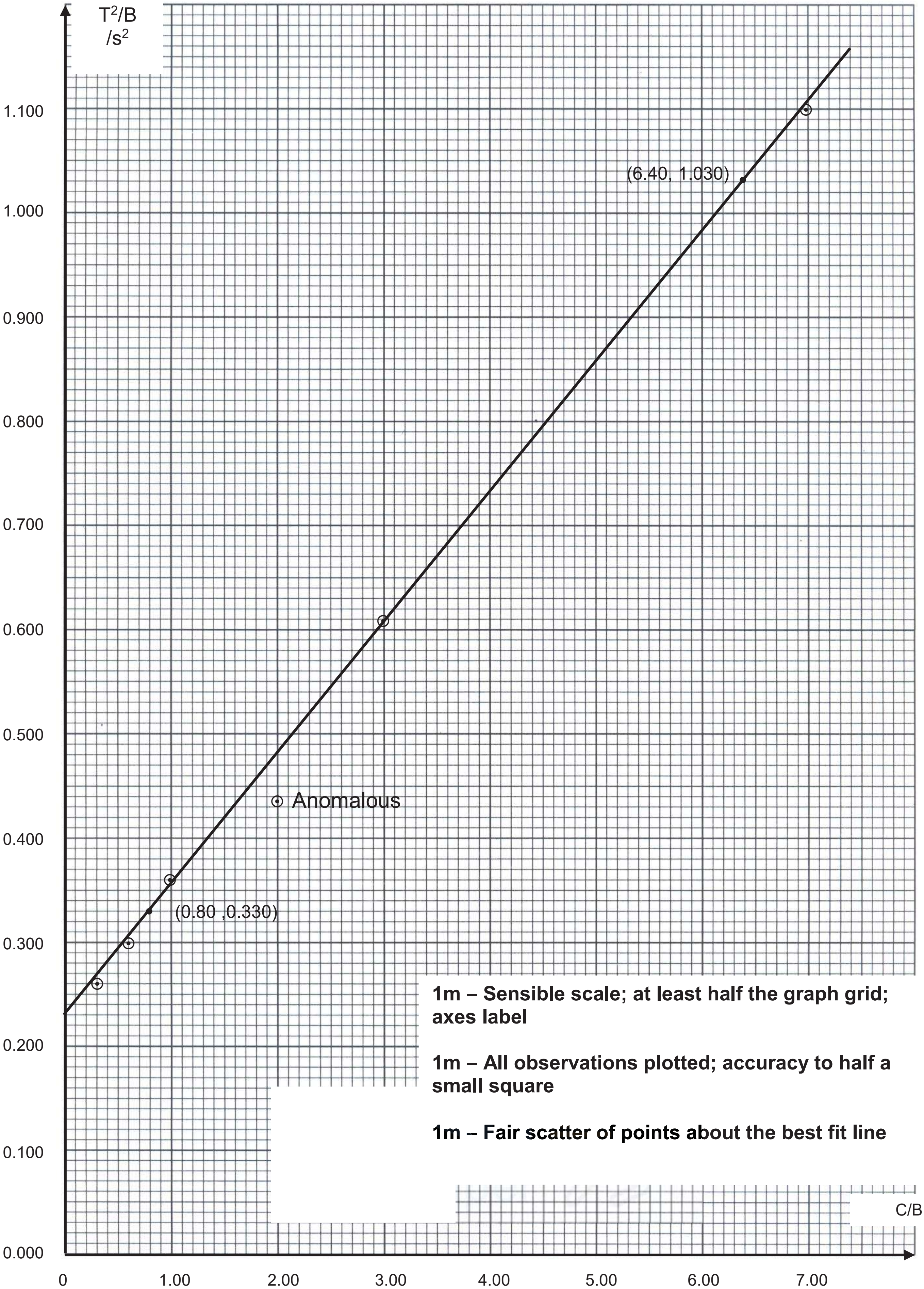
[4]



1m – Sensible scale; at least half the graph grid; axes label

1m – All observations plotted; accuracy to half a small square

1m – Fair scatter of points about the best fit line

[3]

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

There is no anomalous data as all points lie close to the best fit line.
OR
There is no anomalous data as all points lie around the best fit line.
OR
There is/are anomalous data because 1 *(or 2)* points *is/are* very much further from the best fit line compared to rest of the points.

[1]

(h) **(i)** State two significant error or limitation of the procedure in the experiment.

- The loop that was used to loop into the rod was much bigger than the diameter of the rod. When the pendulum swings, the loop slips and slides along with the motion. Friction may affects the time taken of the period.
- As the loop is of fixed length, the length from pivot to mass may change when more slot masses were added to the loop. To accommodate more slot mass, the shape of the loop has to adjust horizontally instead. Thus shortening the length from pivot to center of mass. (see diagram below)
-

[2]

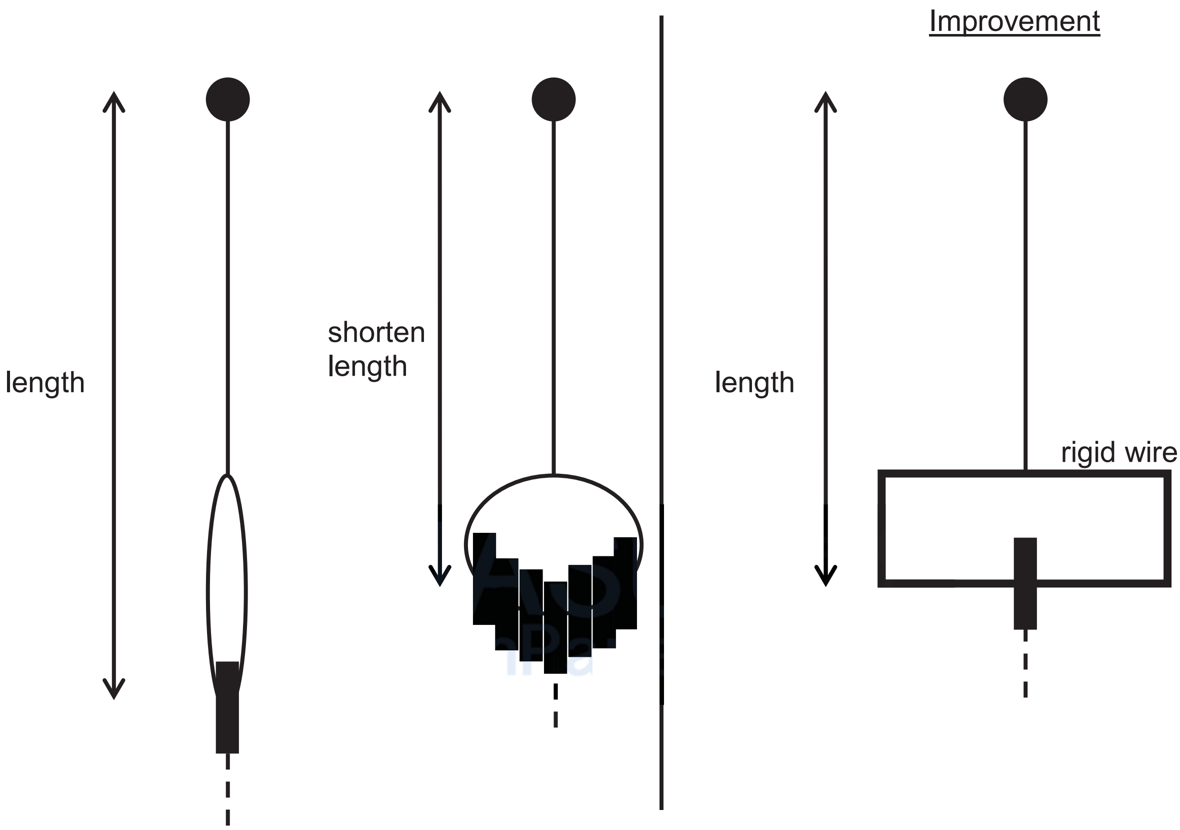
(ii) Suggest an improvement that could be made to the experiment to address the error/limitation in **h**(**i**). You may suggest the use of other apparatus or different procedures.

- Tie the pendulum directly onto the rod instead of looping around the rod.

- Use rigid wire and shape it to accommodate all 8 pieces before the start of experiment. (see diagram)

[1]

[Total: 20]



4 A hot air balloon is tied to the ground using a rope. As the wind blows with speed v, the rope makes an angle θ to the horizontal, as shown in Fig 4.1.

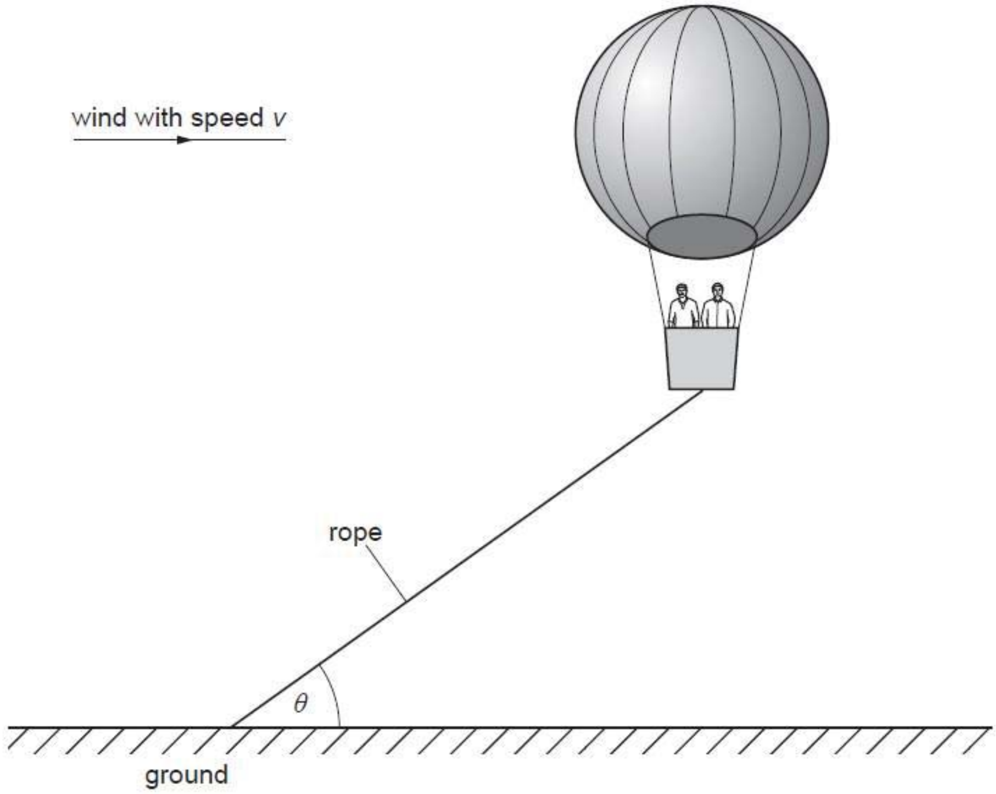


Fig 4.1

It is suggested that

$$\tan\theta = \frac{k}{v^2}$$

where k is a constant.

To model the hot air balloon in the laboratory, a balloon filled with helium is used. You may also use any of the other equipment usually found in a physics laboratory.

Design a laboratory experiment using a small helium-filled balloon to test the relationship between θ and v, and to determine a value for k.

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

(a) the equipment you would use,
(b) the procedure to be followed,
(b) how the speed of the wind and angle are measured,
(c) the control of variables,
(d) any precautions that would be taken to improve the accuracy and safety of the experiment.

Diagram

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[12]

Defining the problem (3 marks)

P1 v is the independent variable and θ is the dependent variable or vary v and measure θ. [1]

P2 Keep the (shape and) size/volume/surface area/mass of balloon/helium constant [1]
Do not credit 'same balloon'.

P3 Keep the temperature (air/helium/balloon) constant. [1]

Methods of data collection (4 marks)

M1 Labelled diagram of apparatus: balloon, string fixed and method of producing wind.
Method of producing wind to be approximately horizontal to balloon. [1]

M2 Method to change wind speed, e.g. change setting, variable power supply/resistor/change distance from fan. [1]

M3 Method to measure wind speed, e.g. wind speed indicator/detector, anemometer [1]

M4 Method to measure angle – use protractor or rule for measurements for trigonometry methods.
This must be shown correctly on diagram or explained in text. [1]

Method of analysis (2 marks)

A1 Plot a graph of tan θ against $1/v^2$ to obtain a straight line to validate equation. [1]

A2 Relate gradient to k. [1]

Safety considerations (1 mark)

S1 Avoid the moving blades of the fan (safety screen, switch off when changing experiment);
goggles to avoid air stream into eye. [1]

Additional detail (2 marks)

Relevant points might include [2]

D1 Large wind speed to produce measurable deflection/large cross-sectional area of balloon.

D2 Measuring air speed at point where balloon is positioned.

D3 Adjust height of fan so that air flow is horizontally aligned to the balloon.

D4 Reason for adding mass to increase stability/deflection.

D5 Wait for the balloon to become stable.

D6. Preliminary result

Q1

1 Retort Stand with boss and clamp
2 Metre rule
3 Circular piece of filter paper
4 Scissors
5 Stopwatch
6 Sellotape

Q2

1 1.5 V dry cell in holder
2 Component Y
3 10 kΩ resistor
4 Six connecting leads
5 Stopwatch
6 Digital Multimeter
7 Switch

Q3

1 Retort Stand with boss and clamp
2 Metre rule
3 String
4 Eight 10 g slotted mass
5 Stopwatch

Apparatus List

Q1

1 Retort Stand with boss and clamp

2 Metre rule

3 Circular piece of filter paper

4 Scissors

5 Stopwatch

6 Sellotape

Q2

1 1.5 V dry cell in a holder.

2 1000 μF capacitor. The capacitor should be covered in masking tape so that candidates cannot see any details printed on it. It should be labelled "**component Y**" and the polarity of the connections should be indicated with a "**+**" and a "**–**".

3 10 kΩ resistor.

4 Six connecting leads.

5 Stopwatch reading to 0.1 s or better.

6 Digital multimeter set on the 200 μA range.

7 Switch.

Q3

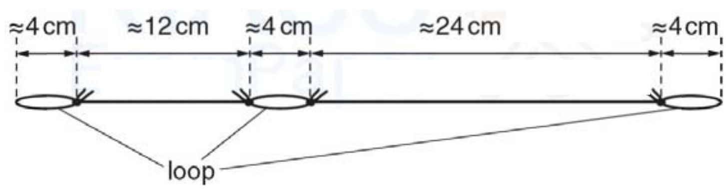
1 Retort Stand with boss and clamp

2 Metre rule

3 String (see diagram)

4 Eight 10 g slotted mass

5 Stopwatch



Each loop should be big enough to accommodate the eight slotted masses.