RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS II

H2 PHYSICS 9749 / 1
PAPER 1

22 SEPTEMBER 2017

1 HOUR

CANDIDATE NAME										
CENTRE NUMBER	S					**INDEX NUMBER**				
CLASS	6									

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class above.

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

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

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 on the Question Paper.
The use of an approved scientific calculator is expected where appropriate.

The total number of marks for this paper is **30**.

This Question Paper consists of 19 printed pages and 1 blank page.

Data

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

Formulae

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

For each question there are four possible answers, **A**, **B**, **C** and **D**. Choose the one you consider to be correct.

1 Four students conduct their own experiments to determine the value of Planck's constant. The following table contains their experimental data.

Which student's measurement is accurate but imprecise, compared to the others?

student	Planck's constant, h / 10^{-34} J s				
A	6.64	6.61	6.61	6.64	6.65
B	6.62	6.63	6.63	6.64	6.63
C	6.63	6.68	6.61	6.68	6.65
D	6.62	6.61	6.63	6.62	6.62

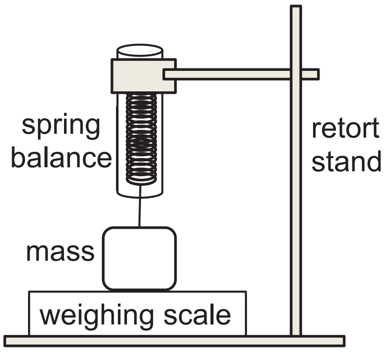
2 A fireman on an aerial ladder 12.0 m above the ground is firing a stream of water at a treetop fire, as shown.

When the hose is pointed at an angle of 15.0° above the horizontal and water exits the hose at a speed of 45.0 m s^{-1}, the stream of water hits the top of a tree 34.0 m away.

What is the height of the tree?

A 6.1 m
B 18.1 m
C 85.1 m
D 97.1 m

3 A mass is attached to a spring balance that is clamped firmly to a retort stand, and placed on a weighing scale, as shown.



Initially, the weighing scale reads 3.0 kg while the spring balance reads 1.0 kg. The setup is then placed in an elevator that accelerates upwards at 2.45 m s^{-2}.

What is the reading on the spring balance and the weighing scale while the elevator is accelerating?

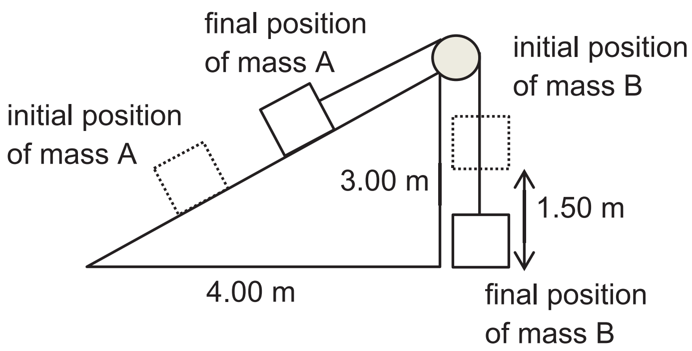
	spring balance reading	weighing scale reading
A	0.5 kg	2.5 kg
B	1.0 kg	2.0 kg
C	1.0 kg	4.0 kg
D	1.5 kg	3.5 kg

4 A wire that obeys Hooke's law is of length x_1 when it is in equilibrium under a tension T_1; its length becomes x_2 when the tension is increased to T_2.

What is the extra energy stored in the wire as a result of this process?

A $\frac{1}{4}(T_2 + T_1)(x_2 + x_1)$
B $\frac{1}{4}(T_2 + T_1)(x_2 - x_1)$
C $\frac{1}{2}(T_2 + T_1)(x_2 + x_1)$
D $\frac{1}{2}(T_2 + T_1)(x_2 - x_1)$

5 Two identical masses weighing 1.00 N each are attached to a pulley and placed on a ramp of height 3.00 m and width 4.00 m. They accelerate from rest until mass B has fallen 1.50 m, as shown.



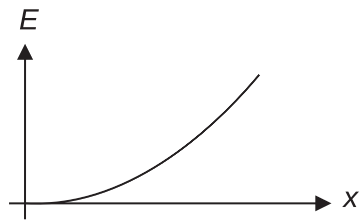
What is the change in the total gravitational potential energy of the two masses when the masses have travelled by 1.50 m?

A –0.60 J
B 0.60 J
C –0.90 J
D 0.90 J

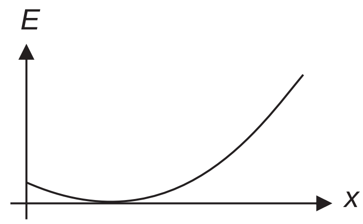
6 A mass is hung from the ceiling by a spring of unstretched length *L*. The spring is initially *compressed* with the mass at rest. The position *x* of the mass is taken to be zero at this point. The setup is then allowed to oscillate.

Which of the following graphs show how the elastic potential energy *E* varies with the position *x* of the mass for this system as it oscillates?

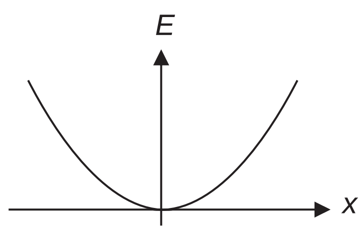
A



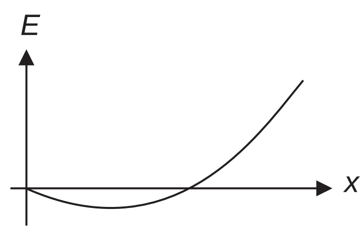
B



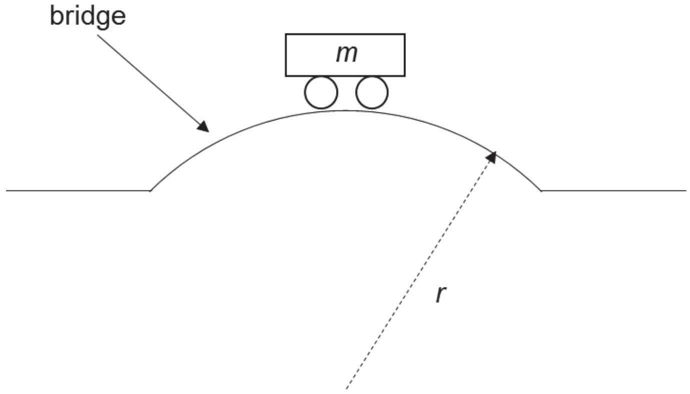
C



D



7 A car of mass m moving at a constant speed v passes over a bridge of radius of curvature r as shown.



Given that the car remains in contact with the road, what is the net force R exerted by the car on the road when it is at the top of the bridge? Take the direction of centripetal force as positive.

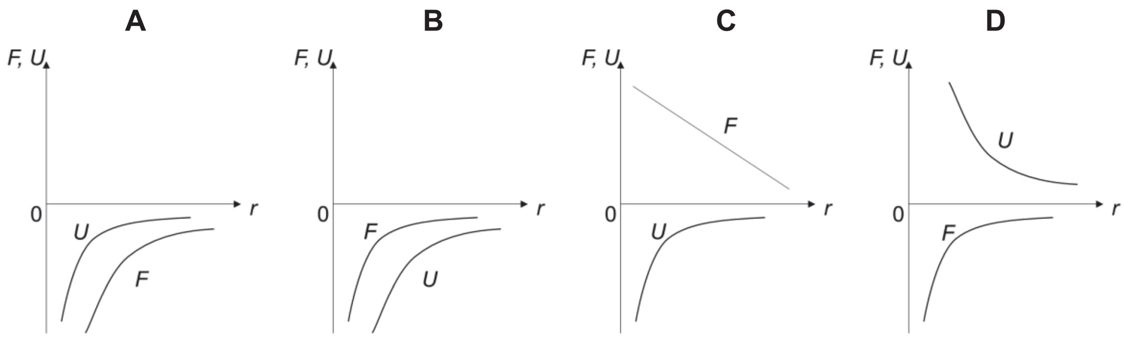
A $R = mg + \dfrac{mv^2}{r}$

B $R = \dfrac{mv^2}{r}$

C $R = mg - \dfrac{mv^2}{r}$

D $R = \dfrac{mv^2}{r} - mg$

8 Which one of the following diagrams shows the variation of gravitational force F on a point mass and gravitational potential energy U of the mass at a distance r from another point mass?

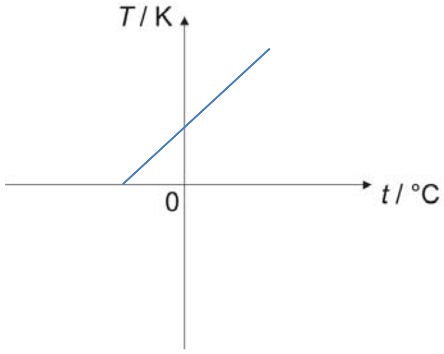


9 A planet of mass P moves in a circular orbit of radius R round a sun of mass S with period T.

Which one of the following correctly shows how T depends on P, R, S?

A $T \propto R^{\frac{3}{2}}$ **B** $T \propto R^{\frac{1}{2}}$ **C** $T \propto S^{\frac{1}{2}}$ **D** $T \propto P^2$

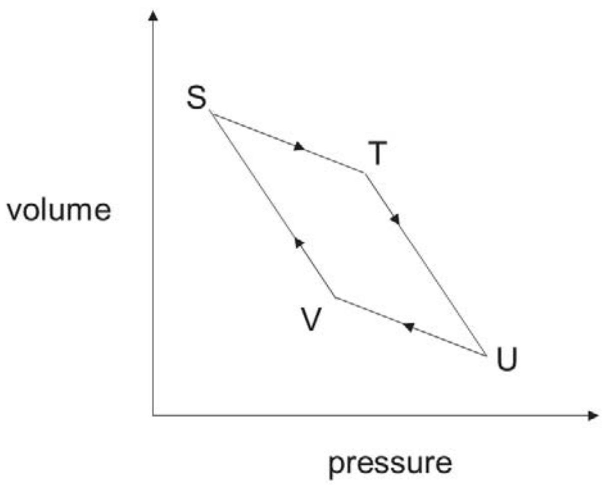
10 A student draws a linear graph on the axes shown below in order to convert temperatures in degrees Celsius to temperatures in Kelvin.



What is the gradient of the line, and intercepts on the horizontal and vertical axes?

	gradient	horizontal intercept	vertical intercept
A	1/273.15	0	–273.15
B	1	–273.15	+273.15
C	1	+273.15	–273.15
D	273.15	0	+273.15

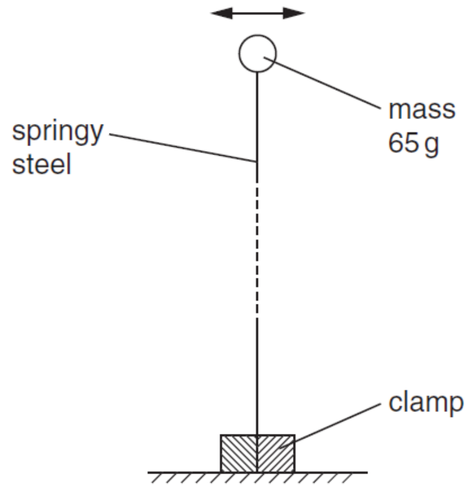
11 A fixed mass of gas undergoes the cycle of changes represented by STUVS as shown. In some of the changes, work is done *on* the gas and, in others, work is done *by* the gas.



In which pair of the changes is work done *on* the gas?

A ST and TU
B TU and UV
C UV and VS
D VS and ST

12 A long strip of springy steel is clamped at one end so that the strip is vertical. A mass of 65 g is attached to the free end of the strip as shown.



The mass is pulled to one side and then released. The variation with time t of the horizontal displacement of the mass is shown below.

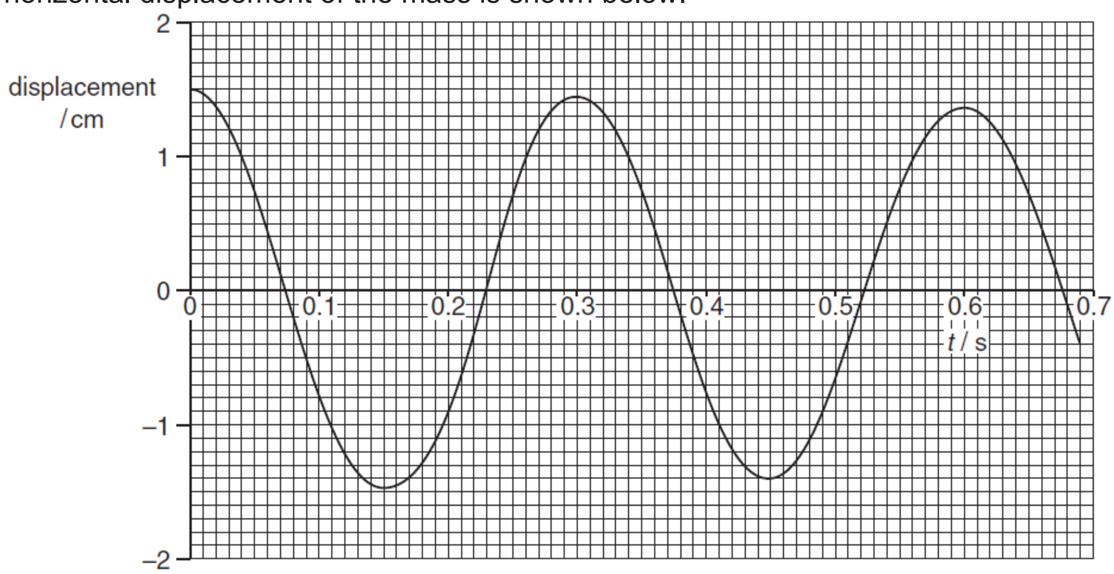


Fig. 11.2

Which of the following statements is incorrect?

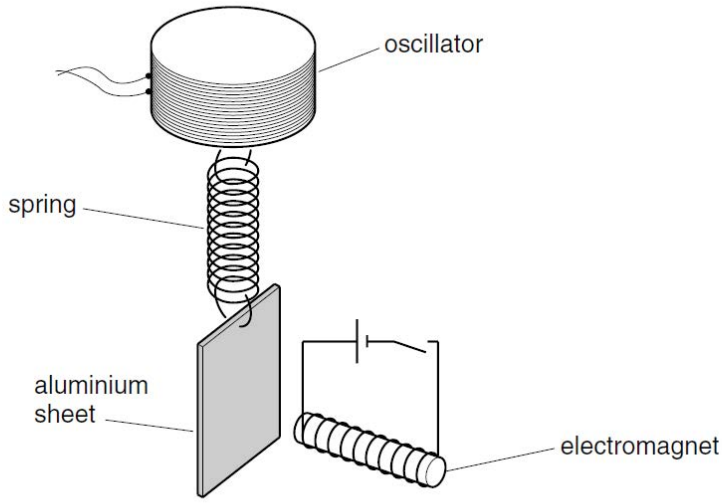
A If the 65 g mass is changed to a 80 g mass, the period will be longer than 0.3 s.

B Maximum acceleration occurs at t = 0 s and decreases gradually with each cycle.

C Maximum velocity occurs at t = 0 s and decreases gradually with each cycle.

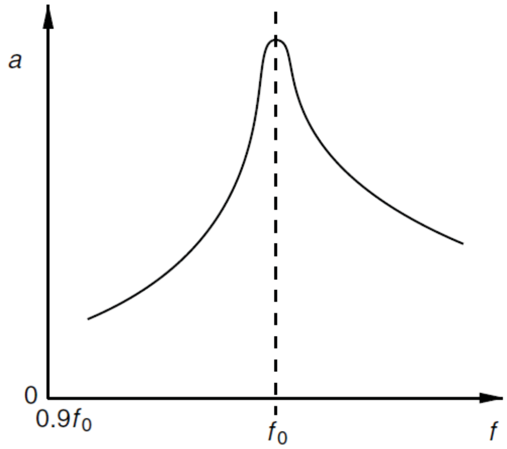
D The oscillations are lightly damped.

13 An aluminium sheet is suspended from an oscillator by means of a spring, as illustrated.



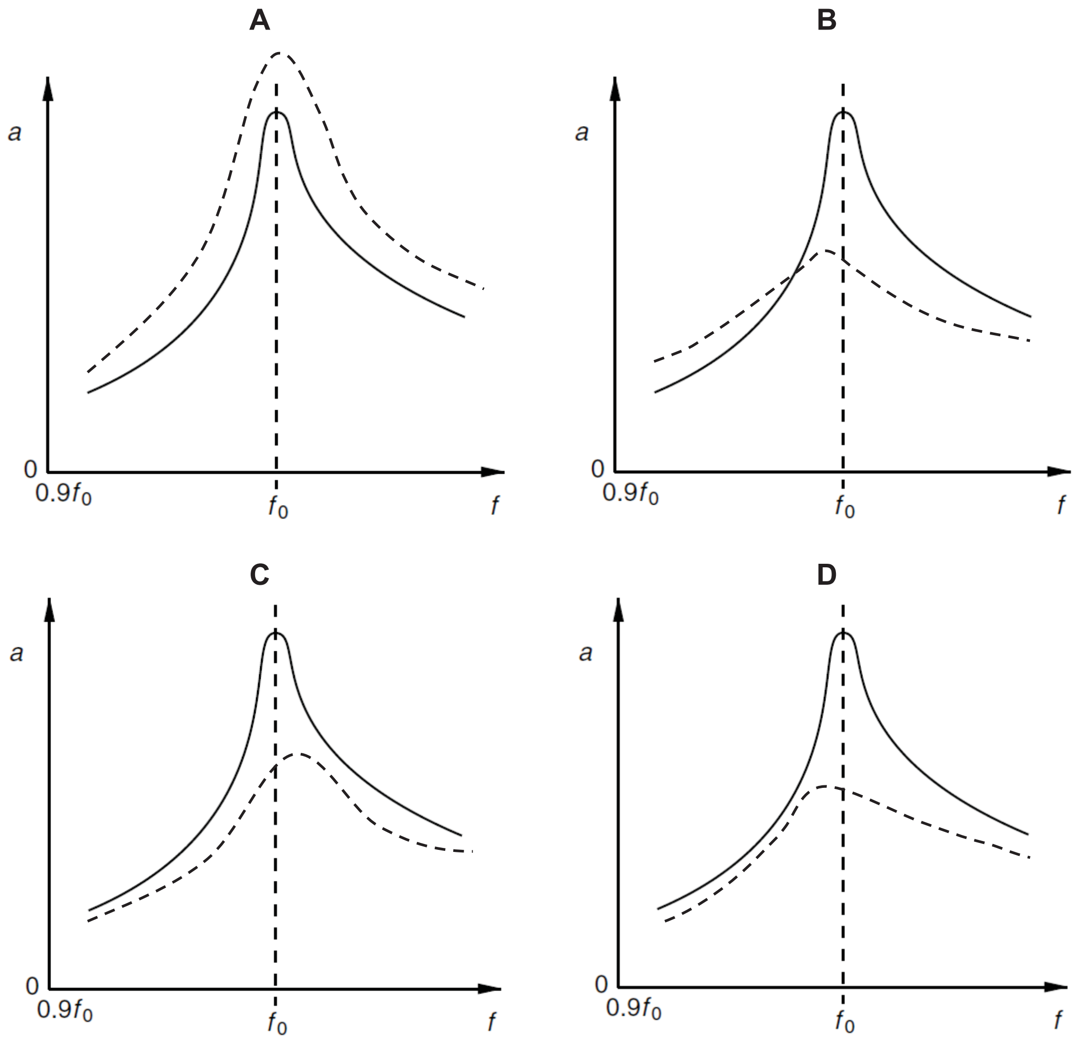
An electromagnet is placed a short distance from the centre of the aluminium sheet.

The electromagnet is switched off and the frequency f of oscillation of the oscillator is gradually increased from a low value. The variation with frequency f of the amplitude a of vibration of the sheet is shown below.



The electromagnet is now switched on and the frequency of the oscillator is again gradually increased from a low value.

Which is the variation with oscillator frequency f of the amplitude a of vibration of the sheet (dotted line)?



14 Fig. A shows the displacement y against position x of a progressive wave at time $t = 0$ and Fig. B shows the displacement y against time t of the same wave at position $x = 0$.

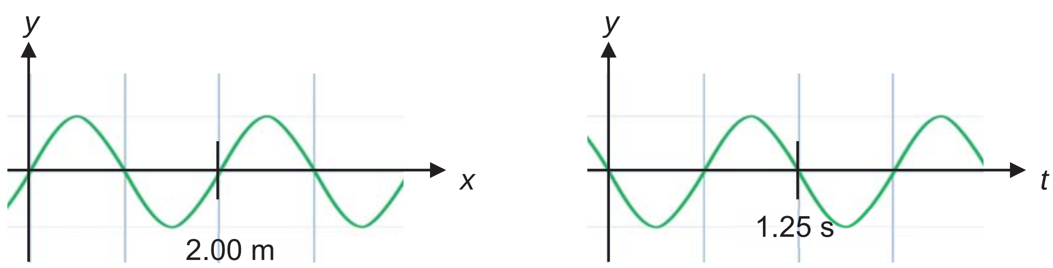
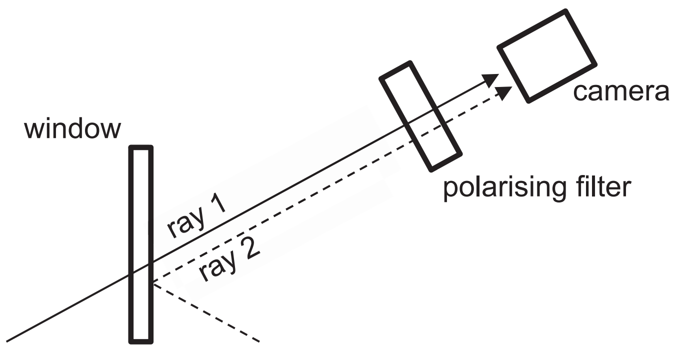


Fig. A **Fig. B**

What is the speed and direction of the wave's propagation?

A $1.60\ \text{m s}^{-1}$ to the right
B $1.60\ \text{m s}^{-1}$ to the left
C $2.50\ \text{m s}^{-1}$ to the right
D $2.50\ \text{m s}^{-1}$ to the left

15 Light reflecting off a glass surface (ray 2) becomes polarised, while light passing through the glass surface from the other side (ray 1) is unpolarised. A photographer reduced the intensity of reflected light reaching the camera by placing a polarising filter in front of the camera, as shown.

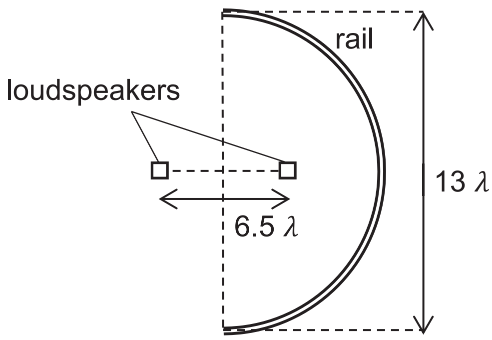


She found that when the intensity of ray 2 was at a maximum, it was equal to that of ray 1 reaching the camera. She then rotated the filter 70° from that position.

What is the ratio of the intensity at the camera of ray 2 to ray 1 in this new position?

A 0.12
B 0.34
C 0.88
D 0.93

16 Two loudspeakers are emitting sound of wavelength λ in all directions. They are in phase with each other and are placed a distance 6.5 λ apart in the middle of a semicircular rail of diameter 13 λ, as shown below. Moveable microphones along the rail are used to detect the sound intensity along the rail.



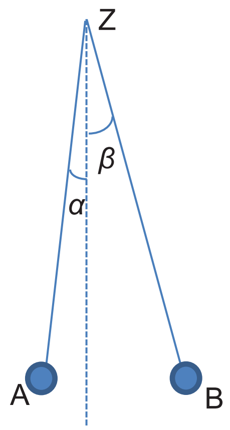
How many minima will the microphones detect?

A 11 **B** 12 **C** 13 **D** 14

17 Which of the following statements about an electric field is correct?

A If the electric field strength at a given point is zero, there is no charge in the vicinity of that point.
B If the electric field strength inside a solid conducting sphere is constant, the electric potential inside the sphere is zero.
C If the electric potential at a given point is zero, there is no charge in the vicinity of that point.
D If the electric potential inside a solid conducting sphere is constant, the electric field strength inside the sphere is zero.

18 The diagram shows two light charged spheres, A and B, which are hung by identical fine nylon threads from a fixed point Z. It is found that, in equilibrium, the angle β is greater than the angle α.



Which one of the following statements must be correct?

A The force of repulsion on A is numerically smaller than that on B.
B The charge on A is numerically smaller than that on B.
C The mass of A is numerically greater than that of B.
D The tension of string holding A is smaller than that of B.

19 Fig. A, B and C show three different circuits.

The cells in each circuit have the same electromotive force and zero internal resistance. The five resistors each have the same resistance R.

In Fig. A, the power dissipated in the resistor is P.

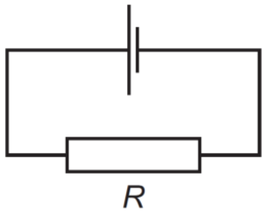


Fig. A

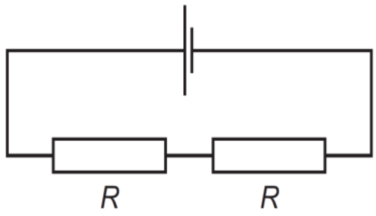


Fig. B

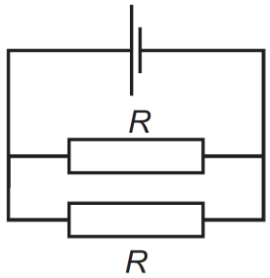


Fig. C

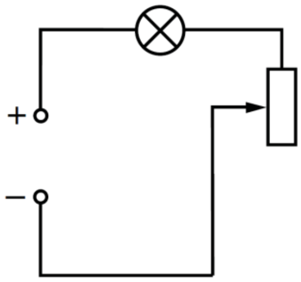
Which of the following statements is incorrect?

A In Fig. B, the power dissipated in the circuit is ½P.
B In Fig. C, the power dissipated in the circuit is 8P.
C The power dissipated in the circuit of Fig. C is quadrupled the power dissipated in the circuit of Fig. B.
D The total current through the cell in Fig. C is larger than the total current through the cell in Fig. B.

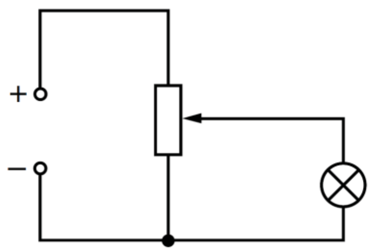
20 A lamp is connected to a power supply of negligible internal resistance.

Which circuit could not be used as a practical means to vary the voltage across the lamp?

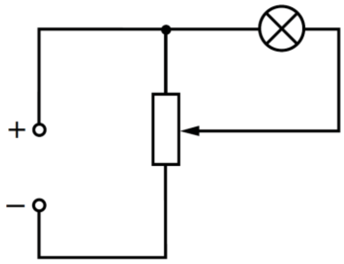
A



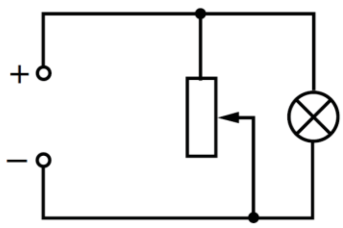
B



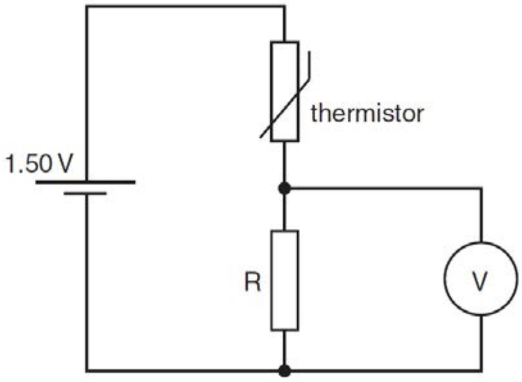
C



D



21 A thermistor has resistance 3900 Ω at 0 °C and resistance 1250 Ω at 30 °C. The thermistor is connected into the circuit shown below in order to monitor temperature changes.



The battery of e.m.f. 1.50 V has negligible internal resistance and the voltmeter has infinite resistance.

If the voltmeter reading is 1.00 V at 0 °C, what will be the voltmeter reading at 30 °C?

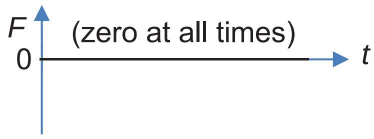
A 0.16 V
B 0.21 V
C 0.32 V
D 1.3 V

22 Two parallel conductors carry equal sinusoidal alternating currents differing in phase by π rad.

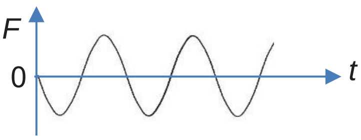
Which one of the following graphs shows how F, the mutual force of attraction, varies with time t?

A

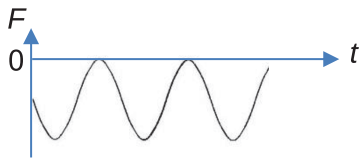
B



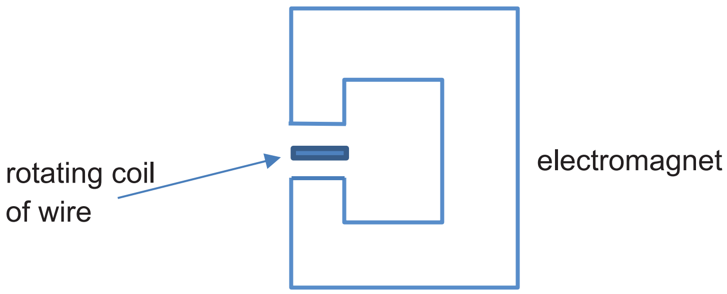
C



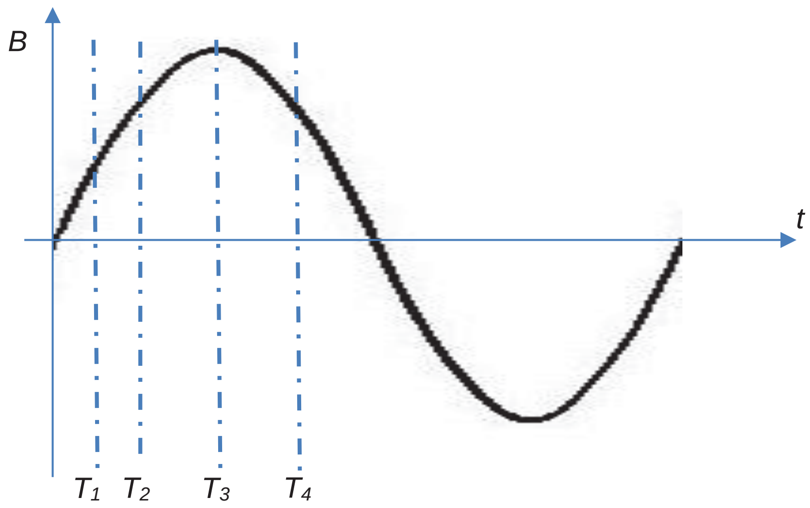
D



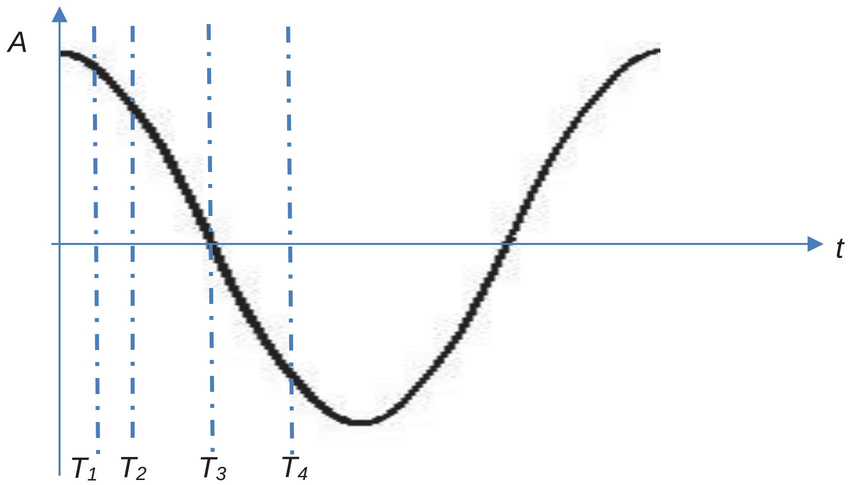
23 An e.m.f is induced in a rotating wire subjected to a changing magnetic field of an electromagnet.



The flux density B of this field varies with time t as shown.



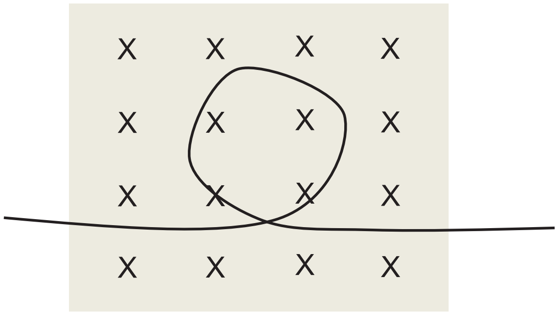
The plane area A normal to the field varies with time t as shown.



At which value of time t is the magnitude of the e.m.f. induced in the wire a maximum?

A T_1
B T_2
C T_3
D T_4

24 A wire is coiled once with an enclosed area of 0.140 m^2. It is placed with its axis parallel to a uniform magnetic field. The flux density of the field is constant at 80 mT. The two ends of the wire are pulled such that the area of the coil is decreased to 0.070 m^2 over a period of 2.0 s.



What is the average magnitude and direction of the induced e.m.f.?

A 2.8 mV, clockwise
B 5.6 mV, clockwise
C 2.8 mV, anticlockwise
D 5.6 mV, anticlockwise

25 Gas molecules are placed inside a sealed box with a loudspeaker. They are made to vibrate with a speed $v = v_0 \sin \omega t$ where v_0 = 3.00 m s^{-1} and ω = 600 rad s^{-1}.

What is the root-mean-square speed v_{rms} of the gas molecules?

A 1.50 m s^{-1}
B 2.12 m s^{-1}
C 3.00 m s^{-1}
D 4.24 m s^{-1}

26 A diode and a resistor are connected in series with an a.c. power supply. This power supply provides an a.c. voltage at 220 V with a frequency of 50 Hz.

What percentage of the average power provided by the source is dissipated across the resistor?

A 0%
B 25%
C 50%
D 71%

27 When fireworks detonate, the thermal energy excites electrons in the shells of metal ions. Characteristic energy transitions of several compounds are given below.

compound	energy transitions / eV
strontium chloride	1.89
barium chloride	2.43
copper chloride	2.87
zinc monoxide	8.73
aluminium nitride	9.83

Given that aluminium nitride emits light in the ultraviolet range when this energy transition occurs, which of the following is most likely to be the compound used in a yellowish-green firework?

A strontium chloride
B barium chloride
C copper chloride
D zinc monoxide

28 Protactinium-234 undergoes beta decay into uranium-234. In this process, it emits beta particles with energies up to 2.27×10^6 eV as well as gamma rays with energies up to 1.97×10^6 eV.

A sample of protactinium-234 is placed in a thick metal box, which blocks beta decay from leaving the box. A detector placed outside the box found gamma rays emanating from the box.

What is the smallest wavelength of gamma ray observed?

A 5.48×10^{-13} m
B 6.31×10^{-13} m
C 8.76×10^{-32} m
D 8.24×10^{-31} m

29 Data for the masses of some particles and nuclei are given below:

	mass / u
proton	1.0073
neutron	1.0087
deuterium (^2_1H)	2.0141

What is the binding energy of deuterium?

A 4.54×10^{-32} eV
B 2.84×10^{-12} J
C 1.77 MeV
D 27.4 MeV

30 One possible fission reaction of uranium-235 is

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{144}_{56}Ba + ^{90}_{36}Kr + 2^{1}_{0}n\ .$$

The binding energy per nucleon of each nucleus is as follows.

$^{235}_{92}U$: 1.2191 × 10^{-12} J

$^{144}_{56}Ba$: 1.3341 × 10^{-12} J

$^{90}_{36}Kr$: 1.3864 × 10^{-12} J

What is the mass equivalence of the energy released in this reaction?

A 1.67 × 10^{-29} kg
B 1.38 × 10^{-28} kg
C 3.38 × 10^{-28} kg
D 1.01 × 10^{-19} kg

END OF PAPER

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RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS II

H2 PHYSICS 9749 / 2
PAPER 2

11 SEPTEMBER 2017

2 HOURS

CANDIDATE NAME	

CENTRE NUMBER	S						**INDEX NUMBER**					

CLASS	6	

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, centre number, index number and class in the spaces at the top of this page and on all work you hand in.

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

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

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

*Answer **all** questions*.

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

FOR EXAMINERS' USE	
Paper 1	**/ 30**
Paper 2	
1	**/ 10**
2	**/ 5**
3	**/ 10**
4	**/ 10**
5	**/ 10**
6	**/ 10**
7	**/ 5**
8	**/ 20**
Deduction	
Paper 2	**/ 80**

This document consists of **20** printed pages.

Data

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

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
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.,	$v = v_0 \cos \omega t$ $= \pm \omega\sqrt{(x_0^2 - x^2)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current/voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil,	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** **(i)** Distinguish between *random* and *systematic error*.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [3]

(ii) Suggest a method to reduce the effect of random error in an experiment.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) A ball approaches a ramp with an inclination of 30°. It hits the surface of the ramp at a speed of 5.0 m s^{-1} at 45° to the normal and bounces off with a speed of 5.0 m s^{-1} as shown in Fig. 1.1.

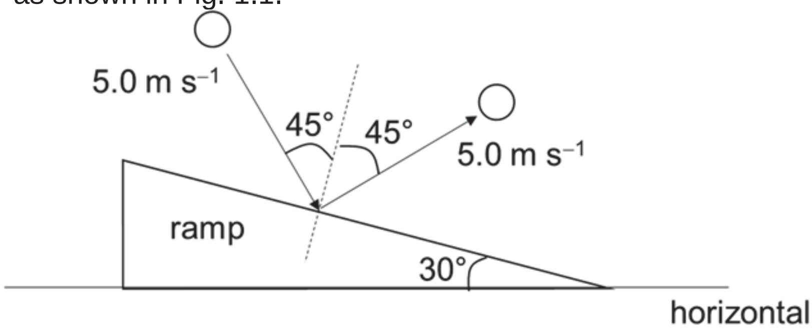


Fig. 1.1

Determine the change in velocity of the ball.

magnitude of change in velocity = ……………………… m s^{-1} [2]

direction of change in velocity is ……………………… °
with respect to the horizontal [2]

(c) The behaviour of many real gases deviates from the ideal gas equation $pV_m = RT$, where V_m refers to molar volume while the other symbols have their usual meaning. Its behaviour can instead be represented quite closely over certain ranges of temperature and pressure by an equation of the form

$$\left(p + \frac{a}{V_m^2}\right)\left(V_m - b\right) = RT$$

in which the values of a and b are characteristic of the particular gas.

Determine the base S.I. units of a and b.

units of a = ……………………….

units of b = ………………………. [2]

2 **(a)** A stone is thrown with an initial velocity v at an angle θ above the horizontal. Assume air resistance to be negligible.

Assuming that the stone returns to the same vertical height, show that the range d (horizontal distance) that it can reach is given by the expression

$$d = \frac{v^2 \sin 2\theta}{g}$$

[3]

(b) Hence or otherwise, show that the maximum range, given that it returns to the same vertical height, is obtained at the angle of 45°.

[1]

(c) Fig. 2.1 shows the path of the projectile motion when the angle of launch is 45°.

On Fig. 2.1, draw possible path(s) of the projectile motion of the stone that can reach point X with the same initial speed.

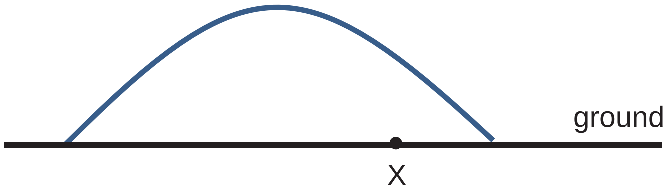


Fig. 2.1

[1]

3 **(a)** Define *density* and *pressure*.

....

....

....

.... [2]

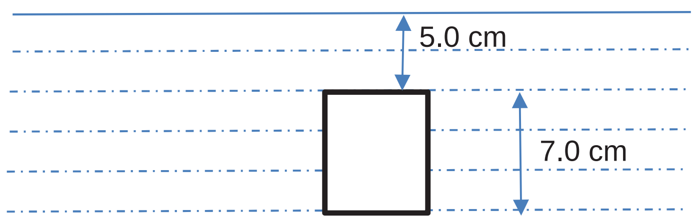
(b) Using the definitions which you have given in **(a)**, derive an expression for the upthrust experienced by an object in a fluid in terms of the fluid density ρ and the volume V of the object.

[3]

(c) A rectangular block of wood of cross-sectional area 10 cm^2 and thickness 7.0 cm is held at a depth of 5.0 cm in water as shown in Fig. 3.1. and Fig. 3.2.

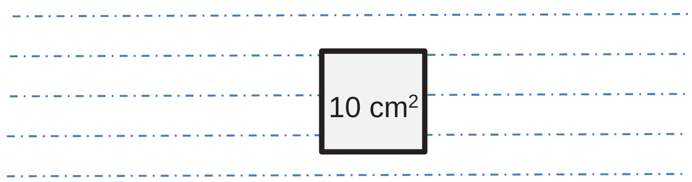
It is subsequently released, and the block moves upwards and leaves the surface of the water completely.

Density of water = 1000 kg m^{-3}
Density of wood = 430 kg m^{-3}



side view

Fig. 3.1



bottom view

Fig. 3.2

(i) On Fig. 3.1. draw and label the forces acting on the block at its initial position, just after its release.

[1]

(ii) Calculate the resultant force of the block just after its release.

resultant force = ……………………… N [1]

(iii) Calculate the time taken for the top surface of the block to just reach the surface of water after its release.

time taken = ……………………… s [2]

(iv) Without making further calculations, sketch a graph showing the variation with time of the resultant force acting on the block from time of release to just before it completely leaves the surface of water.

[1]

4 A smooth sphere of mass *m* is held horizontally between two fixed points A and B by two identical stretched helical springs, each of spring constant *k*, as shown in Fig. 4.1.

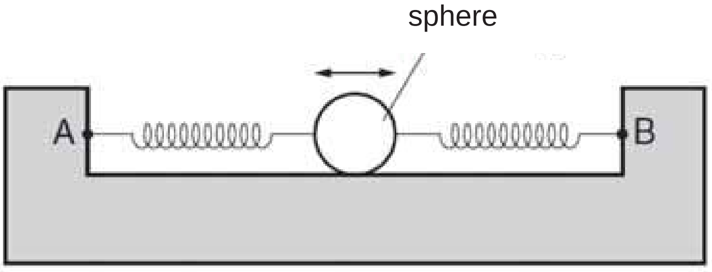


Fig. 4.1

When the sphere is in equilibrium, the extension of each spring is *e*.

The sphere is then displaced a small distance *x* to the right along the axis of the springs.

Both springs remain extended.

(a) **(i)** Show that the resultant force *F* acting on the sphere is given by

$$F = -2kx.$$

[2]

(ii) Hence, explain why, after releasing the sphere from rest, the subsequent motion is simple harmonic.

....

....

....

.... [2]

(b) **(i)** The mass *m* of the sphere is 37 g and the spring constant k is 9.0 N m^{-1}.

Determine the angular frequency of oscillation of the sphere.

angular frequency = …………………….. rad s^{-1} [2]

(ii) Given that x = 2.8 cm, show that the total energy of the oscillations is 7.0 mJ.

[2]

(iii) Calculate the magnitude of the displacement at which the kinetic energy of the sphere is equal to the total potential energy stored in the springs.

displacement = …………………….. m [2]

5 **(a)** A point source emits radio waves with a frequency of 30 kHz in all directions. These radio waves are incident on an antenna 5.0 km away, and can take two possible paths to reach the antenna. Path A is the direct path from source to antenna, while Path B is reflected off the ground, as shown in Fig. 5.1.

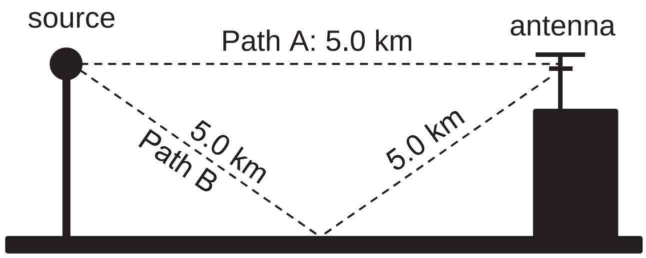


Fig. 5.1

(i) Show that there is a phase difference of π between the oscillations at the source and the oscillations at the antenna for a wave that is travelling along path A.

[2]

(ii) When the radio wave reflects off the ground for Path B, it undergoes a phase change of π.

Determine whether the waves travelling along Path A and Path B undergo constructive or destructive interference at the antenna.

[2]

(b) Instead of emitting radio waves in all directions, radio waves may instead be channelled through a hollow metal tube of constant cross-sectional area. The waves are confined within the tube because they bounce off the metal surfaces.

(i) Explain why this is considered to be a more efficient method of transmitting electromagnetic waves than emitting in all directions.

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

………………………………………………………………………………… [2]

(ii) It is observed that standing waves may develop inside the metal tube. Explain how these standing waves form.

…………………………………………………………………………………….

…………………………………………………………………………………….

…………………………………………………………………………………….

………………………………………………………………………………… [2]

(c) Different radio channels use different wavelengths of radio waves to transmit signals. For example, MediaCorp's Gold 90.5 uses radio waves with a frequency of 90.5 MHz, while Channel U is broadcasted at 579 MHz.

A resident of Pulau Ubin discovered that when he was behind the hills, he was unable to receive reception of Channel U. However, he was still able to listen to Gold 90.5. Suggest why this phenomenon occurs.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

6 A copper cable, of length 0.24 m and diameter 2.4 mm, connects a car's battery to its starter motor. The copper cable carries a current of 150 A and the voltage drop across the cable is 0.13 V.

(a) **(i)** Calculate the resistance of the copper cable.

resistance = ……………………… Ω [2]

(ii) Hence, or otherwise, calculate the resistivity of copper.

resistivity = ……………………… Ω m [3]

(b) **(i)** Given that the number of electrons in the copper cable is 1.6×10^{18}, determine the drift velocity of the electrons in the copper cable.

drift velocity = ……………………… m s^{-1} [3]

(ii) Without any calculations, state and explain the change, if any, to the drift velocity if the same current now flows through another copper cable of which diameter is doubled.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

7 A power station generates 1.0 MW of power and the generated voltage of an alternating current (a.c.) is stepped up to 300 kV by a transformer for transmission as shown in Fig 7.1.

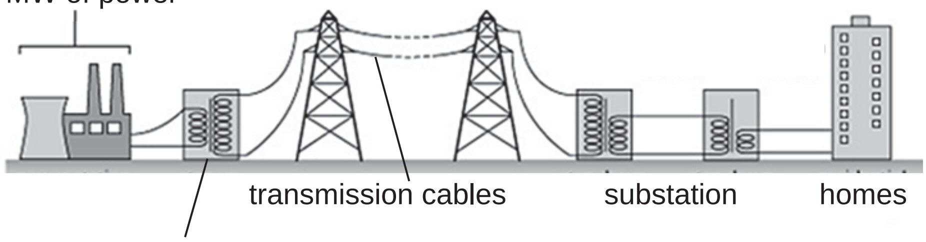


Fig. 7.1

The transmission cables of length 10 km have a total resistance of 8.0 kΩ. At an electrical substation near homes, the voltage is stepped down in various stages to a standard 240 V a.c. power supply for homes.

(a) Calculate the power lost via the transmission cables, and state any assumptions made in your calculations.

power loss = ……………………… kW [2]

(b) A man decides to use a step-down transformer to step down the 240 V a.c. voltage, and then convert it to direct current (d.c.) using a single diode for an electrical appliance which requires 12 V d.c.

Determine the turns ratio N_P/N_S required for the step-down transformer to provide an equivalent d.c. voltage of 12 V.

turns ratio = ……………………… [3]

8 In a photoelectric experiment, a student uses a mercury vapour lamp with filters as a source of light. After applying the filters, the light source consists only of two wavelengths, one of 405 nm and the other of an unknown ultraviolet (UV) wavelength.

The set up is shown in Fig. 8.1 with the sodium metal placed in an evacuated tube and connected to a circuit as electrode B. The sodium metal has a work function of 2.3 eV. A sensitive micro-ammeter and voltmeter are connected to the main circuit with the electrodes to measure values of current and potential difference across the electrodes as the e.m.f. source is varied. When the potential difference between A and B (ΔV) is positive, a constant photoelectric current is detected in the ammeter.

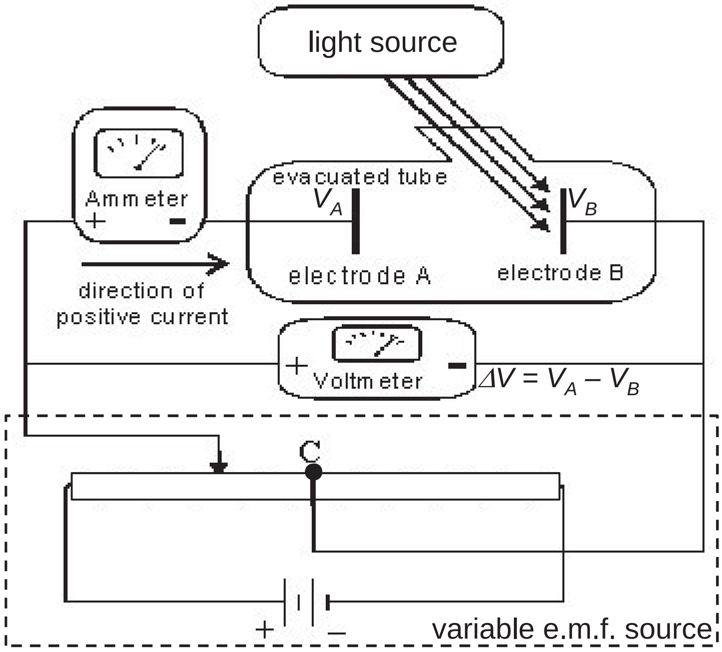


Fig. 8.1

(a) The student varies the potential difference across the electrodes and obtains a relationship between the total detected photoelectric current and the potential difference ΔV as shown in Fig. 8.2.

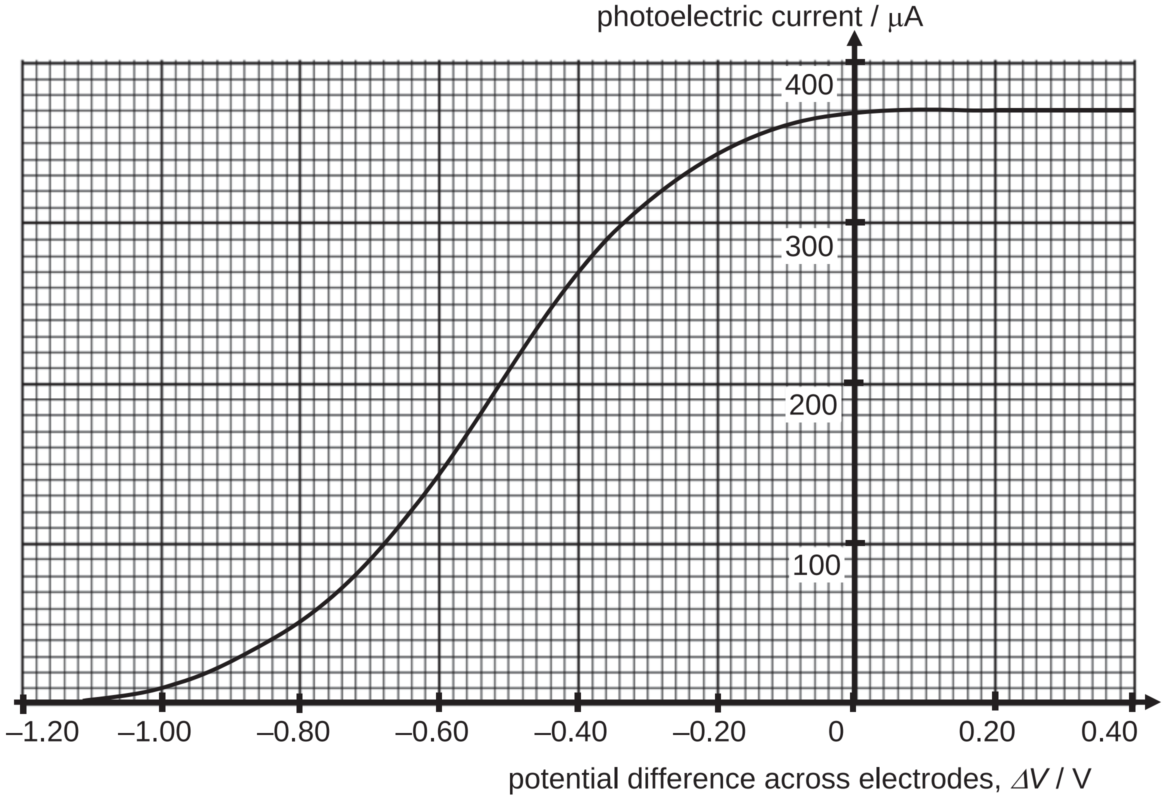


Fig. 8.2

(i) Using Fig. 8.2, describe how the total detected photoelectric current varies with the potential difference across electrodes A and B.

....

....

.... [2]

(ii) Using Fig. 8.2, determine the stopping potential V_S which stops the most energetic photoelectrons from reaching electrode A.

stopping potential V_S = ... V [1]

(iii) Hence, calculate the wavelength of the UV light.

wavelength = ……………………… m [2]

(iv) Show that if the source is monochromatic and only emits light of wavelength 405 nm, the stopping potential would be 0.77 V.

[1]

(v) Assume that for both wavelengths emitted by the lamp, the emitted photons are incident on the metal with the same intensity, and the ratio of photons absorbed to photoelectrons emitted is 1.

Calculate the total power of light incident on the metal due to both wavelengths.

power = ……………………… W [3]

(vi) Assume that for both wavelengths emitted by the lamp, the emitted photons are incident on the metal with the same intensity, and the ratio of photons absorbed to photoelectrons emitted is 1.

Sketch on Fig. 8.2 two graphs to show the variation with potential difference of the photoelectric current for

1. the 405 nm light alone,
2. the UV light alone.

Label your graphs (1) and (2) respectively [2]

(b) The variation of stopping potential V_S with different frequencies f of incident light is given by the expression

$$V_S = \frac{hf}{e} + C$$

where h is the Planck constant, e the elementary charge, and C is a constant.

The student repeats the experiment in **(a)** with different sources of light, measuring the stopping potentials V_S for different frequencies f of incident light on the sodium metal.

Fig. 8.3 shows the readings obtained.

f / 10^{14} Hz	V_S / V
6.0	0.21
6.6	0.45
7.2	0.72
9.1	1.49
10.5	1.86

Fig. 8.3

(i) Complete Fig. 8.3 using the experimental data in Fig. 8.2. [1]

(ii) A graph of some of the data showing the variation of stopping potential V_S with frequency of incident light f is shown in Fig. 8.4.

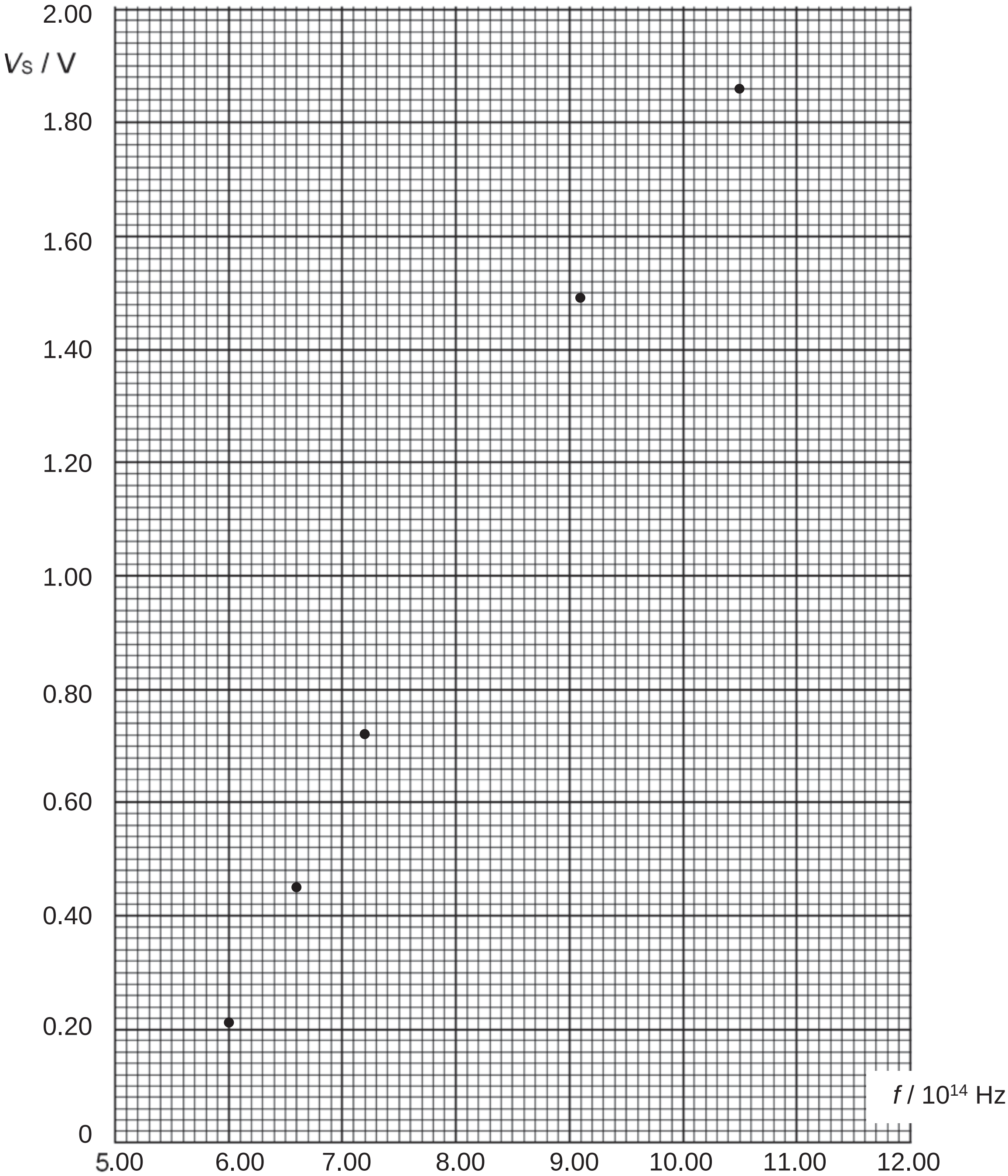


Fig. 8.4

On Fig. 8.4,

1. plot the point corresponding to your answer in **(b)(i)**,
2. draw the line of best fit for the points. [2]

(iii) Determine the gradient of the line you have drawn on Fig. 8.4.

gradient = ……………………… [2]

(iv) Explain, with calculations, whether the graph of Fig. 8.4 supports the expression given in **(b)**.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

(v) Explain using the expression in **(b)**, how the graph in Fig. 8.4 would change if the sodium metal was replaced with calcium metal which has a larger work function.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [2]

END OF PAPER

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIMINARY EXAMINATIONS II

H2 PHYSICS 9749 / 3
PAPER 3

20 SEPTEMBER 2017

2 HOURS

CANDIDATE NAME	

CENTRE NUMBER	S					**INDEX NUMBER**					

CLASS	6	

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Section A
Answer all questions.

Section B
Answer **one** question only.

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

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

This document consists of 24 printed pages and 1 blank page.

FOR EXAMINERS' USE	
Section A – do all questions	
1	**/ 15**
2	**/ 10**
3	**/ 10**
4	**/ 10**
5	**/ 10**
6	**/ 5**
Section B – do ONE question only	
7	**/ 20**
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Deduction	
TOTAL	**/ 80**

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decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 Ion beams consist of a stream of charged particles fired in a particular direction at a uniform speed. They may be used to impart kinetic energy onto a target.

(a) One method of treating cancer involves using ion beams to knock carbon nuclei out of cancer cells.

An ion, travelling with speed v, undergoes a head-on elastic collision with a carbon nucleus that was initially at rest, as shown in Fig. 1.1.

Fig. 1.1

(i) Given that the carbon nucleus has 12.0 times the mass of the ion, determine the final speed of the carbon nucleus just after the collision in terms of v.

final speed of the carbon nucleus = ……………………… [3]

(ii) If the ion in part **(i)** is replaced with an ion of equal mass as the carbon nucleus, but kinetic energy remains unchanged, suggest whether it would be more effective at knocking out the carbon nuclei, and briefly explain why.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………….. [2]

(b) Ion beams may also be used to provide very small amounts of thrust. In 2019, NASA will be using spacecraft with a new ion engine that uses xenon ions to manoeuvre.

Consider a small spacecraft in space with a mass of 500 kg moving towards the right at a uniform speed of 13.0 km s^{-1}. Its engine fires a beam of xenon ions downwards at a speed of 40.0 km s^{-1} at a rate of 2.29×10^{19} ions per second, as shown in Fig. 1.2. These ions each have a mass of 2.18×10^{-25} kg.

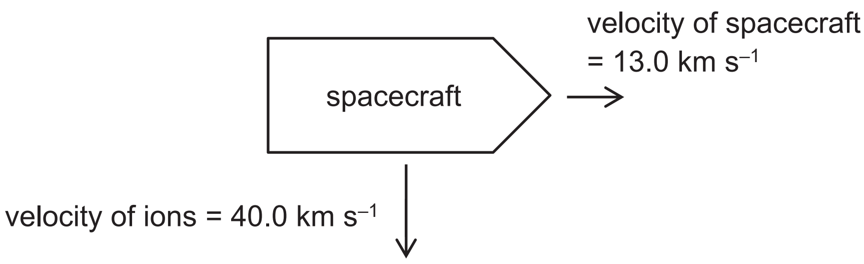


Fig. 1.2

(i) State the direction of the acceleration of the spacecraft.

…………………………………………………………………………….. [1]

(ii) Show that the ion beam causes the spacecraft to accelerate with a magnitude of 3.99×10^{-4} m s^{-2}.

[3]

(iii) Hence determine the vertical displacement of the spacecraft after it has travelled a horizontal distance of 1.00 km.

displacement = ……………………… m [3]

(iv) Before firing the ion beam, the spacecraft was travelling at uniform velocity. An unsecured 2.00 kg toolbox was floating stationary relative to the spacecraft. The dot in Fig. 1.3 shows the initial location of the box. Subsequently the ion beam fires continuously for a very long period of time.

On Fig 1.3, draw a cross (×) to indicate where the position of the box will be **after** the ion beam has been fired for a long period of time but is still continuing to fire.

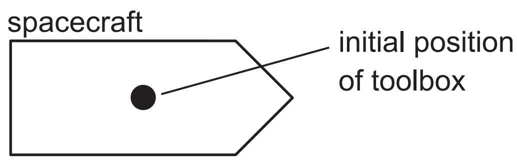


Fig. 1.3

[1]

(v) Hence or otherwise, determine the magnitude of net force on the box in the position indicated in part **(iv)** while the ion beams are still firing.

net force = ……………………… N [2]

2 Computer keyboards use a specialised spring mechanism so that the key pops back up after the user releases it. The magnitude of the total **upward** restoring force *F* exerted by the springs when pressing the key **downwards** is different from that when releasing the key, as shown in Fig. 2.1.

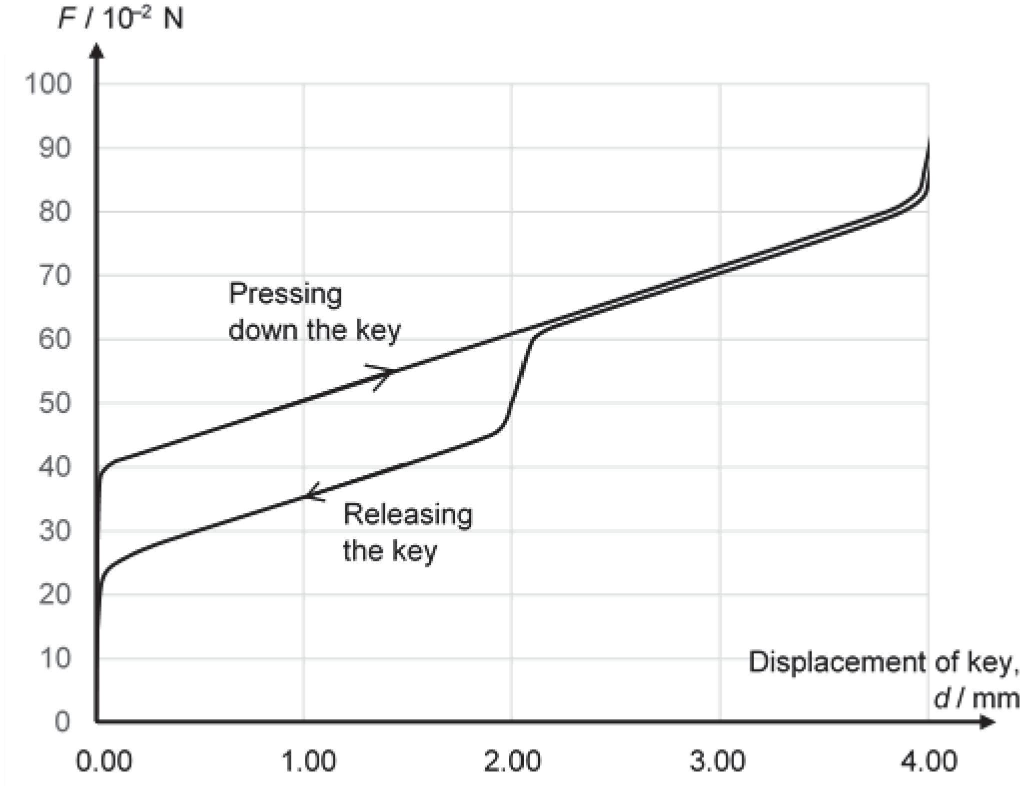


Fig. 2.1

(a) **(i)** Estimate the magnitude of work done by the restoring force when the key is pressed down from 0.00 mm to 4.00 mm.

work done = ……………………… J [2]

(ii) Keyboard specifications are usually given in terms of the amount of force required to press a key. This is measured by placing known masses on a key and noting how much force is required for it to be ‘pressed’ down.

An 80 g mass is placed on a 2.0 g key.
Determine the total change in gravitational potential energy of the key and mass if it travels downwards from 0.00 mm to 4.00 mm.

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

(iii) Hence or otherwise, state and explain whether the key can reach 4.00 mm if the key and mass begin from rest at 0.00 mm.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………….. [2]

(b) **(i)** A keystroke is defined as pressing down a key from 0.00 mm to 4.00 mm, and then returning back to 0.00 mm.

Estimate the net amount of work done by the restoring force of the springs in one keystroke.

net work done by restoring force = ……………………… J [2]

(ii) Top competitive gamers may perform up to 500 keystrokes per minute.

Estimate the average power output of the gamer’s fingers.

power output = ……………………… W [2]

3 **(a)** Two planets, P and Q, are orbiting about a point O, which is the common centre of mass of the two planets. Planet P has half the density of Q, but twice the radius of Q.

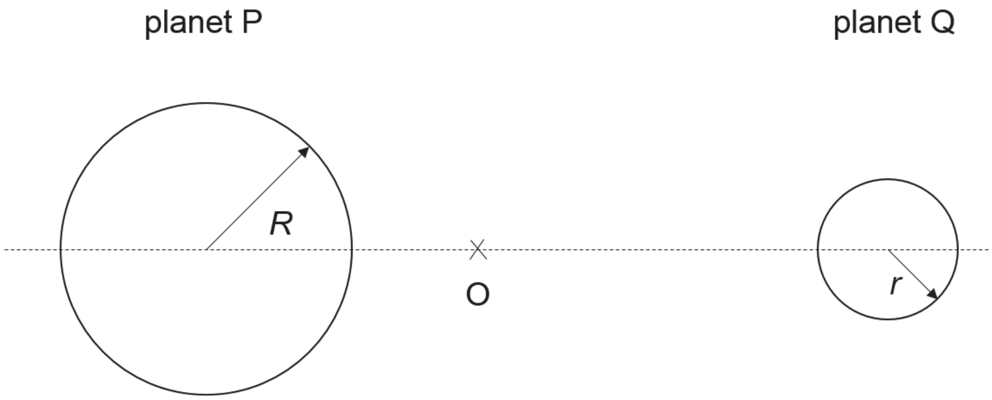


Fig. 3.1

(i) Show that the ratio of masses of planet Q to planet P is given by $\frac{1}{4}$.

[2]

(ii) Planet P is found to have an orbital period of T and the distance from the surface of planet P to the surface of planet Q is $10R$.

Hence, derive an expression for the radius of orbit of planet P.

[3]

(b) A circular motion experiment is conducted on the surface of planet P. A pendulum bob of mass *m* tied to a string of length *L* is set to swing in a horizontal circle. The string makes an angle of 35° with the vertical, as shown in Fig. 3.2. Take the gravitational acceleration to be *g*.

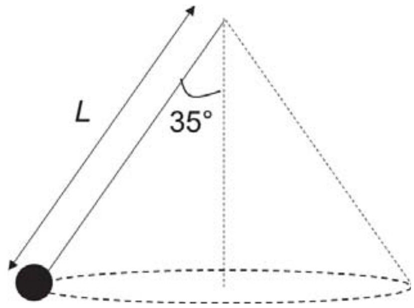


Fig. 3.2

(i) Determine the tension in the string in terms of *m* and *g*.

tension = …………………………… [2]

(ii) Hence, determine the expression for the speed of the bob in terms of *g* and *L*. Leave the numerical part of your answer to 2 s.f.

[3]

4 **(a)** With reference to a point in an electric field, define the term *electric potential*.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) A system of two identical, negatively charged particles X and Y, each of mass 2.7×10^{-26} kg and charge -3.2×10^{-19} C are held at a distance 1.0×10^{-9} m apart.

(i) Calculate the electric potential energy of the system.

electric potential energy = …………………………… J [2]

(ii) Calculate the relative speed of separation when they are very far apart if they are released.

relative speed of separation = ……………………….. m s^{-1} [3]

(iii) With the two charges held at rest at 1.0×10^{-9} m apart, a third charge Z is placed at the midpoint between charges X and Y so that the system of charges is stationary.

1. State and explain the sign of the third charge Z in order for the system of charges to be stationary.

…………………………………………………………………………………

…………………………………………………………………………………

……………………………………………………………………………… [2]

2. Calculate the magnitude of charge Z.

magnitude of charge Z = ……………………….. C [2]

5 **(a)** Define magnetic flux.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(b) Fig. 5.1 shows a short coil wound over the middle part of a long solenoid. Both the coil and solenoid are made of wires with uniform cross-sectional area.

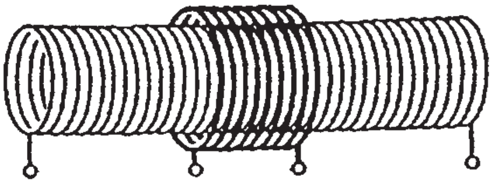


Fig. 5.1

A current passes through the solenoid, and the e.m.f. E induced in the short coil, varies with time t for one cycle of current, as shown in Fig. 5.2.

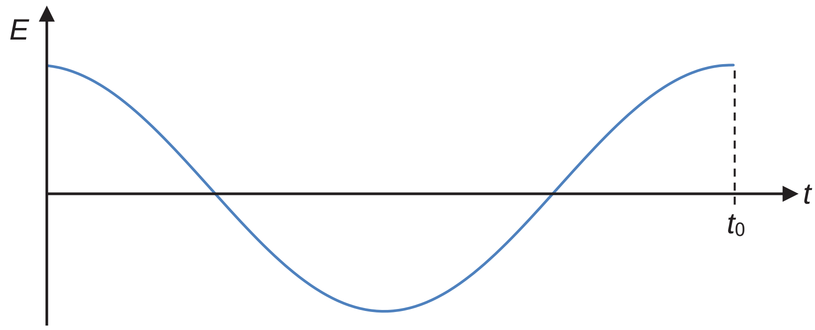


Fig. 5.2

Sketch, for one cycle of induced e.m.f., the variation with time of the

(i) flux ϕ in the **solenoid**,

[2]

(ii) net amount of charge Q which has flowed past a point in the solenoid.

[1]

(iii) Without changing other components in the setup, the number of turns per unit length of the solenoid in **(b)** is doubled.

By considering the magnetic flux, explain the changes (if any) to the induced current in the short coil.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(c) Fig. 5.3 shows a long solenoid which has a small copper disc mounted at its centre. The disc spins on an axle which lies along the axis of the solenoid. The solenoid is connected in series with a d.c. supply and a resistor of resistance *R*. By means of brushes, one terminal of the resistor is connected to the rim of the disc and the other (terminal A) is connected to the axle via a voltmeter.

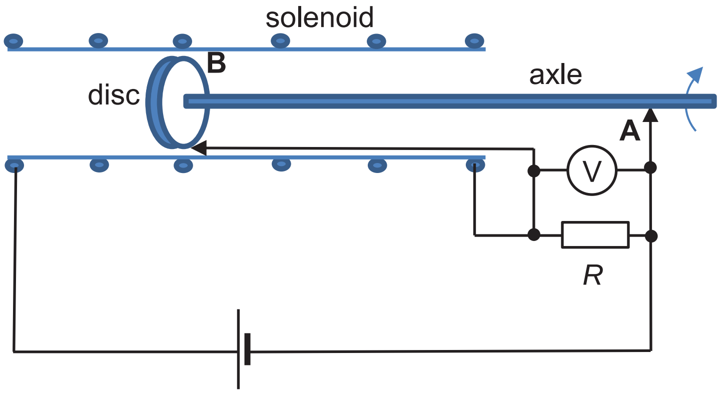


Fig.5.3

(i) Explain briefly why an e.m.f. is generated between the axle and the rim of the disc.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………… [2]

(ii) Suggest, with explanation, the reading on the voltmeter if terminal A is connected to the rim of the disc at point B.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………… [2]

6 A pulse of radio wave lasts for 2.0×10^{-5} s. A photon of the radio wave may be considered to be at a point anywhere within this pulse, although the location of the point is not known.

Determine

(a) the uncertainty in the position of the photon,

uncertainty in the position of the photon = …………………… m [1]

(b) the uncertainty in the momentum of the photon,

uncertainty in the momentum of the photon = …………………… kg m s^{-1} [2]

(c) the uncertainty in the frequency of the photon,

uncertainty in the frequency of the photon = …………………… Hz [2]

Section B

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

7 **(a)** The internal energy of a system is defined as the sum of random distribution of *kinetic and potential energies associated with the molecules of a system*.

(i) Comment on the origins of "*kinetic and potential energies associated with the molecules of a system*".

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(ii) Hence, explain how an increase in temperature relates to an increase in internal energy.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(b) The heating of a solid can change it into a liquid, while the heating of this liquid can change it into a gas.

(i) Define the specific latent heat of a substance.

…………………………………………………………………………………...

……………………………………………………………………………… [1]

(ii) Explain why the latent heat of vaporisation is greater than the latent heat of fusion.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(c) A cup of hot coffee purchased from the school canteen has a temperature of 85 °C. In order to drink the 250 g beverage before Physics lecture, a student placed five ice cubes, at –7.0 °C, of mass 5.0 g each, into the coffee. In order to speed up the rate of heat transfer, the student decided to stir the drink.

The following information is given:

latent heat of fusion of ice, l_f = 334 000 J kg^{-1}
specific heat capacity of ice c_I = 2100 J kg^{-1} K^{-1}
specific heat capacity of water c_W = 4200 J kg^{-1} K^{-1}
specific heat capacity of coffee c_C = 4300 J kg^{-1} K^{-1}

(i) Estimate the final temperature of the drink when all the ice has melted.

[3]

(ii) State two valid assumptions that you have made in your calculations.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………………… [2]

(d) A cube of volume V contains N molecules of an ideal gas. Each molecule has a component v_x of velocity perpendicular to one side W of the cube, as shown in Fig. 7.1.

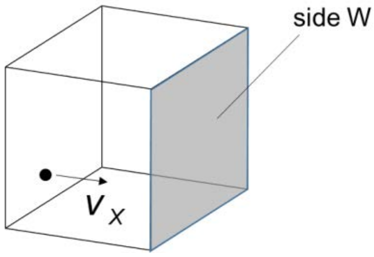


Fig. 7.1

The pressure p of the gas due to the component v_x of velocity is given by the expression

$$pV = Nm < v_x^2 >$$

where m is the mass of a molecule.

Explain how the expression leads to the relation

$$pV = \frac{1}{3}Nm < v^2 >$$

where $< v^2 >$ is the mean square speed of the molecules.

[3]

(e) When air is pumped into a canister rapidly, the adiabatic process can be represented by the line with an arrow as shown in Fig. 7.2.

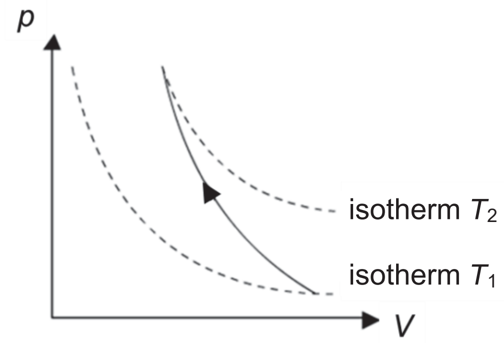


Fig. 7.2

(i) Explain how this type of change can be achieved.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(ii) State two conditions that could have made this process possible.

…………………………………………………………………………………...

…………………………………………………………………………………...

…………………………………………………………………………………...

……………………………………………………………………………… [2]

(iii) Hence, comment on the temperature T_2 of the air after pumping.

…………………………………………………………………………………...

……………………………………………………………………………… [1]

8 **(a)** The α-particle scattering experiment provided evidence for the existence of a nucleus.

Fig. 8.1 shows the paths of three α-particles moving towards a thin gold foil.

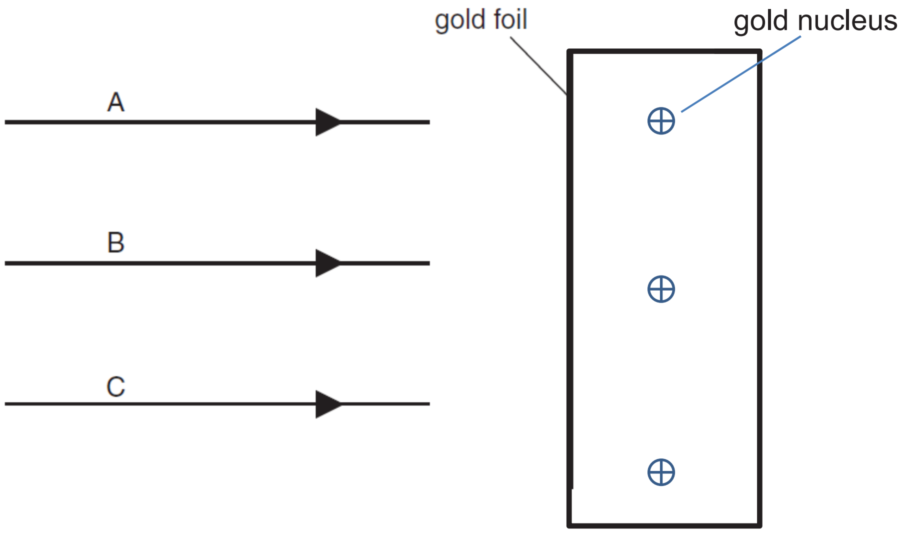


Fig. 8.1

Particle A is moving directly towards a gold nucleus.
Particle B is moving along a line which passes close to a gold nucleus.
Particle C is moving along a line which does not pass close to a gold nucleus.

(i) On Fig. 8.1, complete the paths of the α-particles A, B and C. [2]

State what could be deduced from the fact that

(ii) most α-particles were deviated through angles of less than 10°,

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(iii) a very small proportion of the α-particles was deviated through angles greater than 90°.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(b) An α-particle (${}^{4}_{2}He$) is moving directly towards a stationary gold nucleus (${}^{197}_{79}Au$).

The α-particle and the gold nucleus may be considered to be solid spheres with the charge and mass concentrated at the centre of each sphere.

When the two spheres are just touching, the separation of their centres is 9.6×10^{-15} m.

(i) The α-particle and the gold nucleus may be assumed to be an isolated system.

Calculate, for the α-particle just in contact with the gold nucleus,

1. the gravitational force it experiences,

gravitational force = …………………… N [2]

2. the electric force it experiences.

electric force = …………………… N [2]

(ii) Using your answers in **(b)(i)**, suggest why, when making calculations based on an α-particle scattering experiment, gravitational effects are not considered.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(c) In the α-particle scattering experiment conducted, the typical kinetic energy of the α-particles was 4.6 MeV.

(i) Estimate the closest distance of approach between an α-particle and a gold nucleus.

closest distance of approach = …………………… m [2]

(ii) Hence, suggest why the radius of the target nucleus could not be determined in this experiment.

……..……………………………………………………………………………

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

(d) The α-particles were mostly emitted from radon-222 gas which is a decay product of the radium-226 sample used in the experiment. The half-lives of radium-226 and radon-222 are 1.60×10^3 years and 3.82 days respectively.

(i) For a 5.0 mg sample of radium-226, show that there are 1.3×10^{19} radium nuclei.

[1]

(ii) Hence, deduce the activity of the 5.0 mg of radium-226 sample.

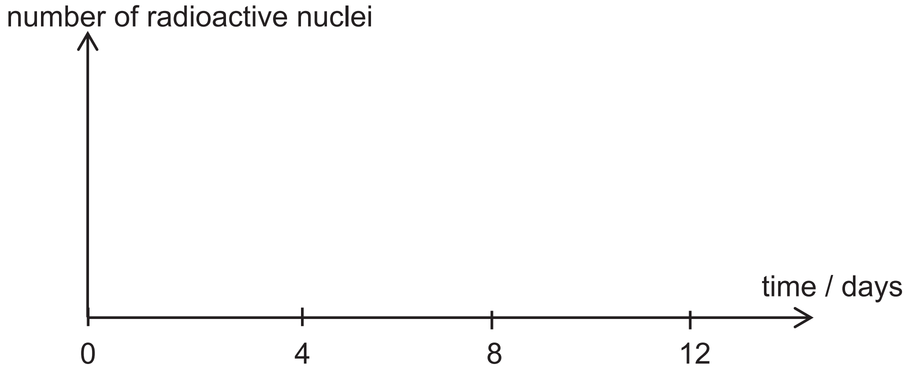
activity of radium-226 = …………………… Bq [2]

(iii) If there were 5.0 mg of radium-226 sample at the time of the experiment, determine the time it would take for the activity of radium-226 sample to drop by 10%.

time taken = …………………… years [2]

(iv) Using your answers from previous parts, sketch the variation with time of the number of radioactive nuclei of radium (label U) and radon (label O) on the axes provided, assuming there are equal numbers of both at the start.

Assume background radiation is negligible.



[2]

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RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIM EXAMINATIONS II

H2 PHYSICS 9749
PAPER 4

28 AUG 2017

2 HRS 30 MIN

CANDIDATE NAME										
CENTRE NUMBER	S					**INDEX NUMBER**				
CLASS	6									

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, class and index number above.

Candidates answer on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

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

Answer **all** questions.

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

SHIFT	
LABORATORY	
FOR EXAMINERS' USE	
1	**/15**
2	**/ 8**
3	**/ 20**
4	**/ 12**
TOTAL	**/ 55**

This document consists of **14** printed pages.

1 This investigation considers the time required to discharge a capacitor. Capacitors accumulate charge from a source of e.m.f., and discharges over a period of time when connected to a load.

(a) You are given a capacitor, a resistor of resistance *r*, a 2.00 V battery, a switch, an analog voltmeter and a digital multimeter that has been set to measure current in microamperes. The terminal of the capacitor labelled as "+" must be connected to the positive terminal of the battery, as shown in Fig. 1.1.

Using the digital multimeter as a microammeter (μA), set up the circuit as shown in Fig. 1.1.

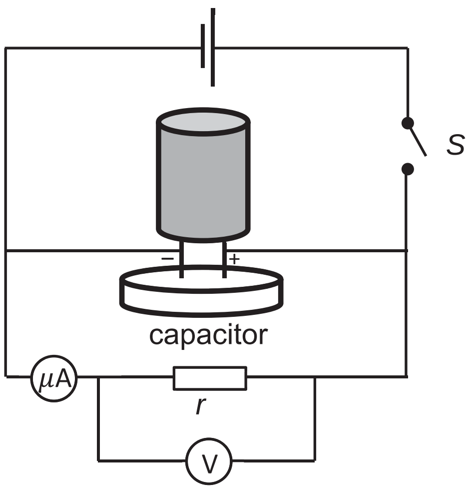

Fig. 1.1

(i) Close switch *S*.

(ii) The current through the ammeter will increase for a very short period of time. Measure and record the magnitude of the maximum current I_0 passing through the ammeter when the current stops increasing.

I_0 = …………………………… [1]

(iii) Record the reading on the voltmeter V_0.

V_0 = ……………………………

(iv) Open switch *S.*

(v) Given that $V_0 = I_0 r_{eff}$, calculate the effective resistance r_{eff} of the resistor and voltmeter in parallel.

r_{eff} = …………………………… [1]

(b) **(i)** Close switch S.

(ii) When the ammeter reading is equal to I_0, open switch *S* and start the stopwatch.

(iii) Record the time *T* taken for the ammeter reading to fall from I_0 to $I_0/2$.

T = ………………………… [1]

(iv) Estimate the percentage uncertainty in your value of *T* in **(b)(iii)**.

percentage uncertainty = ………………………… [1]

(c) **(i)** Close switch *S*.

(ii) When the ammeter reading is equal to I_0, open switch *S* and start the stopwatch.

(iii) At time *T* as found in **(b)(iii)**, measure and record V_T, the voltage across the resistor at that instant.

V_T = ………………………… [1]

(iv) Using the values obtained above, determine the effective resistance r_T of the system at time *T*. Show your working clearly.

r_T = ………………………… [1]

(d) In another similar setup, the resistor is replaced with a light bulb. When V_0 was applied across the light bulb and voltmeter, the current I_0 passing through the light bulb was found to be 0.400 A.

Use your results to predict the current $I_{1/2}$ that passes through the light bulb when the voltage across the light bulb and voltmeter is equal to $V_0/2$.

$I_{1/2}$ = ………………………… [1]

(e) It is suggested that the **time** $t_{1/2}$ required for the current passing through the ammeter to decrease to half its initial value is <u>directly proportional</u> to the **effective resistance** R, and is not affected by the magnitude of the **e.m.f. provided**.

Making use of the additional accumulator and resistor, take further measurements to investigate this suggestion.

State and explain whether or not you agree with this suggestion.

Present your measurements and calculated results clearly.

……………………………………………………………………………………………

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……………………………………………………………………………………………

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

(f) One common application of such circuits is to power the bright flashes used in photography. Connecting a capacitor to a battery allows it to charge up, and when connected to a load such as a camera flash, it discharges by releases energy over a certain length of time. Outdoor photographers may find that the camera flash functions differently during extremely cold winters.

Suggest one change that could be made to this investigation in Singapore to safely study how the discharge time changes at different temperatures. State any relevant precautions or steps taken to quantify this change.

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

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

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

[Total: 15 marks]

2 In this experiment, you will investigate how the heating of a mass of boiling water is affected by the addition of metal mass of a different temperature.

(a) **(i)** Set up the apparatus as shown in Fig. 2.1.

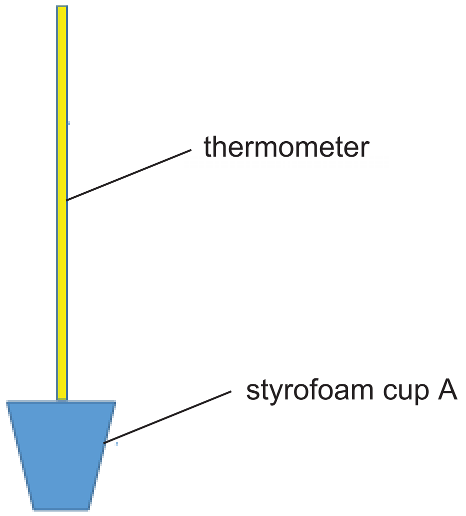

Fig. 2.1

Using a measuring cylinder, fill styrofoam cup A with 100 cm^3 of tap water.

Measure the temperature of the water, t_o.

t_o = ……………………………

(ii) Fill styrofoam cup B with hot water of temperature t_h between 55 °C to 90 °C and place the 100 g mass provided in it. Stir the water and wait for the temperature to stabilise.

Measure the temperature of the hot water with mass, t_h.

t_h = …………………………… [1]

(iii) With a string, transfer the 100 g mass from the cup B to cup A.
Stir the water and wait for the temperature of cup A to stabilise.
Measure the final temperature T of the water and masses in cup A.
Remove the mass and pour away the water in cup A.

T = …………………………… [1]

(b) Repeat **(a)** for three different values of temperature between 55 °C and 90 °C for t_h for the given mass.

Complete Fig. 2.2.

t_o / °C	t_h / °C	T / °C	$(T - t_o)$ / °C	$(t_h - T)$ / °C

Fig. 2.2 [2]

(c) It is suggested that the relationship between temperature increase $(T - t_o)$ in cup A and temperature decrease of the mass is related by

$$t_h - T = k\,(T - t_o)$$

where k is a constant.

(i) Using your data in Fig. 2.2, plot $(t_h - T)$ against $(T - t_o)$, on Fig. 2.3. [2]

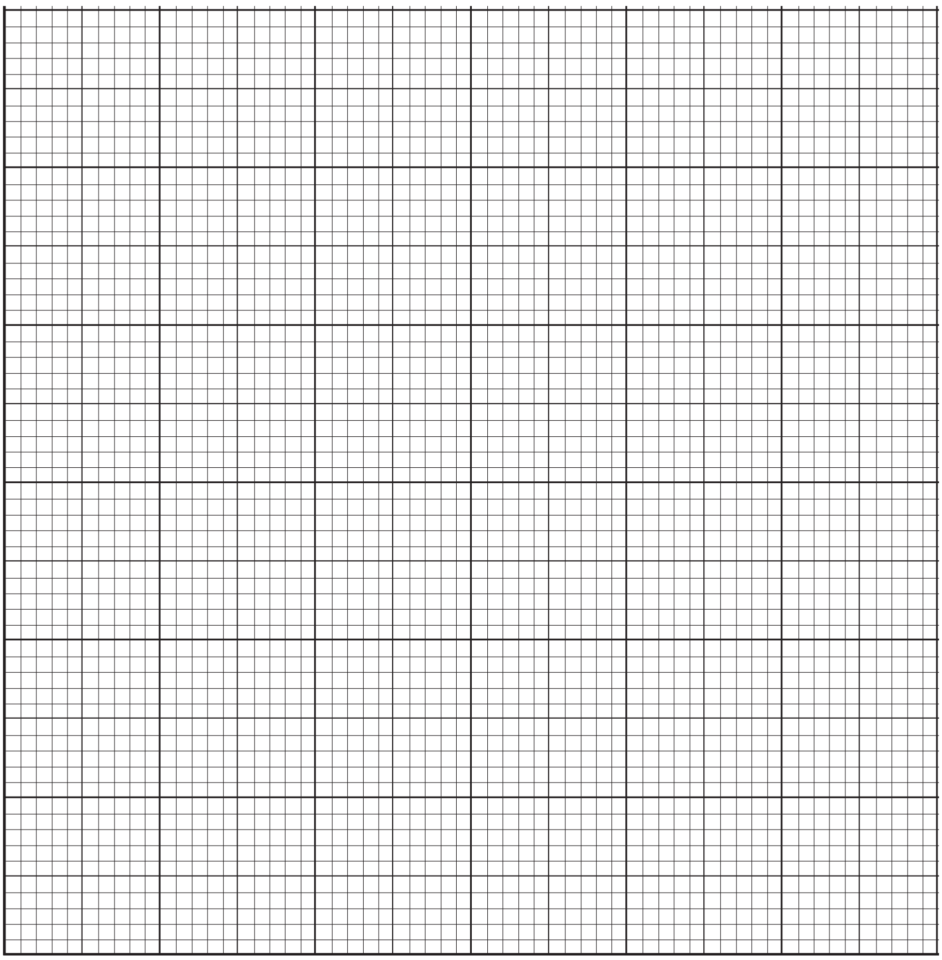

Fig. 2.3

(ii) Hence determine the gradient of the plotted graph in Fig. 2.3.

gradient = ……………………… [1]

(d) Describe one source of uncertainty or limitation of the procedure for this experiment.

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

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

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

[Total: 8 marks]

3 In this experiment, you will investigate the length of a loaded spring as the load is varied.

(a) Measure and record the length L of the long metal rod as shown in Fig. 3.1.

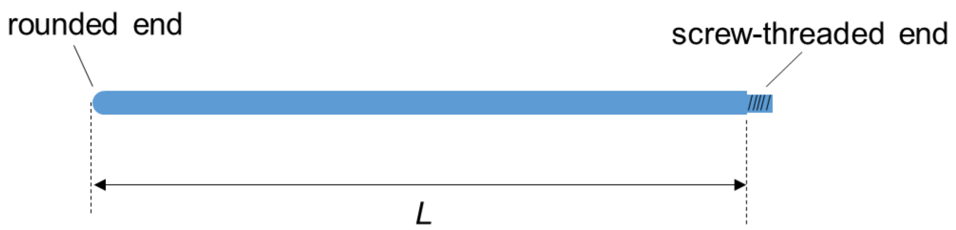

Fig. 3.1

L = ...

(b) **(i)** Support the rod as shown in Fig. 3.2.

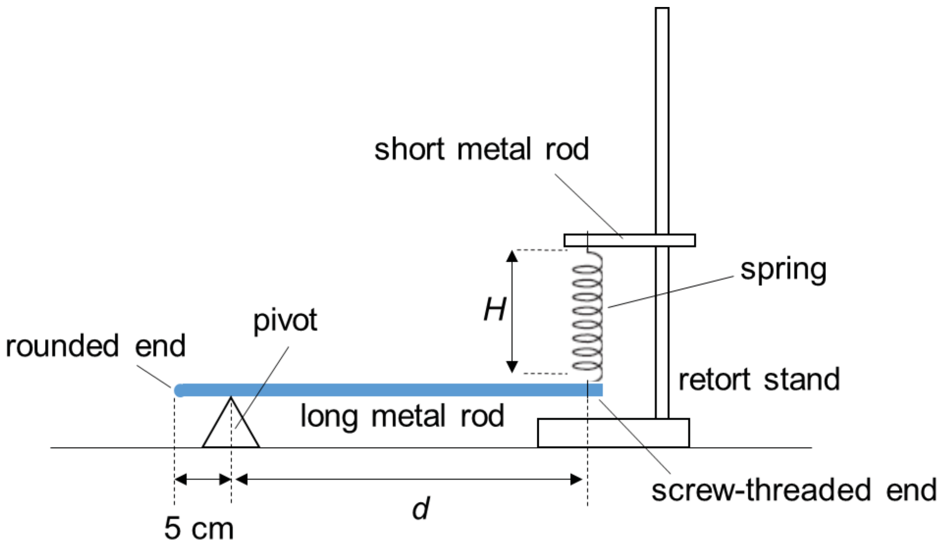

Fig. 3.2

(ii) Adjust the position of the pivot so that it is approximately 5 cm from the free end of the rod.

(iii) Adjust the clamp so that the rod is horizontal and the spring is vertical.

(c) **(i)** Measure and record the length H of the coiled part of the spring and the distance d from the pivot to the point where the spring is hooked to the rod.

H = ... [1]

d = ...

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

percentage uncertainty = ………………………………… [1]

(d) Repeat **(b)(ii)**, **(b)(iii)** and **(c)(i)** to obtain further sets of readings for *d* and *H*.

[6]

(e) Theory suggests that *d* and *H* are related by the equation

$$H = z\left(\frac{W}{k}\right)\left(\frac{1}{d}\right) + \left(\frac{W}{k}\right)$$

where *W* is the weight of the rod, *k* is the spring constant of the spring, given to be 25 N m^{-1} and *z* is a constant.

Plot a suitable graph to determine *W* and *z*.

W = …………………………………

z = ………………………………… [4]

[3]

(f) Suggest a physical meaning for the constant *z*.

……………………………………………………………………………………………

……………………………………………………………………………………… [1]

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

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………… [1]

(h) **(i)** State one significant source of error in this experiment.

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

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

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(i) Sketch another line on your graph to represent an experiment performed with a heavier rod. Label this graph **Q**.

[1]

[Total: 20 marks]

4 Beta particles can be deflected by magnetic fields.

Design a laboratory experiment to investigate how the magnetic flux density B of a magnetic field affects the angle θ through which beta particles are deflected when they pass through a uniform magnetic field.

The only radioactive source that is available to you emits α, β and γ radiation.

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

(a) the procedure to be followed,
(b) the method by which beta particles **only** would be detected,
(c) the method of measuring the angle of deflection,
(d) how the magnetic field would be produced, measured and changed,
(e) any reliability and safety precautions you would take.

Diagram

....

....

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[Total: 12 marks]

END OF PAPER

PRELIMINARY EXAMINATIONS II
H2 PHYSICS 9749/1 answers

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

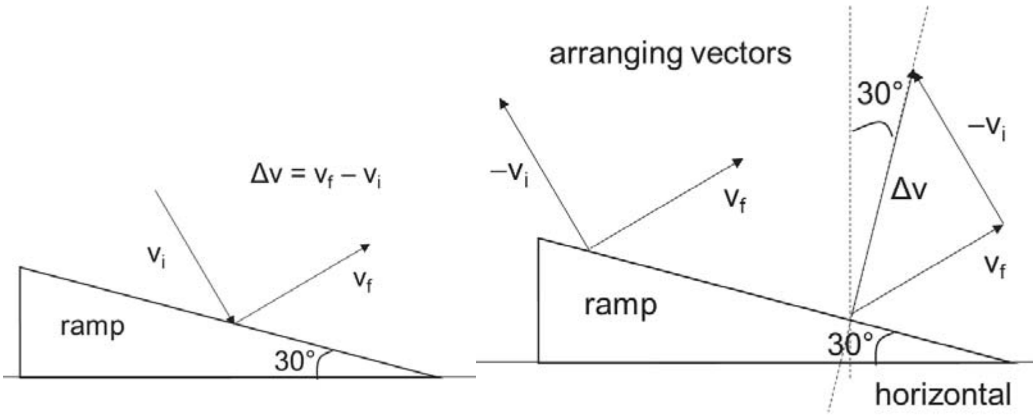
PRELIMINARY EXAMINATIONS II
H2 PHYSICS 9749/2 suggested answers

1 **(a)** **(i)**
- Systematic errors have same magnitude while random errors have different magnitude.
  Or
  Systematic errors are predictable depending on the conditions while random errors are not.
- Systematic errors are either consistently larger or smaller than the true value while random errors scatter about a mean value. (refers to sign of the error)
- Systematic error can be eliminated while random error can only be reduced.

[Award 1 mark for each comparison]

(ii) Random errors can be reduced by plotting a graph and drawing a line of best fit for the points. (do not accept "averaging of data")

(b)



M1 for determining the direction of Δv using $\Delta v = v_f - v_i$

Since Δv is 90° to the surface of the ramp, Δv is 60° with respect to the horizontal [A1]

$$A^2 = B^2 + C^2 - 2BC\cos A$$
$$\Delta v^2 = 5^2 + 5^2 - 2(5)(5)\cos 90^\circ$$ [M1]

$$\Delta v = 7.1\ m\,s^{-1}$$ [A1]

(c)

$$\left(p+\frac{a}{V_m^2}\right)(V_m-b)=RT$$

$$pV_m-pb+\frac{aV_m}{V_m^2}-\frac{ab}{V_m^2}=RT$$

$$b=V_m \text{ and } a=pV_m^2$$

$$\text{unit of } b=m^3mol^{-1}$$

$$\text{unit of } a=Pa\,m^6mol^{-2}=kgm^5s^{-2}mol^{-2}$$

2 **(a)** Horizontal:

$s=vt\cos\theta$ [M1]

Vertical:

$v_f-v_i=at$

$v_f=-v_i=v\sin\theta$

$\frac{2v\sin\theta}{g}=t$ [M1]

Combining both,
[M1 for the act of combining together]

$$s=\frac{2v^2\sin\theta\cos\theta}{g}$$

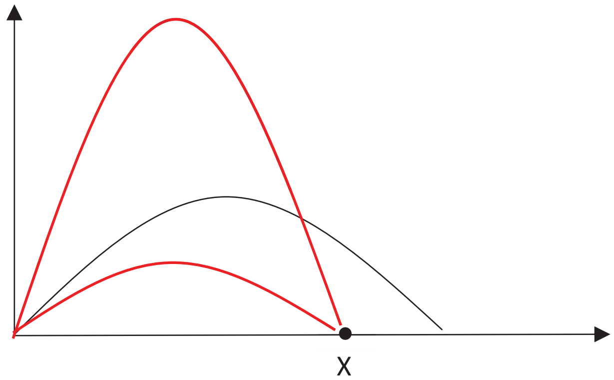
$$=\frac{v^2\sin 2\theta}{g}$$

(b)

$$d=\frac{v^2\sin 2\theta}{g}$$

Max d occurs when sin 2Θ = 1 and Θ = 45 deg [1]

(c)



3 (a) **Density** is defined as the mass per unit volume of a substance.

Pressure is defined as force per unit area, where the force is acting at right angles to the area.

(b) The force F on a surface area A due to surrounding pressure p is given by

$$p = \frac{F}{A}$$

(Note: This force is directed perpendicularly into the surface.)

$$p = \frac{mg}{A}$$

Since density, ($\rho = \frac{m}{V}$),

$$\therefore p = \frac{(\rho V)g}{A}$$

where V is the volume of the fluid above the cross-sectional surface ($V = hA$),

$$\therefore p = \frac{\rho(hA)g}{A} = \rho gh$$ [M1 – do not allow marks for just giving the formula]

⇨ Hence, the pressure at the top face of the body is $p_1 = \rho g h_1$ and force F_1 is $F_1 = \rho g h_1 A$ [M1]

⇨ Similarly, the pressure at the bottom face of the body is $p_2 = \rho g h_2$ and force F_2 is $F_2 = \rho g h_2 A$

⇨ Hence, these two forces result in an upward force on the body, Upthrust $= F_2 - F_1 = \rho g(h_2 - h_1)A = lA\rho g = V_{\text{fluid displaced}}\rho g$ [A1]

(c) (i) Upwards – Upthrust from centre of mass of displaced fluid.
Downwards – Weight from CG

(ii) $upthrust = \rho g V$
Resultant force = upthrust – weight of wood
= (1000 – 430) x 9.81 x 7 x 10^{-5}
= 0.391 N

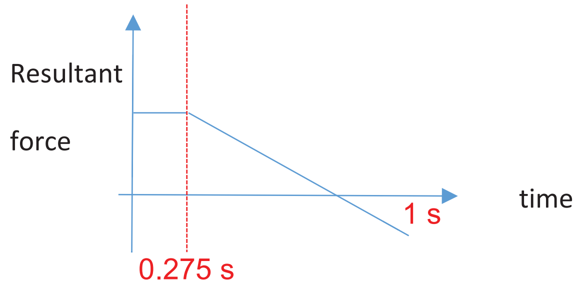
(iii) F=ma
a= 0.391/0.295 = 1.32 ms^{-1}

s = ut + ½ at^2

0.05 = ½ (1.32) t^2

t = 0.275 s

(iv)



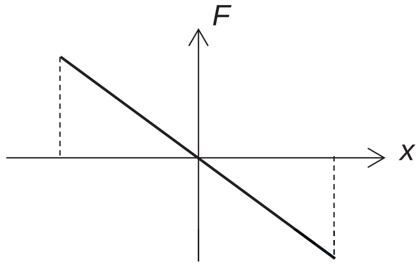
4 **(a)** **(i)** Taking right as positive,
force due to left spring = $-k(e + x)$ and
force due to right spring = $k(e - x)$ C1
resultant force = $-k(e + x) + k(e - x)$ M1
= $-2kx$

(ii) For SHM, $a = -\omega^2 x$ and from (a)(i), $F = -2kx = ma$ (from Newton's second law), hence $a = -(2k / m)x$
so a is directly proportional to x and oppositely directed.

(b) **(i)** $a = -\omega^2 x = -(2k / m)$
$F = -2kx = m$
so $\omega^2 = 2k / m$
$= (2 \times 9.0) / 0.037$
$\omega = 22$ rad s^{-1}

(ii) Solution 1:
total energy of SHM = $\frac{1}{2} m\omega^2 x_0^2$
= $\frac{1}{2} \times 37 \times 10^{-3} \times (22)^2 \times (2.8 \times 10^{-2})^2$
= 7.0×10^{-3} J

Solution 2:
total energy of SHM = WD on system = ½ $F\,x$ where $F = -2kx$



Solution 3:
1. At equilibrium, EPE of 2 springs = $2 \times \frac{1}{2} ke^2 = ke^2$
2. Displaced by x to the right, EPE of 2 springs = $\frac{1}{2} k(e + x)^2 + \frac{1}{2} k(e - x)^2$
= $ke^2 + kx^2$
3. Total energy of oscillations = WD on system = Gain in EPE = kx^2

(iii) Solution 1:
$E_K = E_P$
$\frac{1}{2} m\omega^2 (x_0^2 - x^2) = \frac{1}{2} m\omega^2 x^2$
$x = x_0 / \sqrt{2} = 2.8 / \sqrt{2}$
= 0.020 m

$E_K = E_P = ½E_T$ (because $E_K + E_P = E_T$ and $E_K = E_P$)
Solution 2:
$E_K = 3.5$ mJ
$E_K = ½m\omega^2 (x_0^2 – x^2)$

Solution 3:
$E_P = 3.5$ mJ
$E_P = ½m\omega^2x^2$

5 **(a)** **(i)**

Wavelength is found by $$\lambda = \frac{v}{f} = \frac{3.00 \times 10^8}{3.0 \times 10^4} = 10^4\text{m}$$
Phase difference is found by $$\frac{\phi}{2\pi} = \frac{\text{d}}{\lambda}$$ $$\phi = \frac{2\pi d}{\lambda} = \frac{2\pi(5 \times 10^3)}{10^4} = \pi$$

(ii) Three possible reasonings accepted:

Waves travelling by Path B undergo a total phase difference of 3π (2π from path, π from reflection). [π also accepted as an answer]
Since the phase difference between the two paths is 2π, it undergoes constructive interference.

Path difference between the two waves give a phase difference of π.
After the phase change due to reflection, the total phase difference is 2π, hence constructive interference.

After waves on path B have hit the ground and reflected, they are in phase with the source.
Since they are in phase with the source, and distance from source to antenna is same as distance from ground to antenna, the waves on both paths will be in phase with each other at the antenna and constructive interference occurs.

(b) **(i)** Possible accepted answers take two forms:

• If the waves are emitted in all directions, the intensity of the wave decreases proportional to r^2 <u>**OR**</u> some energy is not delivered to the antenna. • In contrast, since the wave is confined inside the tube, 100% of energy is delivered to the antenna. *Note: "nearly all energy" also accepted as student is accounting for real life energy losses*
• Stating that all the waves are collected at antenna instead of being diffused. • Stating that hence the intensity (or power) is greater vs being dispersed.

(ii) Standing waves form when two waves of **same speed/frequency/wavelength** *(pick 2 out of 3)* meet each other travelling in **opposite** directions (*Note: Mark not given if student does not mention these conditions)*

When waves **reflect off the inside of the waveguide**, the incident and reflected waves thus form standing waves.
Do not accept "waves reflect off open end", but can accept if student says wave reflects off ***antenna***.

(c) Lower frequency means higher wavelength.
Waves with a larger wavelength have wider diffraction, hence the 90.5 MHz broadcast is better able to diffract around the hill.

6 (a) (i) R = V/I = 0.13 / 150 C1
= $8.7 \times 10^{-4}\ \Omega$ A1

(ii) $A = \pi r^2 / 4 = 4.524 \times 10^{-6}$ C1
$\rho = RA / l$ C1
resistivity of copper = $1.6 \times 10^{-8}\ \Omega$ m A1

(b) (i) number of electrons per unit volume,
$n = (1.6 \times 10^{18}) / [(4.524 \times 10^{-6})(0.24)]$
= **1.474×10^{24} m^{-3} C1

$I = nAve$ C1
drift velocity v = 140 m s^{-1} A1

** erratum: n should work out to be 8.45×10^{22} m^{-3} for copper so the number of electrons in the cable should be 9.23×10^{22} instead of 1.6×10^{18}.

(ii) If the diameter of the cable is doubled, the cross-section area of the cable will be quadrupled.
Given that current, electron density and electronic charge are the same, drift velocity is a quarter of the calculated value because v is inversely proportional to A.

7 (a) Assume that transformer is 100% efficient, so power in primary coil is fully transferred to secondary coil in transformer.

$$I_{\text{transmission}} = \frac{P}{V} = \frac{1000000}{300000} = 3.3333\text{A}$$

$$\text{Power lost} = I^2 R = \frac{10^2}{3}(8000) = 88888\text{W} \qquad \text{[C1]}$$

$$= 89\text{ kW (2sf)} \qquad \text{[A1]}$$

(b) for equivalent d.c. voltage of 12 V,
single diode half-wave rectified a.c. peak square voltage = $12^2 \times 4 = 576$
peak voltage = $\sqrt{576} = 24\text{ V}$

r.m.s voltage for full sine-wave = $\frac{24}{\sqrt{2}} = 16.971\text{V}$

turn ratio = $\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{240}{16.971} = 14$

8 **(a)** **(i)** When potential difference is positive, photoelectric current remains constant at 370 μA.
[B1]
As potential difference decreases from zero, the photoelectric current decreases gradually to zero at a potential difference value of –1.11 V.
[B1]

Only award 1 mark if students describe the changes without quoting any values.

(ii) Reading horizontal intercept from graph.
–1.11 V
Acceptable magnitude range: 1.10 < V_s < 1.16

(iii) $E_{photon} = \phi + E_{K\,\max}$

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

$$\lambda = \frac{hc}{\phi + eV} = \frac{(6.63 \times 10^{-34})(3 \times 10^{8})}{(2.3 + 1.11)(1.6 \times 10^{-19})} \quad \text{[C1]}$$

$$= 3.1472 \times 10^{-7} = 365\text{nm} \quad \text{[A1]}$$

Allow e.c.f. for stopping potential from (ii).

(iv) $E_{photon} = \phi + E_{K\,max}$

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

$$V_s = \frac{\frac{hc}{\lambda} - \phi}{e} = \frac{\frac{(6.63\times10^{-34})(3\times10^{8})}{(405\times10^{-9})} - (2.3)(1.6\times10^{-19})}{1.6\times10^{-19}} \qquad \text{[C1]}$$

$= 0.7694\text{V}$ [A1]

(v) $I = 370\times10^{-6}\ \text{A} = Q/t$

$$\frac{n}{t} = \frac{370\times10^{-6}}{1.6\times10^{-19}}$$

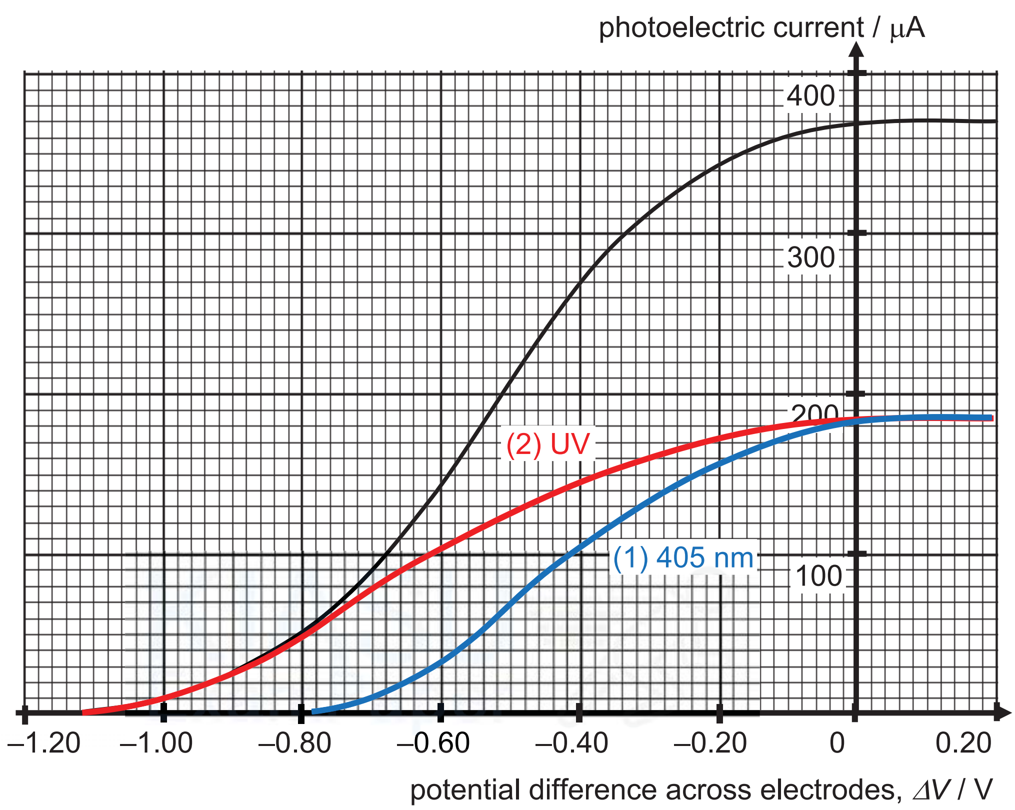
$$P = \frac{nhc}{t\lambda}$$

$$= (0.5)\frac{370\times10^{-6}}{1.6\times10^{-19}}(6.63\times10^{-34})(3\times10^{8})\left(\frac{1}{405\times10^{-9}} + \frac{1}{365\times10^{-9}}\right) \qquad \text{[C1]}$$

$$= (0.5)2.39585\times10^{-3}$$

$= 1.2\times10^{-3}$ W [A1]

(vi)



Correct stopping potentials for (1) and (2) (allow ecf) [B1]
Correct saturation current at 185 μA [B1]
If curves are not smooth –1 mark

(b) (i)

f / 10^{14} Hz	V_S / V
7.2	0.72
8.2	1.13
9.1	1.49

Correctly calculated values which follow dp of columns [B1]
Allow e.c.f using (7.4, 0.77) or other quoted V_s value from (a)(ii).

(b) (ii)

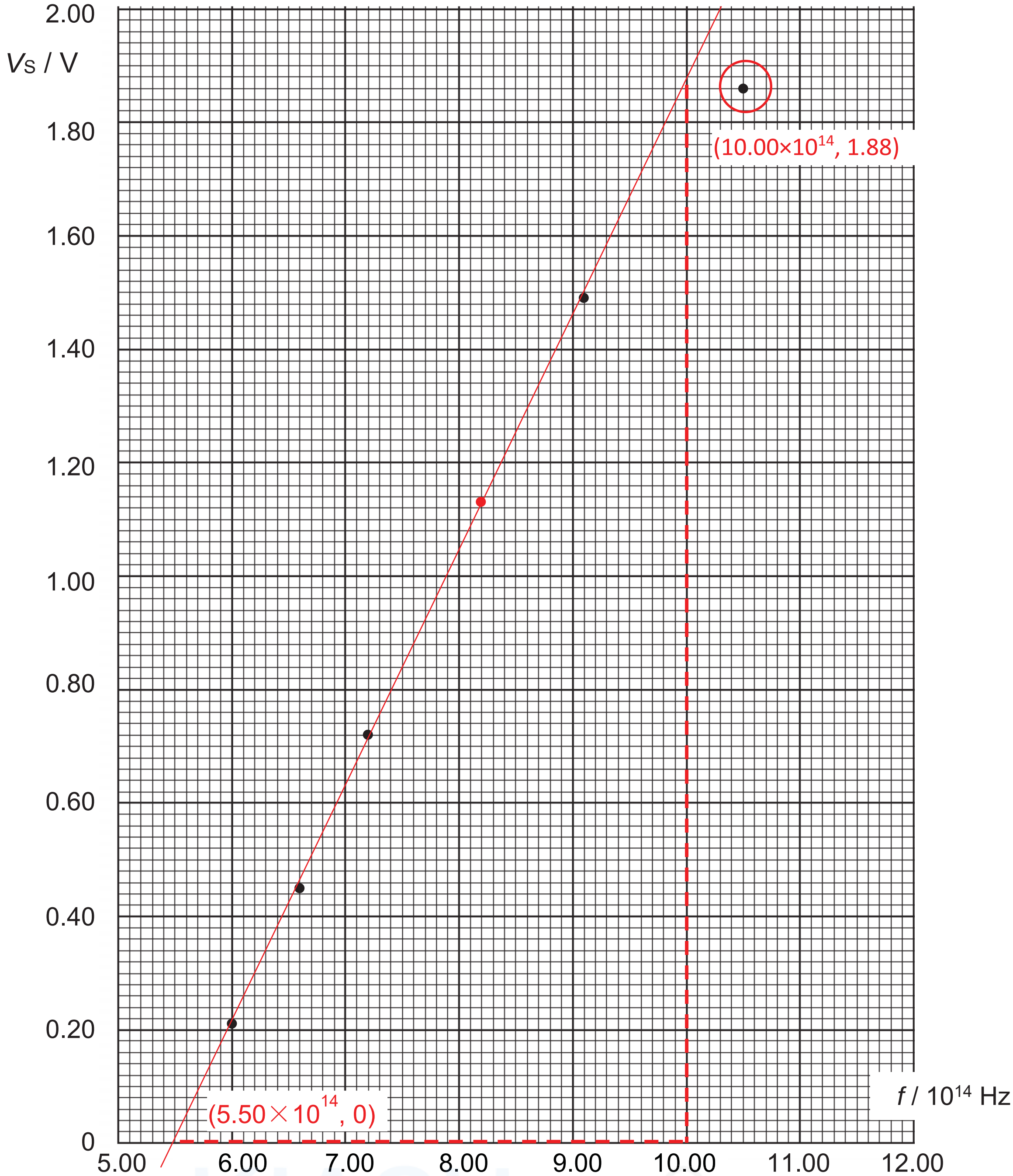


Fig. 8.4

Correctly plotted point accurate to half smallest division [B1]
Best fit line has appropriate scatter with identification of anomalous point [B1]

(iii)

$$\text{gradient} = \frac{1.88 - 0}{10.00 \times 10^{14} - 5.50 \times 10^{14}} \quad [C1]$$

$$= 4.17778 \times 10^{-15}$$

$$= 4.18 \times 10^{-15} \text{ Vs} \quad [A1]$$

(iv) Gradient should represent h/e with theoretical value of 4.14×10^{-15}. [M1]
Calculated gradient is 0.88% deviation from theoretical value, which is insignificant. [B1]
Graph supports the expression given in (b). [A0]

(v) The vertical intercept *C* represents the negative value of work function of the metal divided by elementary charge. [B1]
If work function is larger, the graph will be shifted/translated downwards for a more negative vertical intercept. [B1]

PRELIMINARY EXAMINATIONS II
H2 PHYSICS 9749/3 suggested answers

1 **(a)** **(i)**

Let m be the mass of the ion, v_{ion} be the final speed of the ion and v_c the final speed of the carbon nucleus. Take right as positive.
Momentum is conserved: $mv = mv_{ion} + 12mv_c$
Can simplify this to $v = v_{ion} + 12v_c$
Elastic collision: $v = v_c - v_{ion}$ Alternatively, apply conservation of energy
Solve for v_c by eliminating v_{ion}: $v = (v_c - v) + 12v_c$ $v_c = 2/13\ v = 0.154\ v$ (to 3 s.f.)

(ii) For collisions between two particles of **<u>equal mass</u>**, **<u>all KE (or momentum)</u>** is imparted / exchange speeds / similar answer
[note: do not award for "greater mass → more KE" (not always true)]
It will be **<u>more effective.</u>**

(b) **(i)** Upwards

(ii)

Method 1:	Method 2:
The force exerted on the ions is equal to $$F = \frac{dP}{dt} = \frac{d(mv)}{dt} = \frac{dm}{dt}v$$	By CoM, each ion fired results in the spacecraft gaining $$\Delta p = m_{xenon} \times v_{xenon}$$
The rate at which mass is ejected is $$\frac{dm}{dt} = \frac{dN}{dt} \times m_{xenon}$$	Force is equal to the rate at which momentum changes: $$F = \frac{\Delta p}{\Delta t} = \Delta p \times rate\ of\ fire$$
Using F = ma, $$m_{spaceship} \times a = \frac{dN}{dt} \times m_{xenon} \times v_{xenon}$$ $$a = \frac{(2.29 \times 10^{19})(2.18 \times 10^{-25})(40.0 \times 10^3)}{500} = 3.99 \times 10^{-4} m\ s^{-2}$$	

(iii)

Time taken = 1 km / (13.0 km s^{-1}) = 0.0769 s
Apply s = ut + ½ a t^2 in the vertical direction: $$s_y = 0 + \frac{1}{2}(3.99 \times 10^{-4})(0.0769)^2$$
Answer is 1.18 × 10^{-6} m

(iv)

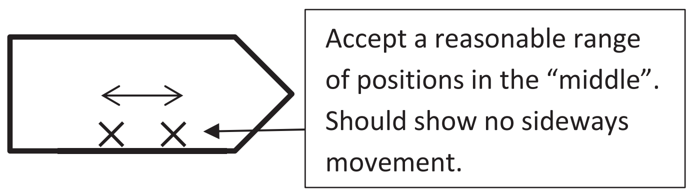


Fig. 1.3

		(v)	Box must accelerate together with the spacecraft. $F = ma = (2\text{ kg})(3.99 \times 10^{-4}\text{ m s}^{-2})$ $F = 7.98\text{ N}$
2	**(a)**	**(i)**	Work done is area under graph from (0.00,40) to (4.00,80) *[Mark given for identifying the correct values or parts of the graph, accept up to 90 for higher bound. For counting squares, the method mark will go to using the right number of squares.]* Area under graph: $\frac{1}{2} \times (4.00 \times 10^{-3}\text{ m})(40 + 80) \times 10^{-2}\text{ N} = 2.4 \times 10^{-3}\text{ J}$ *[Mark is given for putting in the correct values and getting a result within the range of up to $\pm 0.2 \times 10^{-3}$ J]* *[other methods of calculation or estimation also allowed, e.g. counting squares.]*
		(ii)	$\Delta GPE = mgh = 0.082 \times 9.81 \times 0.004$ *(method mark given for either correct numbers put in, or if that isn't done, mark can be given if student explicitly writes the correct equation)* Ans: –3.2 × 10^{-3} J
		(iii)	Kinetic energy of the key at 4.00 mm is equal to |ΔGPE| – |WD| by *F*. Since KE of key is positive [or |ΔGPE| > |WD|], it is able to reach 4.00 mm. *[mark with ecf based on students' answers to (i) and (ii)*
	(b)	**(i)**	Conceptual understanding: • In one full loop, there is no change in GPE. • When pressing down the key, typist does work against spring, spring is doing negative work (i.e. storing potential energy). • When releasing the key, the spring is doing positive work to push the key back, i.e. typist is doing negative work. • Hence, net work done by the typist is positive while net work done by spring is negative. • Magnitude of net work is the area bounded the graph. Estimate area as a parallelogram from 0 mm to 2 mm: $A = 0.002\text{ m} \times (15 \times 10^{-2}\text{ N})$ *[other reasonable methods are allowed, e.g. finding area of other curve and subtracting, counting squares, etc]* Ans: – 3.0 × 10^{-4} J *[accept up to $\pm 1 \times 10^{-4}$ J; student loses A1 if +^{ve} ans is given]*
		(ii)	Average power = work done / time = rate of keystrokes × work done per keystroke = (500/60) × 3.0 × 10^{-4} Ans: 2.5 × 10^{-3} J *[mark magnitude of ans based on value provided by student in part (i). Accept +^{ve} even if student gave positive value in part (i) to account for assuming magnitude; accept –^{ve} ans iff student gave +^{ve} ans in part (i)]*

1 **(a)** Two planets, P and Q, are orbiting about a common point, O. Planet P has half the density of Q, but twice the radius of Q.

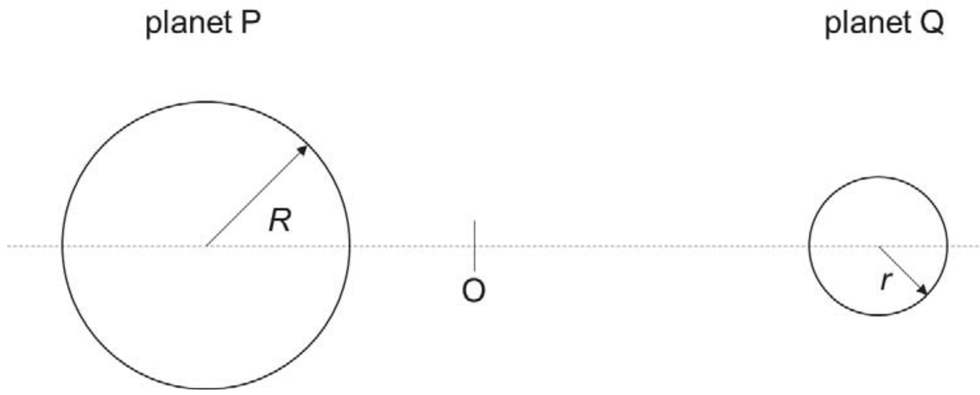


Fig. 2.1

(i) Show that the ratio of mass of planet Q to planet P is given by $\frac{1}{4}$. [2]

$$m_P = \rho_P V_P \qquad V_P = \frac{4}{3}\pi R^3$$

$$m_Q = \rho_Q V_Q \qquad V_Q = \frac{4}{3}\pi r^3 \qquad \text{[M1]}$$

$$\frac{m_Q}{m_P} = \frac{\rho_Q V_Q}{\rho_P V_P} = \frac{2\rho_P (r)^3}{\rho_P (2r)^3} \qquad \text{[M1]}$$

$$= \frac{1}{4} \qquad \text{[A0]}$$

(ii) Planet P is found to have an orbit period of T and the distance from the surface of planet P to planet Q is $10R$. Hence, derive an expression for the radius of orbit of planet P.

Gravitational force provides for centripetal force [M1]

$$\frac{Gm_P m_Q}{(11R+r)^2} = m_P x \omega^2 \qquad \text{[M1]}$$

$$x = \frac{Gm_Q T^2}{4\pi^2 (11R+r)^2} \qquad \text{[A1]}$$

Other forms of expression accepted as long as the Physics is correct

……… [3]

(b) A circ… planet P. A pendulum bob of mass m tied to a string of length L is set to swing in a horizontal circle. The string makes an angle of 35° with the vertical, as shown in Fig. 2.2. Take the gravitational acceleration to be g.

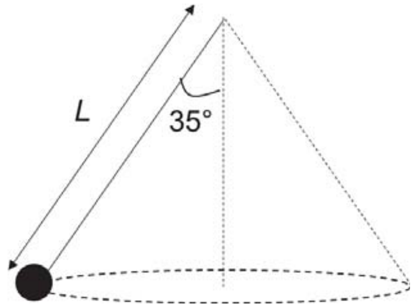


Fig. 2.2

(i) Find the tension in the string. [2]

vertical component of T = Tcos35° = mg [M1]

$$T = \frac{mg}{cos35^\circ} = 1.22mg$$ [A1]

(ii) Hence, determine the expression for the speed of the bob. Leave the numerical part of your answer to 2 s.f.

radius of circular motion, r = Lsin35° [M1]

horizontal component of T = Tsin35°

$$Tsin35^\circ = \frac{mv^2}{L}$$ [M1]

$$1.22gLsin^2 35^\circ = v^2$$

$$v = 0.63\sqrt{gL}$$ [A1]

……………….. [3]

2	(a)	With reference to a point in an electric field, define the term *electric potential*.			
		Definition of Electric Potential: The electric potential V at a point in an electric field is defined as the ***work done against the electric force per unit positive charge*** by an ***external agent*** in bringing a small test charge ***from infinity to that point*** (***without any net change in K.E.*** of the point charge).			
		....			
		....			
		....			[1]
	(b)	Two identical negatively charged particles X and Y, each of mass 2.7 ×10^{-26} kg and charge −3.2 ×10^{-19} C are held at a distance 1.0 ×10^{-9} m apart.			
		(i)	Calculate the electric potential energy of the system. E.P.E. of system $= \dfrac{q^2}{4\pi\varepsilon_0 r}$ $= \dfrac{(-3.2\times10^{-19})^2}{4\pi\times8.85\times10^{-12}\times1.0\times10^{-9}}$ $= 9.2\times10^{-19}$ J		
			electric potential energy = ... J		[2]
		(ii)	Calculate the relative speed of separation when they are very far apart after they are released.		
			By the conservation of energy, loss in E.P.E. of system = gain in K.E. of system $9.2\times10^{-19} = 2\left(\frac{1}{2}mv^2\right)$ $v = \sqrt{\dfrac{9.2\times10^{-19}}{2.7\times10^{-26}}}$ M1 v = 5.8×10^{3} m s^{-1} relative speed of separation is 2 x 5.8×10^{3} M1 = 1.2×10^{4} m s^{-1} A1		
			relative speed of separation = ... J		[3]
		(iii)	With the two charges held at rest at 1.0 ×10^{-9} m apart, a third charge Z is placed at the mid-point along XY so that the system of charges is stationary.		

1. State and explain the sign of the third charge in order for the system of charges to be stationary.

In order for the either of the negative charges to be stationary, the resultant force must be zero. Since charge X exerts a repulsive force on charge Y, the third charge must exert an attractive force on charge Y, hence it must be a positive charge.[M1]

The sign of the third charge is positive.[A1]

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

2. Calculate the magnitude of charge Z.

$$F_{YZ} = F_{YX}$$

$$\frac{q_Y q_Z}{4\pi\varepsilon_0\left(\frac{1}{2}r\right)^2} = \frac{q_Y q_X}{4\pi\varepsilon_0 r^2}$$

$$\frac{q_z}{\left(\frac{1}{2}\right)^2} = q_x$$

$$q_z = \frac{1}{4}(3.2 \times 10^{-19})$$

$$q_z = 8 \times 10^{-20}\ \text{C}$$

magnitude of charge = ……………………….. C [2]

2 (a) Define magnetic flux.

Magnetic flux Φ is defined as the product of the area of the surface through which the field is passing, and the component of the magnetic flux density B that is normal (perpendicular) to this surface.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Fig. 2.1 shows a short coil wound over the middle part of a long solenoid. Both the coil and solenoid are made of wires with uniform cross-sectional area.

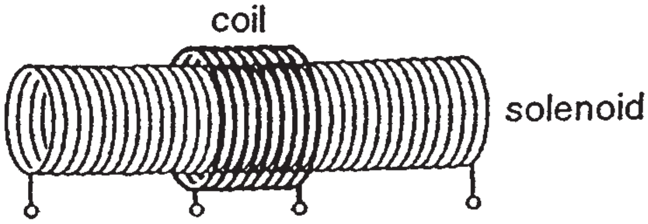


Fig. 2.1

The e.m.f. *E* induced in the short coil is varied with time *t* as shown in Fig. 5.2

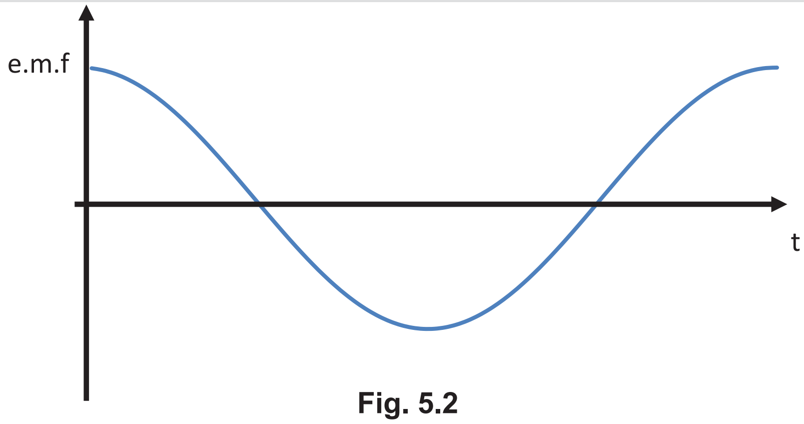
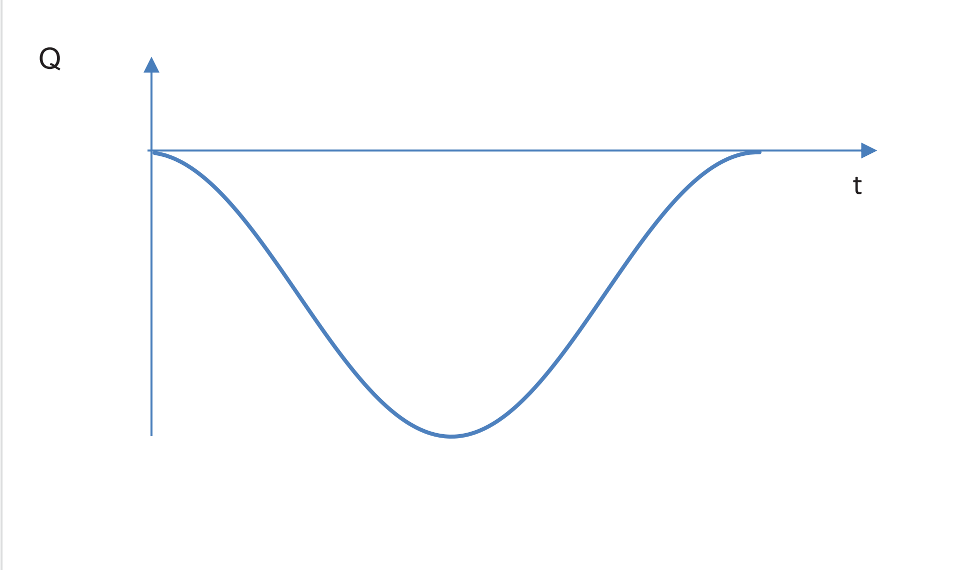


Fig. 5.2

Sketch the variation with time of the

(i)	flux ϕ in the solenoid	[2]
	Negative sine curve.	
(ii)	net amount of charge Q which has flowed past a point in the solenoid.	[1]



(iii) Without changing any other components in the setup, the number of turns of the solenoid in (ii) are increased to twice their original number each. Using the concept of magnetic flux, explain the changes (if any) to the induced current in the short coil.

In the transformer, the magnetic flux is the same in the primary and secondary coil.

As number of turns is doubled, the n is doubled but I is halved since the resistance is doubled. Hence, the magnetic flux at the solenoid remains the same. M1

The rate of change of Magnetic flux ($\phi = BA$) is the same on the primary and the secondary side.

$$\Phi_p = N_p BA$$
$$\Phi_s = N_s BA$$

$$E = -\frac{d\Phi}{dt} = -N\frac{d\phi}{dt}$$

Induced emf will halved because $\frac{d\phi_p}{dt} = \frac{d\phi_s}{dt}$ => $\frac{E_s}{N_s} = \frac{E_p}{N_p}$

Using conservation of Energy,

Hence, induced current will be doubled of the primary side. That will mean that the induced current is the same as before. A1

.... [2]

(c) Fig.5.3 shows a long solenoid which has a small copper disc mounted at its centre. The disc spins on an axle which lies along the axis of the solenoid. The solenoid is connected in series with a d.c. supply and a resistor of resistance *R*. By means of brushes, one terminal of the resistor is connected to the rim of the disc and the other (terminal A) is connected to the axle via a voltmeter.

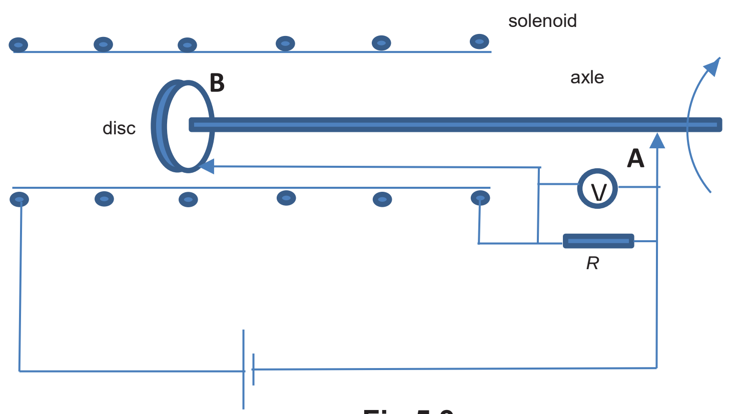


Fig.5.3

(i) Explain briefly why an emf is generated between the axle and the rim of the disc.

When the battery is switched on, there is a magnetic field generated by the solenoid. The spinning disc rim cuts through the magnetic flux lines generating a emf as suggested by Faraday's Law. [1]

The part A is connected to the axle does not cut any the magnetic flux lines as it is just spin. Therefore it is at zero potential. [1]

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

(ii) Suggest with explanation the possible outcome if terminal A is connect to the rim of the disc at point B.

There will be no readings on the voltmeter [A1] as both the terminal that is connected to the voltmeter is connected to the copper disc that is moving at the same speed. Because it is moving at the same speed the emf generated is the same and therefore no pd is observed at the voltmeter [M1]

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

3	A pulse of a radio wave lasts for 2.0×10^{-5}s. A photon of the radio wave may be considered to be at a point anywhere within this pulse, although the location of the point is not known. Calculate			
	(i)	the uncertainty in the position of the photon, Since the position of the radio photon can be anywhere within the pulse Length of pulse = uncertainty in the position = = 6.0×10^3m		
		uncertainty in the position of the photon = …………………… m		[1]
	(ii)	the uncertainty in the momentum of the photon, $\Delta x \Delta p_x \geq \frac{\hbar}{2}$ where $\hbar = \frac{h}{2\pi}$ $\Delta p \times \Delta x \geq 5.276 \times 10^{-35}$ $\Delta p \geq 8.79x10^{-39}$		
		uncertainty in the momentum of the photon = …………………… $kgms^{-1}$		[2]
	(ii)	the uncertainty in the frequency of the photon,		
		$\lambda = \frac{h}{p}$ $C = f\lambda$ $\Delta f = \frac{c}{h}\Delta p$ $\Delta f = 3977 = 4000\ Hz$		
		uncertainty in the frequency of the photon = …………………… Hz		[2]

Section B

3	**(a)**	The internal energy of a system is defined as the sum of a random distribution of *kinetic and potential energies associated with the molecules of a system*.	
		(i)	Comment on the "*kinetic and potential energies associated with the molecules of a system*".
			Microscopic potential energy is due to the inter-molecular forces between the molecules. It depends on the phase of the system (solid, liquid or gas). [B1] Microscopic kinetic energy is due to the random thermal motion of the molecules. [B1]
			……………………………………………………………………… [2]
		(ii)	Hence, explain how an increase in temperature relates to an increase in internal energy.
			The average microscopic kinetic energy of a system is directly proportional to the temperature of the system. [B1] Hence, an increase in temperature would mean an increase in the average kinetic energy of the molecules and an increase in the internal energy. [B1]
			……………………………………………………………………… [2]
3	**(b)**	The effect of heating on a solid can change it into a liquid, while the heating of a liquid can change it into a gas.	
		(i)	Define the specific latent heat of a body.
			The specific latent heat of a substance is defined as the amount of thermal energy required to convert 1 kg of a substance to another phase (or state) without a change in temperature. [1]
		(ii)	Hence, explain why the latent heat of vaporisation is greater than the latent heat of fusion.
			Energy is needed to do work against the atmosphere. [B1] Difference in potential energies between molecules in the liquid state and gaseous state is larger than between solid and liquid state. [B1]
			……………………………………………………………………… [2]

(c) A cup of hot coffee purchased from the school canteen has a temperature of 85°C. In order to drink the 250 g beverage before Physics lecture, a student placed five ice cubes, at – 7.0°C, of mass 5.0 g each, into the coffee. In order to speed up the rate of heat transfer, the student decided to stir the drink.

The following information is given:
latent heat of fusion of ice = 334 000 J kg^{-1}
specific heat capacity of ice = 2100 J kg^{-1} K^{-1}
specific heat capacity of water = 4200 J kg^{-1} K^{-1}
specific heat capacity of coffee = 4300 J kg^{-1} K^{-1}

(i) Estimate the final temperature of the drink when all the ice has melted.

$$m_{ICE}c_{ICE}(0-(-7))+m_{ICE}L_{ICE}+m_{WATER}c_{WATER}(T-0)=m_{COFFEE}c_{COFFEE}(85-T)$$

$$(5\times5\times10^{-3})(2100)(7)+(5\times5\times10^{-3})(334\times10^{3})+(5\times5\times10^{-3})(4200)(T)$$ [M1]

$$=(250\times10^{-3})(4300)(85-T)$$

$$367.5+8350+105T=91375-1075T$$ [M1]

$$1180T=82657.5$$

$$T=70°C\ (2\ s.f.)$$ [A1]

[3]

(ii) State 2 valid assumptions that you have made in your calculation.

The specific heat capacity of the stirrer/cup is not taken into consideration.
No heat loss from the coffee except to the ice cubes.

heat lost due to evaporation is negligible.

…………………………………………………………………………………………...

……………………………………………………………………………………… [2]

(d) A cube of volume V contains N molecules of an ideal gas. Each molecule has a component v_X of velocity perpendicular to one side W of the cube, as shown in Fig. 1.1.

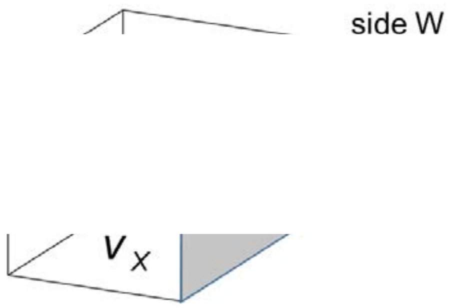


Fig. 1.1

The pressure p of the gas due to the component v_X of velocity is given by the expression

$$pV = Nm < v_X^2 >$$

where m is the mass of a molecule.

Explain how the expression leads to the relation

$$pV = \frac{1}{3}Nm < v^2 >$$

where $< v^2 >$ is the mean square speed of the molecules.

molecule has component of velocity in three directions	B1
random motion and averaging	B1
$<c^2> = <c_x^2> + <c_y^2> + <c_z^2> = 3<c_x^2>$	B1
so, $pV = ⅓Nm<c^2>$	A0

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(e) When air is pumped into a canister rapidly, the adiabatic process can be represented by the line with an arrow as shown in Fig. 1.2.

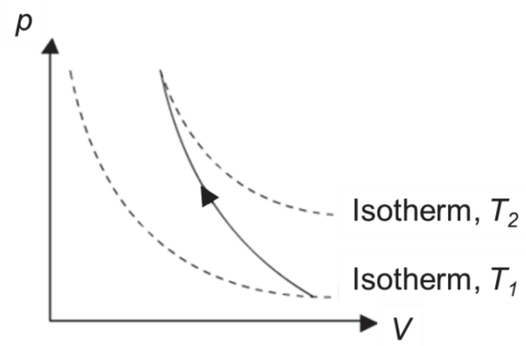


Fig. 1.2

(i) Explain how can this type of change be achieved. [2]

Using 1st law of thermodynamics

$\Delta U = Q + W$ [M1]

$\Delta U = 0 + W$ since Q = 0

$\Delta U = W$, increase in internal energy is due to work done on gas [B1]

(ii) State two conditions that could have made this process possible.

The canister is insulated [B1]

The change in pressure and volume occur faster than the exchange of heat [B1]

……………..

……………..

			…………………………………………………………………………………………	
			…………………………………………………………………………………	[2]
		(iii)	Hence, comment on the temperature of the air, T_2, after pumping.	
			$T_2 > T_1$ [B1]	
			…………………………………………………………………………………………	
			…………………………………………………………………………………	[1]

4 **(a)** **(i)** A doubles back, either side
B carries on, slightly deflected
C carries straight on
all 3 correct 2 marks, 1 wrong minus 1

(ii) nucleus is small in comparison to size of atom

(iii) nucleus is massive/heavy/dense B1
and positively charged B1

(b) **(i)** 1. $F = GM_1M_2/R^2$
force = $\{6.67 \times 10^{-11} \times 197 \times 4 \times (1.66 \times 10^{-27})^2\} / (9.6 \times 10^{-15})^2$
$= 1.57 \times 10^{-33}$ N

2. $F = Q_1Q_2/(4\pi\varepsilon_0R^2)$
force = $79 \times 2 \times (1.6 \times 10^{-19})^2 / [4\pi \times 8.85 \times 10^{-12} \times (9.6 \times 10^{-15})^2]$
$= 395$ N

(ii) electric force >> gravitational force

(iii) loss in KE = gain in EPE
4.6 MeV = $7.36 \times 10^{-13} = Q_1Q_2 / 4\pi\varepsilon_0R$
$r = 4.94 \times 10^{-14}$ m

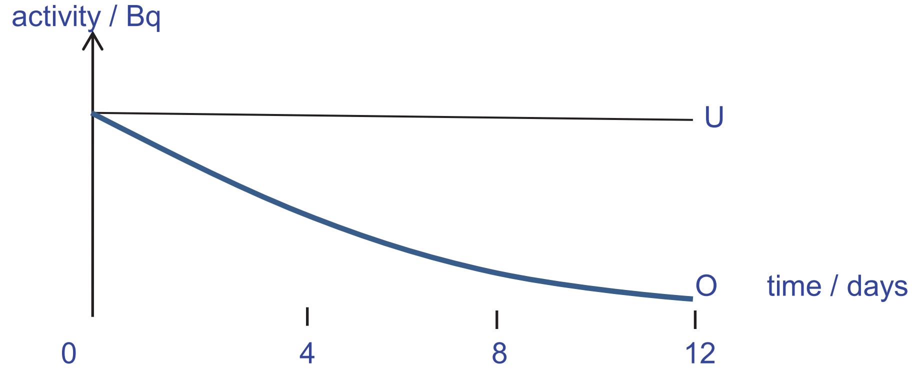
(iv) not enough energy to get close to the nucleus

(c) **(i)** $(5 \times 10^{-3}) / 226 \times (6.02 \times 10^{23})$ M1

(ii) $t_{½} = (1.60 \times 10^3 \text{ years})(365)(24)(60)(60)$ C1
$A = \lambda N$ C1
$A = (\ln 2 / t_{½})\, N = 1.83 \times 10^8$ Bq A1

(iii) $A = A_0\, e^{-\lambda t}$ C1
$\ln 0.90 = -\lambda t$
$t = 243$ years A1

(iv)



horizontal line for U
decay curve for O

RIVER VALLEY HIGH SCHOOL
YEAR 6 PRELIM EXAMINATIONS 2

H2 PHYSICS 9749
PAPER 4

28 AUG 2017

2 HRS 30 MIN

NAME Teacher's Copy

CLASS 6 (   )

INDEX NO. ______________________

INSTRUCTIONS TO CANDIDATES

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.

Read these notes carefully.
Write your name, class and index number above.

Candidates answer on the Question Paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

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

Answer **all** questions.

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

SHIFT	
LABORATORY	
FOR EXAMINERS' USE	
1	**/15**
2	**/ 8**
3	**/ 20**
4	**/ 12**
TOTAL	**/ 55**

This document consists of 14 printed pages.

1 This investigation considers the time required to discharge a capacitor. Capacitors accumulate charge from a source of e.m.f., and discharges over a period of time when connected to a load.

(a) You are given a capacitor, a resistor of resistance r, a 2.00 V battery, a switch, an analog voltmeter and a digital multimeter that has been set to measure current in microamperes. The terminal of the capacitor labelled as "+" must be connected to the positive terminal of the battery, as shown in Fig. 1.1.

Using the digital multimeter as a microammeter (μA), set up the circuit as shown in Fig. 1.1.

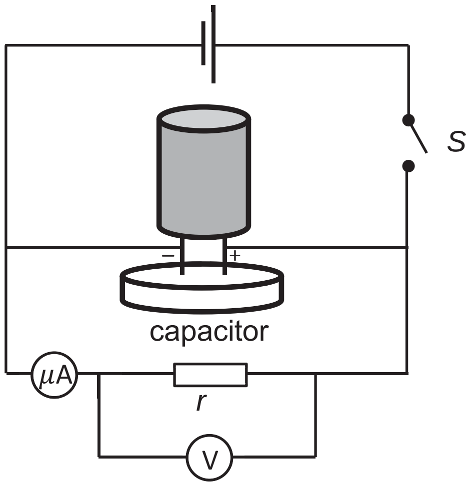


Fig. 1.1

(i) Close switch S.

(ii) The current through the ammeter will increase for a very short period of time. Measure and record the magnitude of the maximum current I_0 passing through the ammeter when the current stops increasing.

Expect 500+ μA for 2 V, 1000 μA for 4 V.

Record to 3-4 s.f.

Correct unit (μA or A)

I_0 = ... [1]

(iii) Record the reading on the voltmeter V_0.

Not graded but d.p. here will be used in part (iv)

V_0 = ...

(iv) Open switch S.

(v) Given that $V_0 = I_0 r_{eff}$, calculate the effective resistance r_{eff} of the resistor and voltmeter in parallel.

Expected values range from 3500 – 3900 Ω.

Follow smallest s.f. based on parts (ii) and (iii)

Correct method ($r = E/I_0$)

Correct units (Ω)

r = ... [1]

(b) **(i)** Close switch S.

(ii) When the ammeter reading is equal to I_0, open switch *S* and start the stopwatch.

(iii) Record the time *T* taken for the ammeter reading to fall from I_0 to $I_0/2$.

Sample data (if different R is used will vary):

Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	t_{avr}:
11.1	11.0	11.1	11.2	10.7	11.0

1-2 d.p. both accepted *[but 1 d.p. more appropriate – see part (iv)]*

Correct unit (seconds)

(iv) Estimate the percentage uncertainty in your value of *T* in **(b)(iii)**.

Uncertainty should be on the scale of 0.2 - 0.8 s: human reaction time and sampling rate of meter.

Sample values:

t	Δt	% uncertainty
10.5	0.5	4.8
11.5	0.2	1.7

Correct method (Δt/t × 100% = _____ %)

To 2 s.f. max

(c) **(i)** Close switch *S*.

(ii) When the ammeter reading is equal to I_0, open switch *S* and start the stopwatch.

(iii) At time *T* as found in **(b)(iii)**, measure and record V_T, the voltage across the resistor at that instant.

Tested values range from 0.9 – 1.0 V.

Record to 1 d.p.

Correct unit (V)

(iv) Using the values obtained above, determine the resistance r_T of the system at time *T*. Show your working clearly.

Sample values:

$I_0/2$	V_T	R_{eff}
269	1.0	3700
270	0.9	3300

Expect a range of values between 3300 – 4000.

Correct calculation method.

1 or 2 s.f. following part (iii)

Correct units (Ω)

(d) In another similar setup, the resistor is replaced with a light bulb. When V_0 was applied across the light bulb and voltmeter, the current I_0 passing through the light bulb was found to be 0.400 A.
Use your results to predict the current $I_{1/2}$ that passes through the light bulb when the voltage across the light bulb and voltmeter is equal to $V_0/2$.

- If (c)(iii) is exactly $v_0/2$ (or student says "approximately equal to"), allow $I_{1/2} = I_0/2$ directly.
- If student uses V=IR with same R for both, the value in (a)(v) must be same as the value in (c)(iv) (or student says approx.)
- If neither of the above, student should use ratios or other appropriate method, e.g. "when current half, V =, so when V half…"
- ***Theory should not be used.***

(e) It is suggested that the **time** $t_{1/2}$ required for the current passing through the ammeter to decrease to half its initial value is <u>directly proportional</u> to the **effective resistance** *R*, and is not affected by the magnitude of the **e.m.f.**

provided.

Making use of the additional accumulator and resistor, take further measurements to investigate this suggestion.

State and explain whether or not you agree with this suggestion.

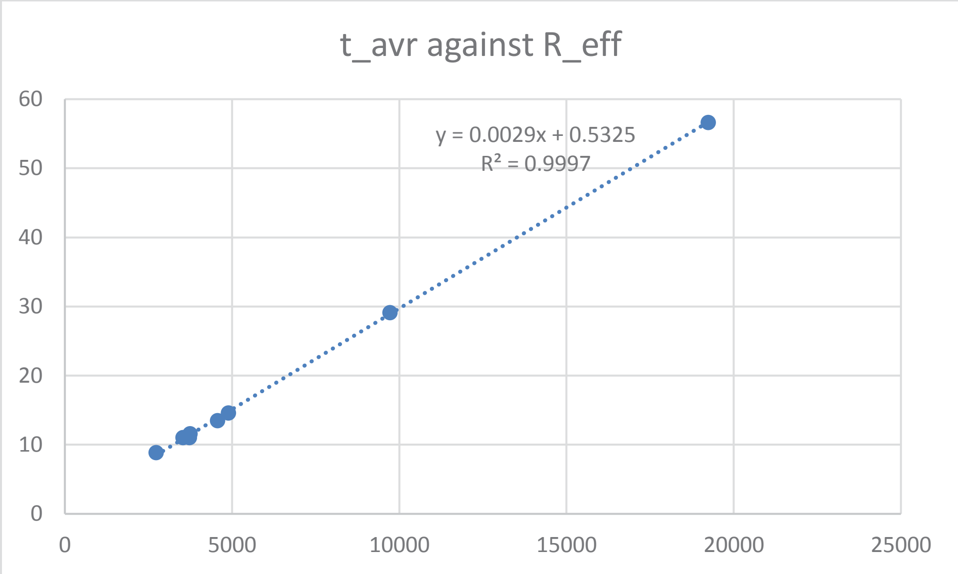
Present your measurements and calculated results clearly.

Varying resistance while keeping emf constant. Possible methods: • Another resistor in series/parallel • Removing voltmeter from circuit/placing voltmeter in series
Either **correct calculation** of ***effective*** resistance using voltage and current, or realizing that voltmeter affects effective resistance and removing voltmeter from circuit. If working not shown (e.g. showing values of R without showing current) mark not given
Conclusion based on ***quantitative*** data from varying resistance. Should be less than 10%, also accept if student says >5% so not proportional.
Varying emf while keeping resistance constant. Possible methods: • Adding second battery • Using potential divider with the other resistor
Conclusion based on ***quantitative*** data from varying emf. Possible evidence: • Compare two cases where only e.m.f. differs. Show that time is approximately constant ***(ideally within human reaction time or experimental error)*** • Have more than two cases with different R and e.m.f. (e.g. 3 – 4 cases which vary R, emf or both), and show that the proportionality constant between R and T are same for all.

Summary of sample data:

Reff /Ω:	**t_{avr} /s:**	**V /V**
4555.809	13.48	2
2721.088	8.846667	2
19230.77	56.65	2
4889.976	14.62	2

Reff /Ω:	**t_{avr} /s:**	**V /V**
9718.173	29.11	2
3741.815	11.59667	4
3717.472	11.024	2
3525.046	11.024	2


t_avr against R_eff
y = 0.0029x + 0.5325
R² = 0.9997
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000

(f) One common application of such circuits is to power the bright flashes used in photography. Connecting a capacitor to a battery allows it to charge up, and when connected to a load such as a camera flash, it discharges by releases energy over a certain length of time. Outdoor photographers may find that the camera flash functions differently during extremely cold winters.

Suggest one change that could be made to this investigation in Singapore to safely study how the discharge time changes at different temperatures. State any relevant precautions or steps taken to quantify this change.

Student states method for changing temperature of entire circuit or relevant components.

Possible answers: Immerse in ice bath, use cold pack, place in freezer <u>while putting measuring devices outside</u>, use room with air conditioning or cold storage rooms, etc.

Precautions:

EITHER

Student states precautions taken to avoid short-circuiting.
Possible answers: Seal in air-tight bag, use of cold pack instead of ice, only insert relevant components into ice bath, etc

OR

Student states precautions taken regarding cold injuries.
Possible answers: Appropriate gloves/winter wear

OR

Student states other relevant consideration

Student states suitable method for measuring the temperature.

Experimental setup	Appropriate methods for measurement
Immerse in ice bath	Measure temperature of water (e.g. with thermometer or thermocouple)
Use cold pack	Touch thermocouple directly to circuit; use infrared thermometer.
Put in freezer or air-conditioned room (or similar method of changing ambient temperature)	Award a mark for a suitable method of measuring air temperature inside the freezer.

Students who design an experiment using a camera or describe flashes or other lights will lose marks due to not reading the question. Students who replace resistor with thermistor will also be penalized.

2 In this experiment, you will investigate how the heating of a mass of boiling water is affected by the addition of metal mass of a different temperature.

(a) **(i)** Set up the apparatus as shown in Fig. 2.1.

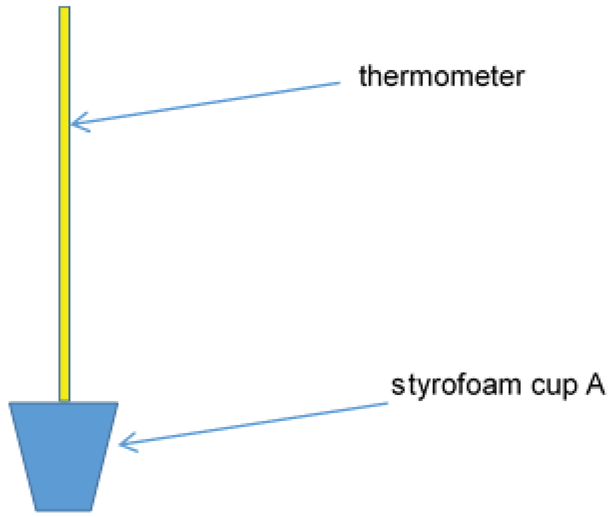


Fig. 2.1

Using a measuring cylinder, fill up styrofoam cup A with tap water with 100 cm^3 of tap water.

Measure the temperature of the water, t_o.

t_o = ...28.0 °C......

(ii) Fill styrofoam cup B with hot water (55 °C > t_h > 90 °C) and place the 100 g mass provided in it. Wait for the temperature to stabilise.

Measure the temperature of the hot water with mass, t_h.

correct unit
correct precision
between 55 °C > t_h > 90 °C

t_h = ...86.0 °C...... [1]

(iii) With a string, transfer the 100 g mass from the cup B to cup A.
Wait for the temperature of cup A to stabilise.
Measure the final temperature of the water and masses, T.
Remove the mass and pour away the water in cup A.

correct unit
correct precision
$> t_o$ °C

T = ... 33.0 °C .... [1]

(b) Repeat **(a)** for different values of temperature between 55 °C and 90 °C for t_1 for the given mass.

Complete Fig. 2.2.

t_o / °C	t_h / °C	T/ °C	$(T - t_o)$ / °C	$(t_h - T)$ / °C
28.0	86.0	33.0	5.0	53.0
28.0	75.0	32.5	4.5	42.5
28.0	69.0	32.0	4.0	37.0
28.0	66.0	31.0	3.0	35.0
28.0	61.0	30.0	2.0	31.0
28.0	57.5	29.5	1.5	28.0

All 6 values of T taken successfully, $(T - t_o)$ and $(t_h - T)$ *decrease as* t_h *decreases* [1]

All temperature values calculated correctly and appropriate s.f. [1]

Fig. 2.2

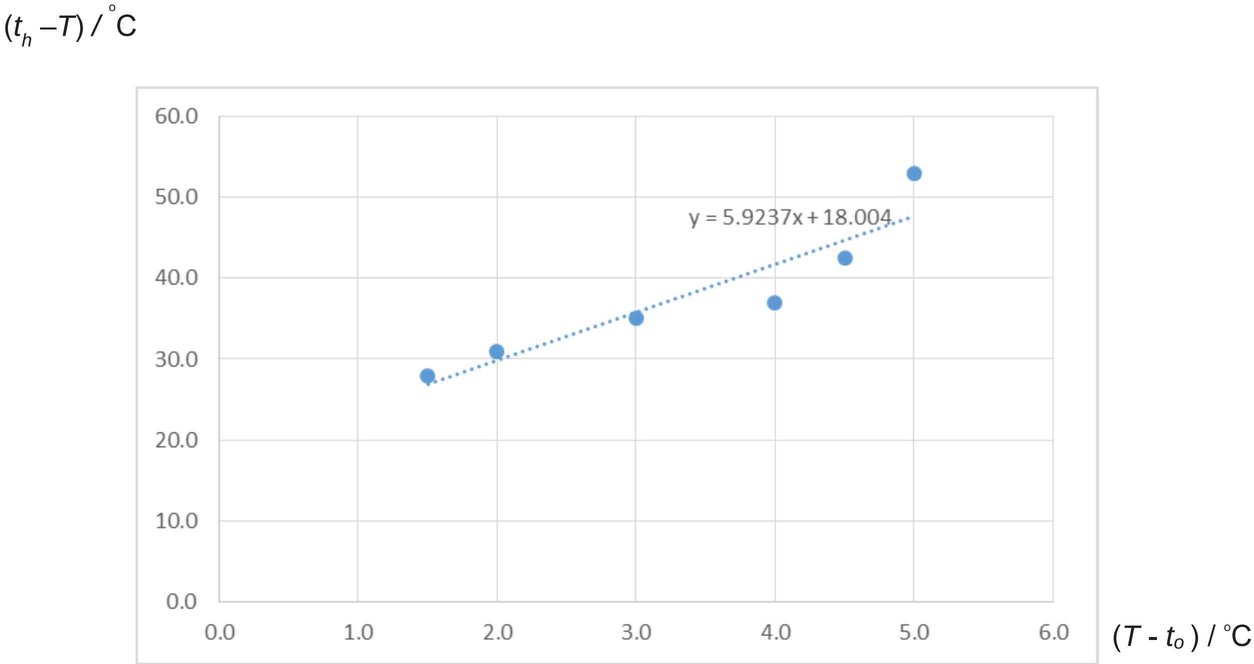
[2]

(c) It is suggested that the relationship between temperature increase ($T - t_o$) in cup A and temperature decrease of the mass is related by

$$t_h - T = k\,(T - t_o)$$

where k is a constant.

(i) Using your data in Fig. 2.2, plot ($t_h - T$) against ($T - t_o$), in Fig. 2.3.



[2]

(ii) Hence determine the gradient of the plotted graph in Fig. 2.3.

Gradient = 5.92 [Correct Calculation of gradient

No units

gradient = ………………………… [1]

(d) Describe one source of uncertainty or limitation of the procedure for this experiment.

Extra amount of water in the cup and during transfer.
Water stick the the mass when transfer.

[1]

3 In this experiment, you will investigate the length of a loaded spring as the load is varied.

(a) Measure and record the length *L* of the metal rod.

99.9 cm

L = ...

(b) **(i)** Support the rod as shown in Fig. 3.1

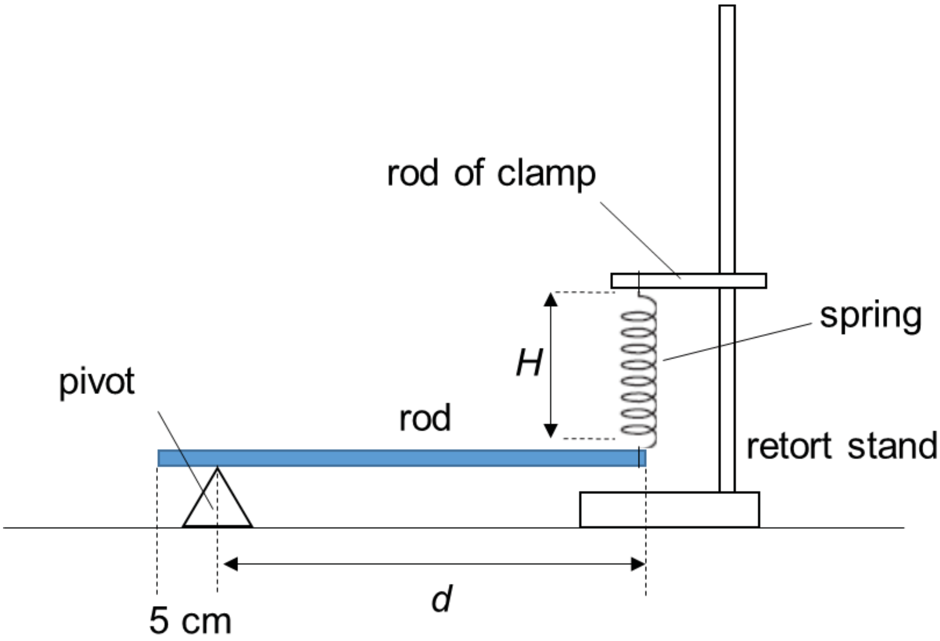


Fig. 3.1

(ii) Adjust the position of the pivot so that it is approximately 5 cm from the free end of the rod.

(iii) Adjust the clamp so that the rod is horizontal and the spring is vertical.

(c) **(i)** Measure and record the length *H* of the coiled part of the spring and the distance *d* from the pivot to the point where the spring is hooked to the rod.

Correct d.p
Correct unit

8.5 cm

H = ... [1]

94.0 cm

d = ...

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

ΔH ≥ 0.2 mm
Correct s.f.
Correct calculation

percentage uncertainty = ... [1]

(d) Repeat (b)(ii), (b)(iii) and (c)(i) to obtain further sets of readings for *d* and *H*.

d / m	*H* / m	1/*d* / m^{-1}
0.940	0.085	1.06
0.900	0.080	1.11
0.850	0.075	1.18
0.800	0.070	1.25
0.750	0.065	1.33
0.700	0.058	1.43
0.650	0.050	1.54
0.600	0.042	1.67
0.550	0.032	1.82

[1] Raw data: to correct precision of metre rule
[1] Processed value: to correct s.f. based on raw data
[1] Range of d ≥ 20 cm, d > 40 cm
[1] Layout: column headings (raw data and calculated quantities: *(d, H, 1/d)*. Each column heading must contain a quantity and unit as shown.
[2] Award 2 marks if candidate has successfully collected 6 or more sets of data *((d, H)* without assistance or intervention.
Award 1 mark if candidate has successfully collected 5 sets of data *((d, H)* without assistance/intervention.
Award zero mark if candidate has successfully collected 4 or fewer sets of data *(d, H)* without assistance/intervention.
Deduct 1 mark if candidate requires some assistance/intervention but has been able to do most of the work independently.
Deduct 2 marks if candidate has been unable to collect data

[6]

(e) Theory suggests that *d* and *H* are related by the equation

$$H = z\left(\frac{W}{k}\right)\left(\frac{1}{d}\right) + \left(\frac{W}{k}\right)$$

where *W* is the weight of the rod, *k* is the spring constant of the spring and *z* are constants.

Plot a suitable graph to determine *W* and *z*.

[1] Linearising equation
[1] Gradient - the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square.
[1] Value of W calculated correctly and with correct units.
[1] Value of z calculated correctly and with correct units.

$$Fd = W\left(d - \frac{L}{2}\right)$$

$$h = \frac{A}{d} + B$$

$$h = z\left(\frac{W}{k}\right)\left(\frac{1}{d}\right) + B$$

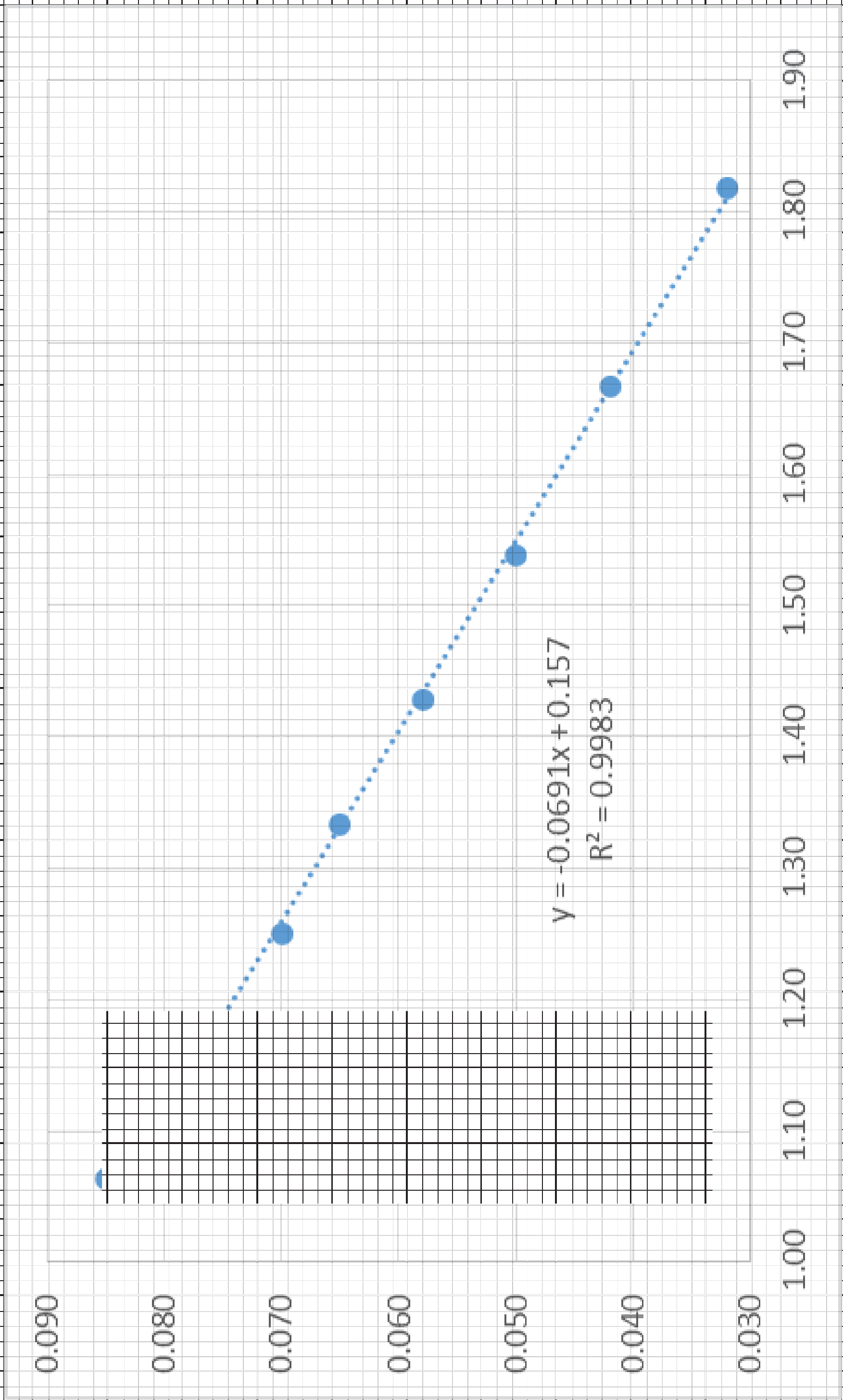
actual mass of rod =		330 g =	0.330	kg
y-intercept =		0.157	= W/k	
	W =	3.611		
convert to mass =		0.368	kg	
grad =	-0.0691	= z(W/k)		
therefore	z =	-0.44013		

Physical meaning of z is half the length of the uniform rod or position of the c.g. of the rod w.r.t. to one end.

z = …………………………………… [4]

For graph:
[1] Sensible scales must be used. Awkward scales (e.g. 3:10) and numbering are not allowed. Scales must be chosen so that plotted points occupy at least half the graph grid in both x and y directions. Axes must be labelled with the quantity which is being plotted.
[1] All observations must be plotted. Work to an accuracy of half a small square.
[1] Straight line of best fit - judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.

[3]



(f) Suggest a physical meaning for the constant *z*.

z is half the length (or position of the c.g. from one end) of the metal rod.

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

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

There are no anomalous data as all points follow the trend of the best fit line.

or

There is an anomalous data as it lies relatively far from the best fit line as compared to the other points. [1]

(h) **(i)** State one significant sources of error in this experiment.

It is difficult to measure the value of H without disturbing the equilibrium of the system.

It is difficult to manually hold the metre rule to stably measure the value of H. [1]

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

Use a light fiducial marker attached to the end of the spring, to assist in the reading-off from the metre rule.

Use a retort stand and clamp to secure the metre rule vertically to enable a stable reading-off.

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

(i) Sketch another line on your graph to represent an experiment performed with a heavier rod. Label this graph **Q**.

[1]

Heavier rod → W larger
Hence, **Q** will have steeper gradient and larger vertical intercept

[Total: 20 marks]

4 Beta particles can be deflected by magnetic fields.

Design a laboratory experiment to investigate how the magnetic flux density B of a magnetic field affects the angle θ through which beta particles are deflected when they pass through a uniform magnetic field.

The only radioactive source that is available to you emits α, β and γ radiation.

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

(a) the procedure to be followed,
(b) the method by which beta particles **only** would be detected,
(c) the method of measuring the angle of deflection,
(d) how the magnetic field would be produced, measured and changed,
(e) any reliability and safety precautions you would take.

Diagram

	marking scheme	
	DESIGN	
A1	Sensible choice of equipment and basic idea OK Source / magnetic field / detector Inappropriate choice of apparatus cannot score this mark. Ignore lead or aluminium plates at this stage.	1
A2	Method of measuring angle of deflection (e.g. detector at edge of large protractor / lengths & trig ratio used) Do not allow vague 'use a protractor'. This mark can be awarded even if the detector has not been specified.	1
A3	Use Hall probe / search coil / current balance to measure field strength Allow Helmholtz coils expression if Helmholtz coils used. (see below) Allow a current or voltage measurement as indication of field strength (as $I \alpha B$)	1
	PROCEDURE	
B1	Method of removing α radiation or statement that α radiation almost undeflected Use paper or distance to detector > few cm/air to absorb alpha Could be shown on the diagram. Do not allow lead / aluminium plate. Allow α to be shown deflecting in the opposite direction to β on the diagram.	1
B2	γ-radiation undeflected / deflect beta particles using electric field Can be shown on diagram. Do not allow 'absorb gamma with lead plate'.	1
B3	Method of changing field strength. Do not allow changing magnets of different strengths. Do not allow changing number of coils.	1
B4	Workable procedure for uniform fields Measure deflection and field strength; change current in coils and repeat.	1

	SAFETY and ANALYSIS	
C1	Any two safety precautions e.g. use source handling tool store source in lead lined box when not in use do not point source at people/do not look directly at source place lead sheet at 'end of experiment' to absorb unwanted rays	1
C2	Plot graph of lg θ against lg B	1
	DETAIL	
D1/2	Any good/further detail. Examples of creditworthy points might be: Type of detector (GM tube/film/screen/scintillation counter). N/A cloud chamber/CRO Repeat readings to allow for randomness of activity Correct deflection of beta on diagram/left hand rule ideas (diagram or written) Separation of coils = radius of coils for uniform field Discussion of count rate (and not just count) Plane of semiconductor slice is perpendicular to field lines Calibrate Hall probe Detail of calibration Collimation ideas (*collimate: to make parallel; line up*) Allow other valid points. Any three, one mark each. B1 = B2 = B4 = 0 if lead or aluminium plate is placed in front of the source. Allow thin (less than 1 mm) sheet or foil	3

*UNDERLINING
In the marking scheme, underlining indicates information that is essential for marks to be awarded.

……………………………………………………………………………………………

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……………………………………………………………………………………………

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[Total: 12 marks]

END OF PAPER