BP~489

HWA CHONG INSTITUTION
JC2 Preliminary Examinations
Higher 2

CANDIDATE NAME		**CT GROUP**	21S
CENTRE NUMBER		**INDEX NUMBER**	

PHYSICS

9749/01

Paper 1 Multiple Choice

20 September 2022

60 minutes

Additional Materials: Optical Mark Sheet

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Do not use staples, paper clips, glue or correction fluid.

Write your name, CT, NRIC or FIN number on the optical mark sheet (OMS). Shade your NRIC or FIN in the spaces provided.

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

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

Each correct answer will score one mark. A mark will **not** be deducted for a wrong answer.

Any rough working should be done in this booklet.

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

This paper consists of **16** printed pages.

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

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

1 Which of the following is **not** a reasonable estimate?

A The diameter of a strand of human hair is 80 μm

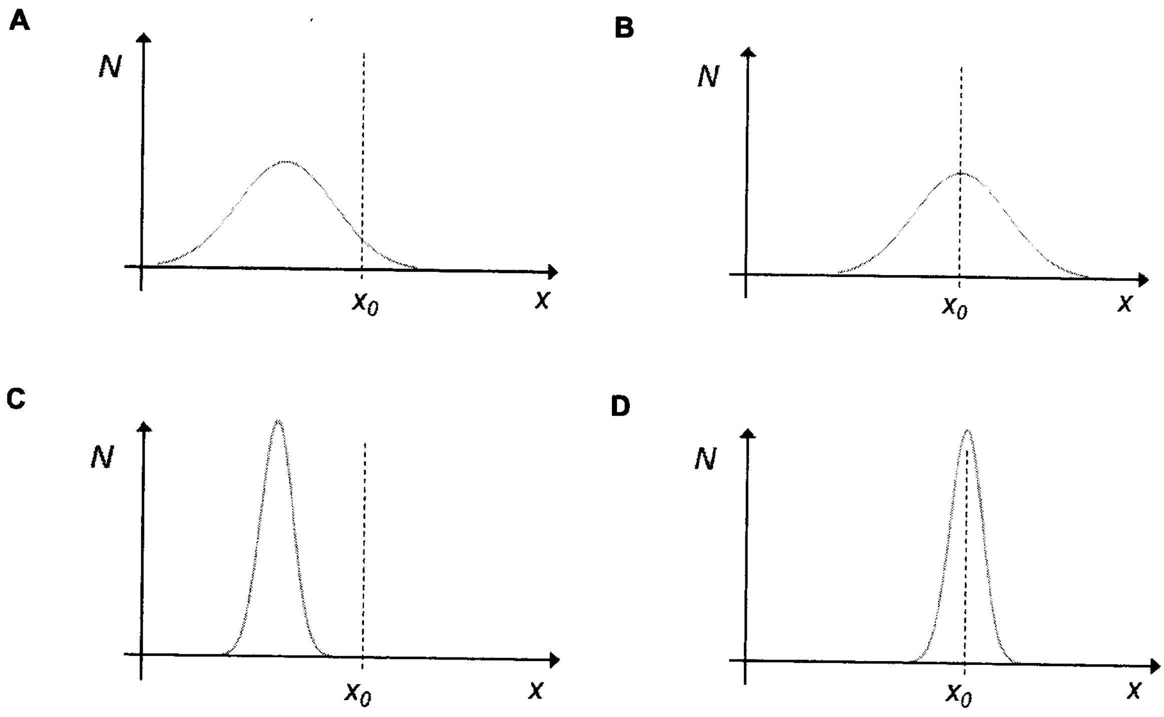
B The volume of an apple is 200 cm^3

C The weight of a sheet of A4 paper on Earth is 50 mN

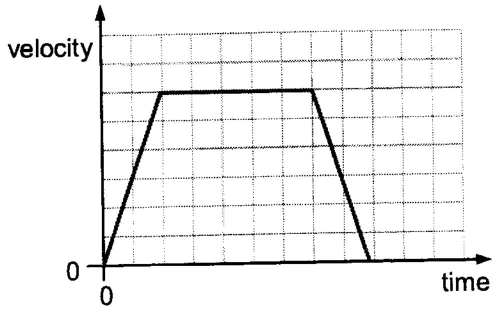
D The frequency of light from a green laser is 550 GHz

2 A quantity x was measured multiple times. The number N of measurements giving a value x is plotted against x. The true value of the quantity is x_0.

Which of the following graphs best represents accurate measurements with poor precision?



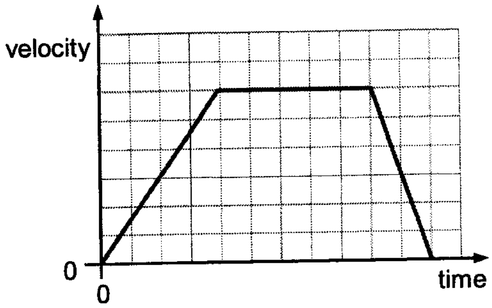
3 The velocity – time graph for a train starting at one station and stopping at the next station is shown.



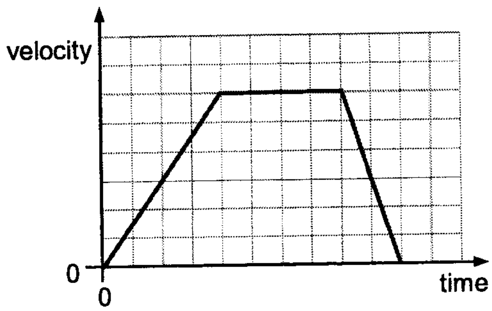
Another train has half of the initial acceleration but the same maximum speed and the same final deceleration.

Which velocity-time graph, on the same scale, shows the motion of this train between the same two stations?

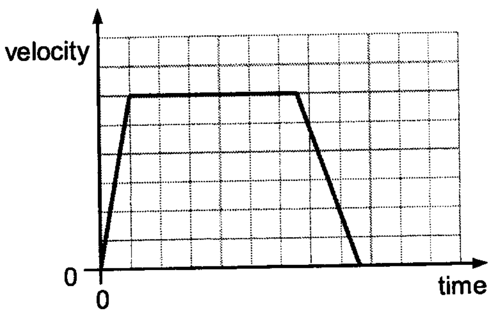
A



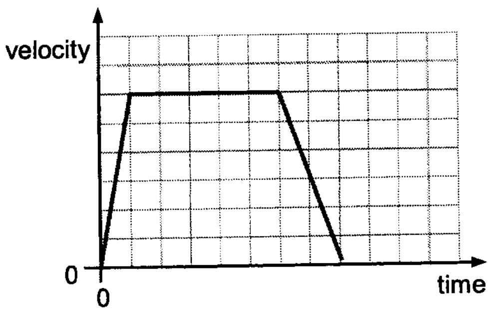
B



C



D

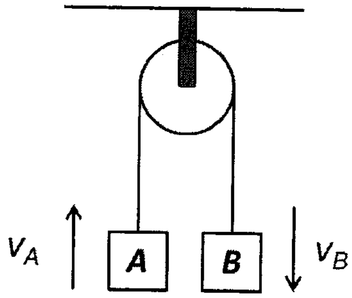


4 Two objects, A and B, are connected via a light string that runs over a smooth pulley.

Their masses are m_A and m_B respectively.

The diagram shows A moving up with velocity v_A and B moving down with velocity v_B.

Which statement is incorrect?



A If $m_A = m_B$, v_A and v_B are of the same magnitude.

B If $m_A = m_B$, v_A and v_B can only be zero.

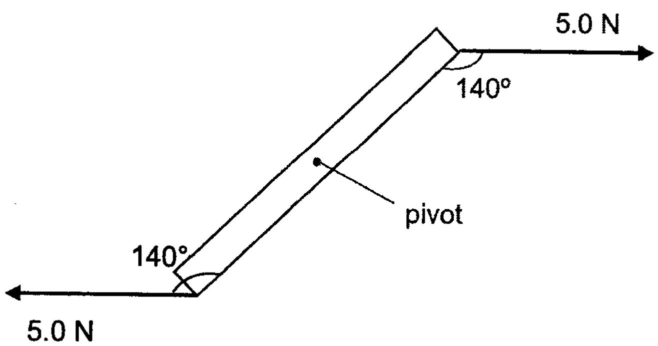
C m_A can be larger than m_B.

D m_A can be smaller than m_B.

5 A bowling ball undergoes head-on elastic collision with a stationary bowling pin. The bowling ball's mass is 5 times that of the pin. Given that the pin's speed immediately after the collision is 3.33 m s^{-1}, what is the speed of the bowling ball just before the collision?

A 1.33 m s^{-1} **B** 2.00 m s^{-1} **C** 3.33 m s^{-1} **D** 4.00 m s^{-1}

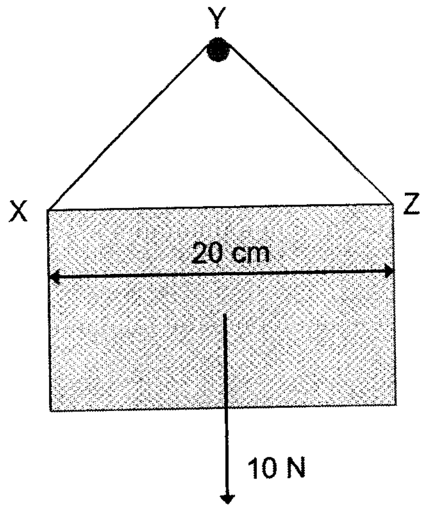
6 A thin meter rule is pivoted at its centre. Equal and opposite forces of magnitude 5.0 N are applied to the ends of the ruler, creating a couple as shown.



What is the magnitude of the torque of the couple on the ruler when it is at the position shown?

A 1.6 N m **B** 3.2 N m **C** 3.8 N m **D** 5.0 N m

7 A uniform rectangular metal sheet of length 20 cm and weight 10 N is to be suspended from a hook by a light cord XYZ, as shown below.



The material used for the cord can support a maximum tension of 20 N before breaking.

Determine the minimum length of cord that is required.

A 21 cm **B** 23 cm **C** 40 cm **D** 80 cm

8 A constant force F is applied to a stationary object of mass m on a frictionless surface. The object accelerates uniformly to reach a velocity v in time t covering a distance s during this time.

Which of the following is the correct expression for the kinetic energy of the object at time t?

A Fv **B** Fvt

C Fs **D** Fst

9 A part in an engine is rotating in a circle of radius 8.0 cm at 3000 revolutions per minute. What is its centripetal acceleration?

A 25 m s^{-2} **B** 7900 m s^{-2} **C** 3.1×10^4 m s^{-2} **D** 7.2×10^7 m s^{-2}

10 Two sites are being considered for a rocket launch. Site A is at the equator while site B is nearer to the North Pole. Taking the Earth to be a uniform sphere, which of the following statements is true?

A The escape speed for both sites are the same as gravitational potential at both sites are the same.

B The escape speed for site A is higher as gravitational potential at site A is larger.

C The escape speed for site A is lower as gravitational potential at site A is lower.

D The escape speed is independent of the gravitational potential.

11 A satellite of mass m is in a circular orbit around a planet of mass M and radius R. The satellite is traveling at a constant speed v at a height of H above the surface of the planet.

What is the total energy of the satellite?

A $\frac{1}{2}mv^2 - \frac{GMm}{R}$

B $\frac{1}{2}mv^2 - \frac{GMm}{R+H}$

C $\frac{1}{2}mv^2 + \frac{GMm}{R}$

D $\frac{1}{2}mv^2 + \frac{GMm}{R+H}$

12 Equal amount of an ideal gas was housed separately in containers A and B.

The volume of B is larger than that of A.

Gases in both containers were maintained at a common temperature for both containers.

Which statement best describe the gases inside the two containers.

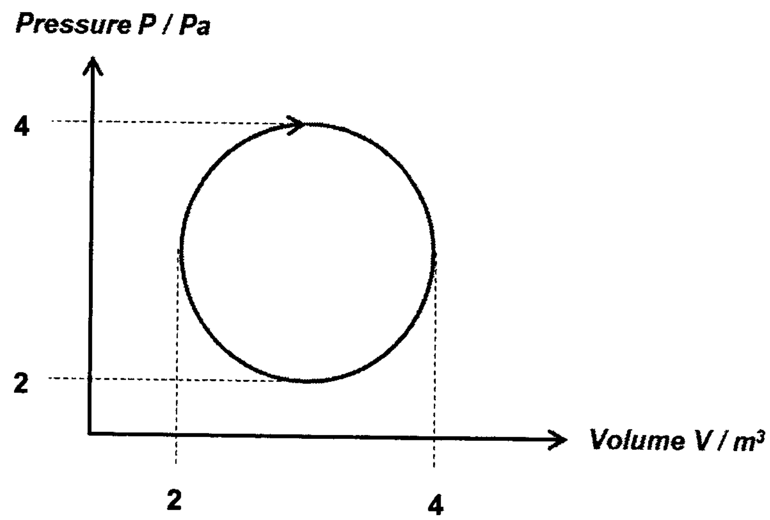
A The average microscopic kinetic energy of A is larger than that of B.

B The gas pressure of B is larger than that of A.

C The root-mean-square speed of both gases are not the same.

D The gas density of A is larger than that of B

13 An ideal gas is made to run a circular cyclic process as shown.



What is the net heat transfer for this process?

A 0 J **B** 3 J into gas **C** 3 J out of gas **D** 6 J out of gas

14 Figure (a) below shows the variation with frequency f of the amplitude x_0 of the forced oscillation of a system. This system is then subjected to a periodic driving force F as shown in Figure (b).

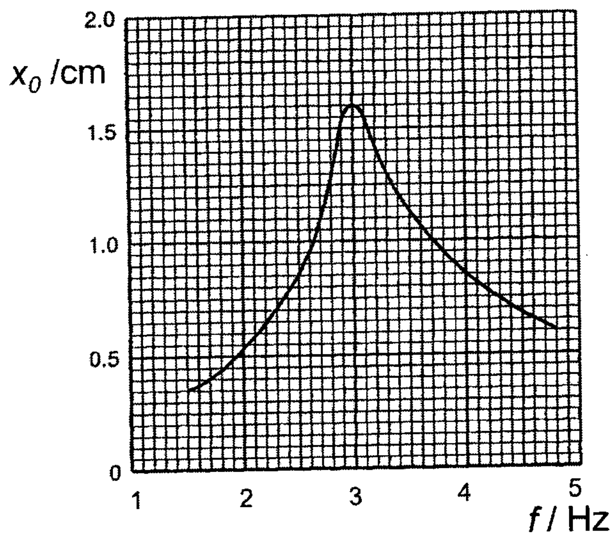


Figure (a)

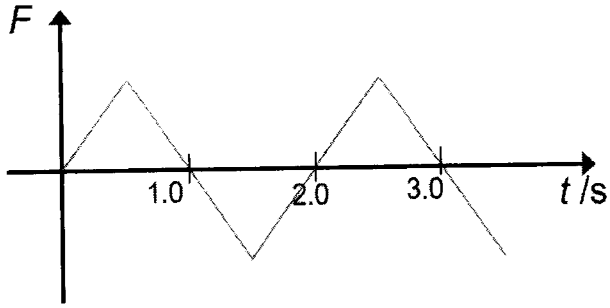
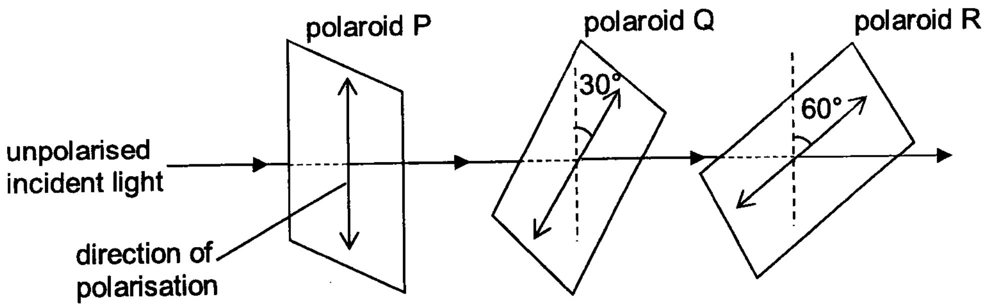


Figure (b)

What is the frequency that the system will oscillate at?

A 0.33 Hz **B** 0.50 Hz **C** 2.0 Hz **D** 3.0 Hz

15 Three sheets of polaroids P, Q and R are arranged as shown below. Polariod Q and R's direction of polarization is 30° and 60° relative to that of polaroid P.



A beam of light passes through all three polariods. After passing through polaroid P, the transmitted beam has an intensity of I.
What is the intensity of the beam after passing through R?

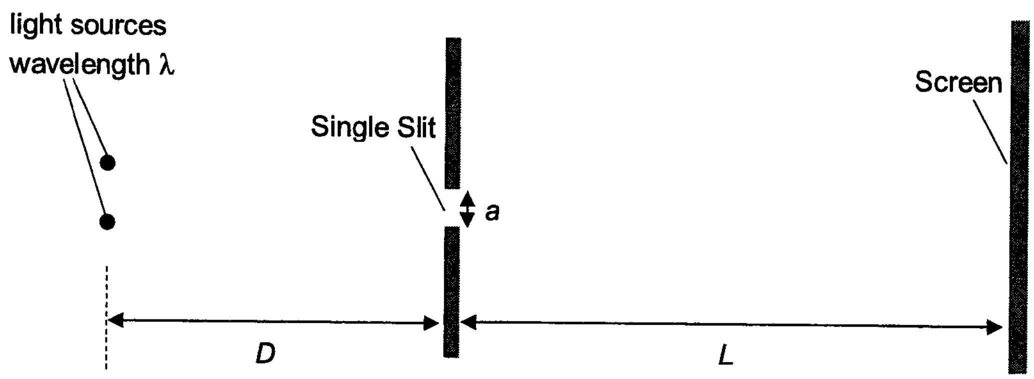
A $0.19I$ **B** $0.43I$ **C** $0.56I$ **D** $0.75I$

16 A point source emits energy in the form of waves such that a detector of cross-sectional area A at a distance of x from the point source receives power P. A second detector of cross-sectional area $2A$, is placed at another position such that its distance is $0.5x$ from the same point source.

What is the power received by the second detector?

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

17 Two monochromatic light sources of wavelength λ are separated by a fixed distance. Light from the sources passes through a single slit of slit width a at a distance of D. The image of the light sources is projected on a screen a distance of L from the single slit.



One is just able to distinguish that there are two light sources from the image captured on the screen.

For the image captured on screen, which of the following changes will **not** make it easier to distinguish that there are two light sources?

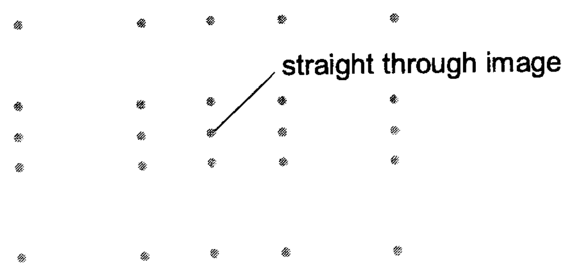
A λ is reduced.

B D is reduced.

C a is increased.

D L is increased.

18 The image below (which is to scale) is formed by shining a monochromatic laser light perpendicularly through a fine nylon mesh consisting of very close vertical and horizontal threads. The vertical threads are equally spaced such that the distance between each thread is constant. The horizontal threads are also equally spaced.



Which statement about the spacing between the vertical threads and horizontal threads is true?

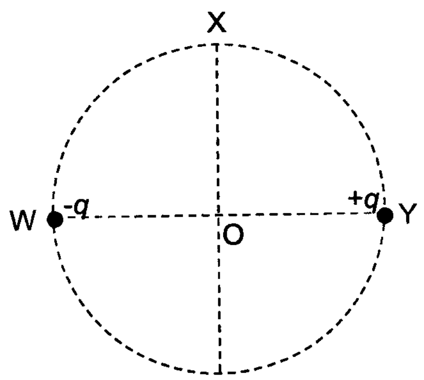
A The vertical and horizontal spacing are the same.

B The vertical spacing is smaller than the horizontal spacing.

C The vertical spacing is greater than the horizontal spacing.

D There is insufficient information to determine the relative spacing between the vertical and horizontal threads.

19 W, X and Y are three points on the rim of a circle with centre O.



A point charge $-q$ is fixed at W and another point charge $+q$ is placed originally at Y.

When the positive charge $+q$ at Y is moved to position X, which of the following statements is correct?

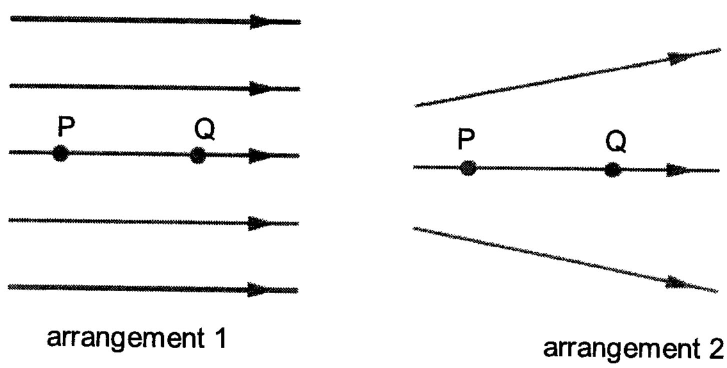
A The electrical force between the two charges decreases.

B The electric field strength at O increases.

C The electric potential energy of the system decreases.

D The electric potential at O increases.

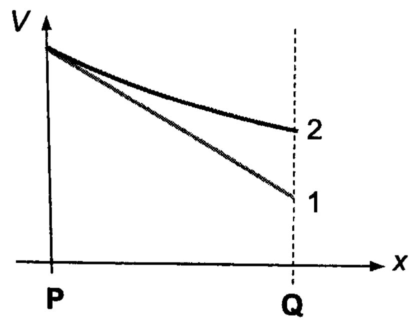
20 The figure below shows two arrangements of electric field lines drawn to the same scale.



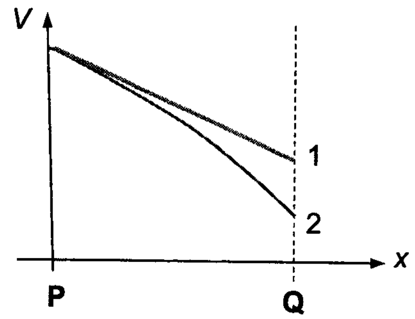
P and Q are points in the electric fields and have equal separations in both arrangements. The electric field strength and the potential at P is the same in both arrangements as well.

Which of the following graph shows the possible variation with distance x along the line PQ of the potential V?

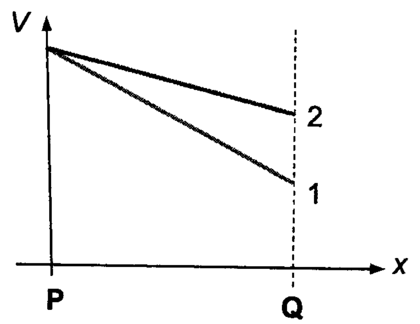
A



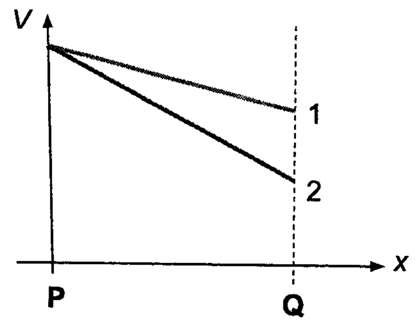
B



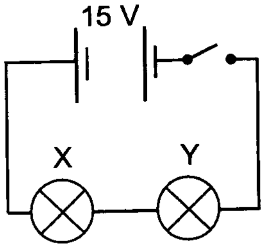
C



D



21 Two bulbs are connected in series to a 15 V power supply. Bulb X is rated 10 V, 20 W and Bulb Y is rated 5 V, 2 W.



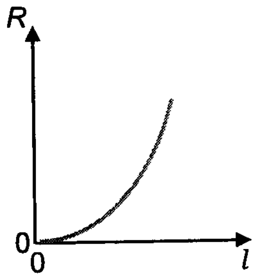
Which of the following best describes the power output of the bulbs when the switch is closed?

	power output of bulb X	power output of bulb Y
A	20 W	2 W
B	greater than 20 W	smaller than 2 W
C	smaller than 20 W	greater than 2 W
D	smaller than 20 W	smaller than 2 W

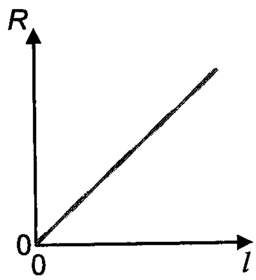
22 Several identical metal blocks are made into wires of different lengths. Each block is melted to form a single wire with uniform cross-sectional area.

Which graph shows the variation with its length l of the resistance R of the wires?

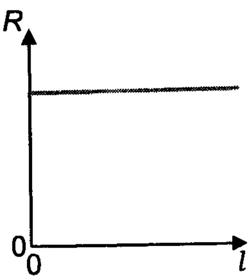
A



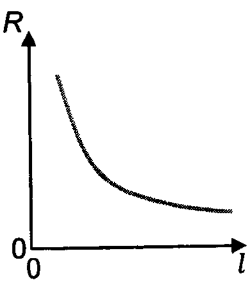
B



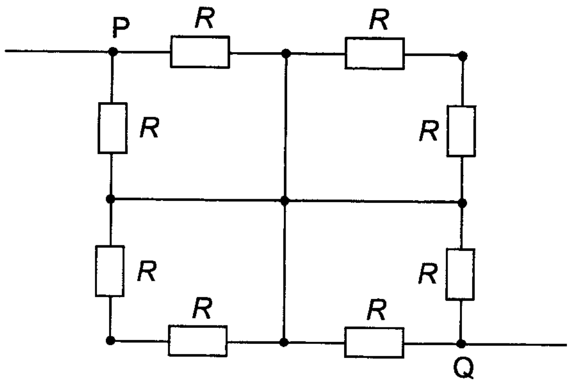
C



D



23 Eight identical resistors, each of resistance R, are connected in a network as shown below.

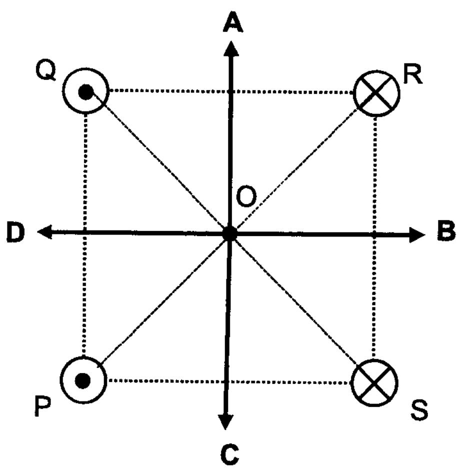


What is the effective resistance between the terminals P and Q?

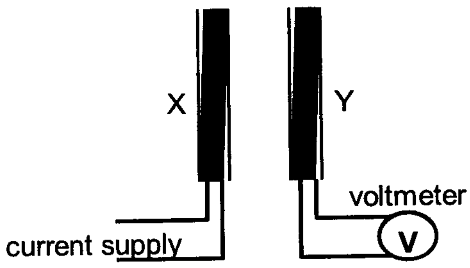
A $\frac{R}{8}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

24 Four parallel straight wires carrying equal currents pass through four corners of a square PQRS as shown below. The currents in wires P and Q are directed out of the page and the currents in wires R and S are directed into the page.

Which one of the options gives the direction of the resultant magnetic field at O?



25 Two coils X and Y are arranged as shown. Coil X is connected to a current supply and coil Y is connected to a voltmeter.



Which of the following will **not** produce a reading in the voltmeter?

A Increasing quickly the direct current supply to coil X.

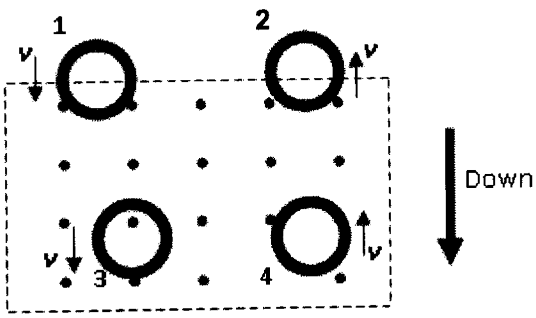
B Decreasing slowly the direct current supply to coil X.

C Using a low alternating current supply to coil X.

D Using a high direct current supply to coil X.

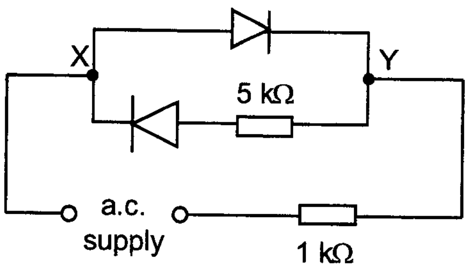
26 The figure below shows a region of uniform magnetic field directed out of the page. Outside the region, the magnetic field is zero. Four circular copper loops move with velocity v as indicated.

Which of the loop/s would experience a magnetic force directed ***upwards*** at the instant shown?



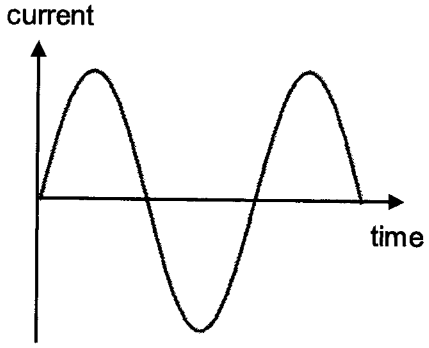
A 1 and 2 **B** 2 only **C** 1 only **D** 3 and 4

27 The figure below shows an a.c. supply connected to resistors and diodes.

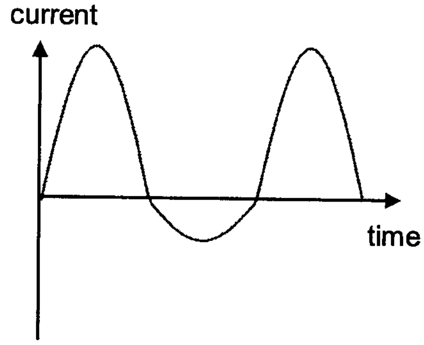


Which of the folllowing graphs represents the variation of current with time through XY of the circuit?

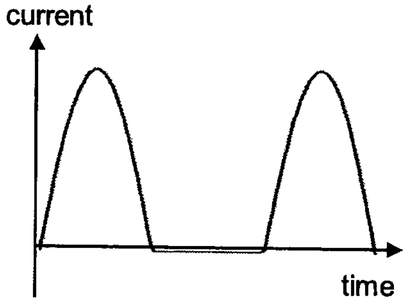
A



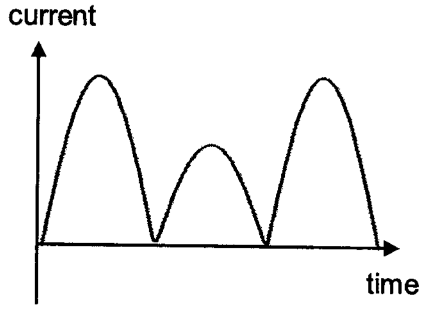
B



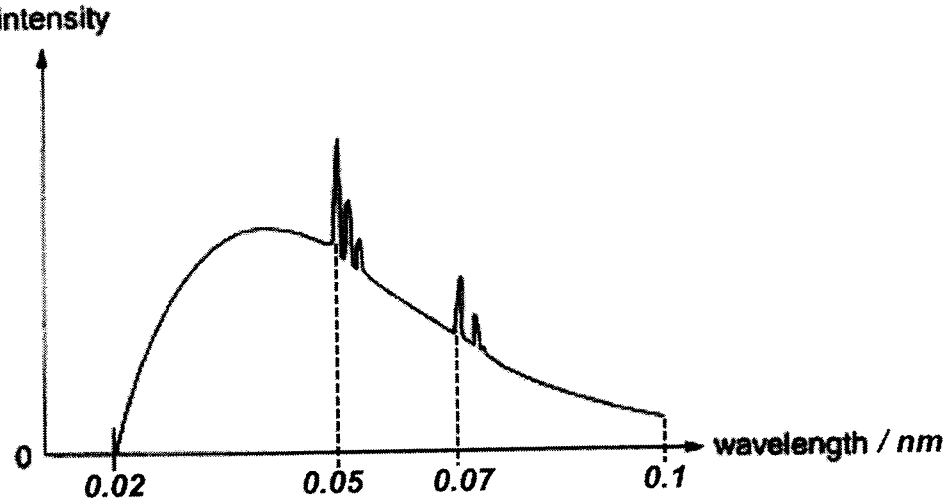
C



D



28 In x-ray production, electrons are accelerated through a high voltage V and then decelerated when they strike a metal target. The x-ray spectrum is shown below.



What is the minimum value of V, in volt, required to produce this spectrum?

A 12 000 **B** 25 000 **C** 18 000 **D** 62 000

29 When a nucleus of uranium-235 absorbs a neutron in a nuclear reactor, it undergoes fission to form various products and releases further neutrons.

In one nuclear reaction involving the fission of uranium-235, barium-144 and another element, Z, are the products. Two neutrons are also released when these products are formed. The reaction is shown in the equation.

$$^{235}_{92}U + n \rightarrow {}^{144}_{56}Ba + Z + 2n$$

How many neutrons are there in the nucleus of Z?

A 53 **B** 54 **C** 90 **D** 91

30 The ratio ^{14}C : ^{12}C of living material has a constant value during life but the ratio decreases after death because the ^{14}C is not replaced. The half-life of ^{14}C is 5600 years.

The ^{14}C content of a 5 g sample of living wood has a radioactive count rate of about 100 per minute. If the count rate of a 10 g sample of ancient wood is 50 per minute, the age of the sample is about

A 1400 years. **B** 2800 years. **C** 5600 years. **D** 11200 years.

END OF PAPER

HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		CT GROUP	21S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS

9749/02

Paper 2 Structured Questions

13 September 2022

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre Number, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

The number of marks is given in brackets [ ] at the end of each question or part question.
You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
Paper 2		
1		11
2		8
3		10
4		8
5		10
6		11
7		22
Deductions		
Total		80

This document consists of **25** printed pages.

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

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	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** A student uses the following setup in Fig. 1.1 to find the spring constant *k* of a spring.

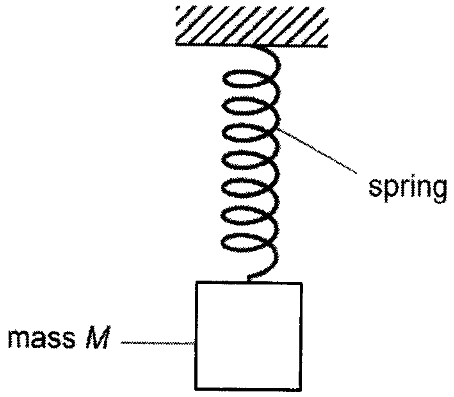


Fig. 1.1

The student obtained the following results from his experiment:

Length of spring when no mass is added: L_1 = (1.3 ± 0.1) cm

Length of spring when mass *M* is added: L_2 = (3.7 ± 0.2) cm

Mass of *M* = (98.5 ± 0.2) g

You may assume that the elastic limit of the spring has not been exceeded in his experiment.

(i) Show that the spring constant *k* of the spring is 40.3 N m^{-1}.

[2]

(ii) Calculate the actual uncertainty in *k*.

actual uncertainty in *k* = ... N m^{-1} [2]

(iii) State the value of *k* and its actual uncertainty to the appropriate precision.

k = (.............................. ± ....) N m^{-1} [1]

(b) Fig. 1.2 shows a wooden cube P of volume V floating on the surface of a liquid with density ρ. 30% of the volume of the cube is above the surface of the liquid.

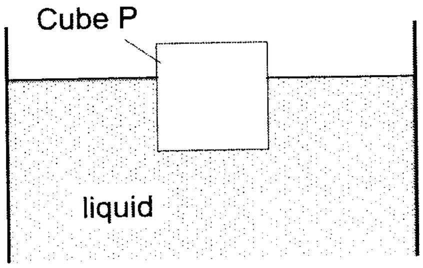


Fig. 1.2

The top face of cube P is now connected to a light string, which passes over a smooth pulley and supports an identical cube Q at its other end, which rests on a smooth inclined plane at an angle θ to the horizontal, as shown in Fig 1.3.

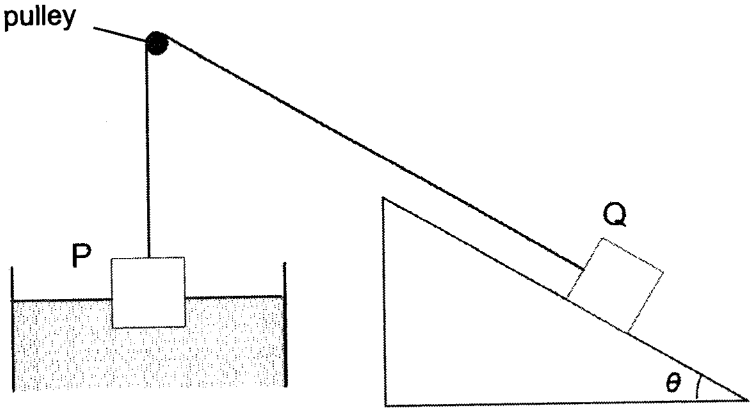


Fig. 1.3

At its new equilibrium position, 60% of the volume of Cube P is now above the surface of the liquid.

(i) On Fig. 1.4, label clearly all forces acting on Cube P when it is at its new equilibrium position.

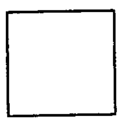


Fig. 1.4 [2]

(ii) State the expression for the weight W of cube P in terms of V and ρ.

[1]

(iii) Hence, show that the tension in the string is $\frac{3}{7}W$.

[2]

(iv) Determine the value of θ.

θ = ... ° [1]

[Total :11]

2 Jupiter has close to eighty moons, of which eight of them are in approximately circular orbits. Jupiter has a mass M_J, radius R_J and a Jupiter-day is approximately 0.417 Earth-days.

The orbital radii and periods of two of the moons of Jupiter are tabulated in Fig. 2.1. The orbital radii and the orbital periods of these moons are expressed in units of R_J and Earth-days respectively.

Name of Moon	**Orbital Radius / R_J**	**Orbital Period / Earth-days**
Amalthea	2.62	....
Thebe	3.18	0.676

Fig. 2.1

(a) **(i)** Show that the period T of a circular orbit around Jupiter, expressed in terms of the radius of the orbit R is given by

$$T = \sqrt{\frac{4\pi^2 R^3}{GM_J}}$$

[2]

(ii) Using the data provided in Fig 2.1, complete Fig. 2.1 with the orbital period for Amalthea. Show all working in the space below.

orbital period = ... Earth-days [2]

(b) **(i)** Determine an expression for the orbital speed *v* of a moon in terms of its orbital radius *R* and any other constants.

[1]

(ii) It is suggested that Jupiter's rings are formed from material ejected from the moons as the moons collide with meteorites.

Assuming no change in the speed of a moon, explain whether the moon can stay in orbit if it experiences a constant loss of mass.

....

.... [1]

(c) Using the data available for the moons of Jupiter, a graph of the orbital period was plotted against the orbital radius as shown in Fig 2.2.

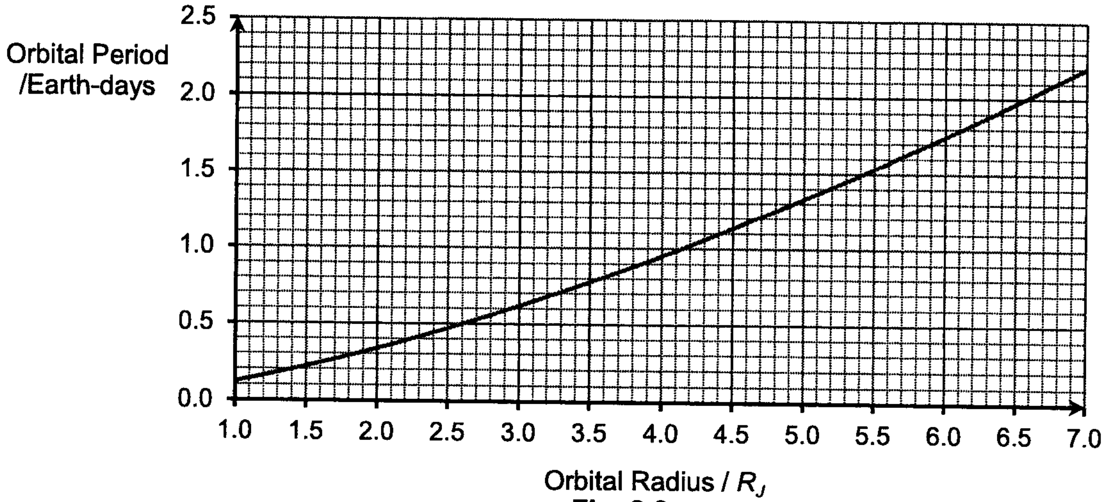


Fig. 2.2

(i) A satellite is moving in a "geostationary orbit" about Jupiter i.e. it is in an orbit above the same geographical spot on Jupiter. Using Fig. 2.2, estimate the radius of this "geostationary orbit".

radius = ... R_J [1]

(ii) Suggest a possible use for this "geostationary satellite" in **(c)(i)**.

....

....[1]

[Total: 8]

3 A sound wave that is **propagating towards the left** is represented by the two graphs below.

Fig. 3.1 shows the variation with position along the wave of the displacement of the air particles from their equilibrium position at time t = 0. Fig. 3.2 shows the variation with time t of the displacement of an air particle from its equilibrium position.

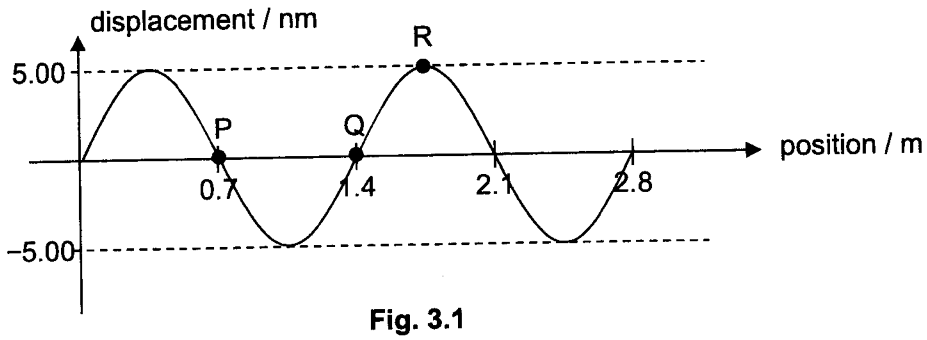


Fig. 3.1

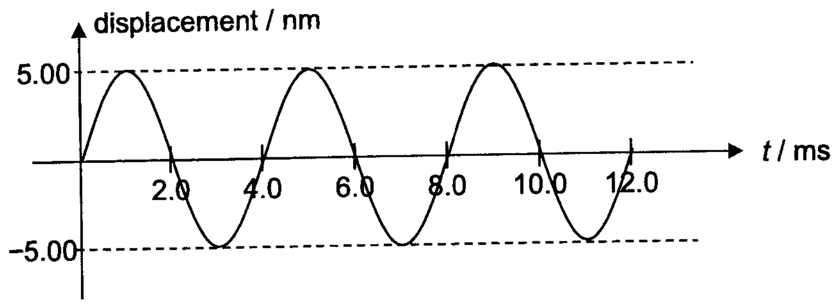


Fig. 3.2

(a) Calculate the speed of the sound wave.

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

(b) Fig. 3.1 shows three particles P, Q and R along the sound wave.
Taking rightwards to be positive, identify the particle that is

(i) instantaneously at rest at t = 0.

particle : .... [1]

(ii) at the centre of a rarefaction at t = 0.

particle : .... [1]

(iii) represented by Fig. 3.2.

particle : .... [1]

(c) Particle S is 0.70 m to the right of particle R.

(i) Determine the phase difference between particle S and R.

phase difference = ... [2]

(ii) Sketch in Fig. 3.1 the graph of the wave 1.0 ms later. Label the graph Y. [2]

(iii) Sketch in Fig. 3.2 the graph that corresponds to particle S. Label the graph Z. [1]

[Total: 10]

4 A thermistor is connected in series with a fixed resistor of 1.20 kΩ and a battery, as shown in Fig 4.1. The e.m.f. E of the battery is unknown and its internal resistance is negligible.

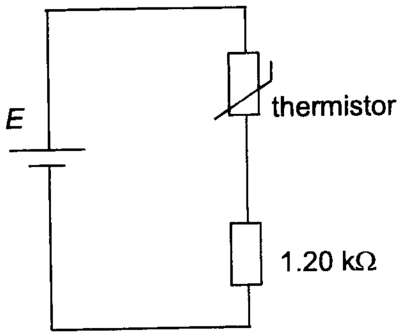


Fig. 4.1

The variation with temperature θ of the resistance R of the thermistor is shown in Fig. 4.2.

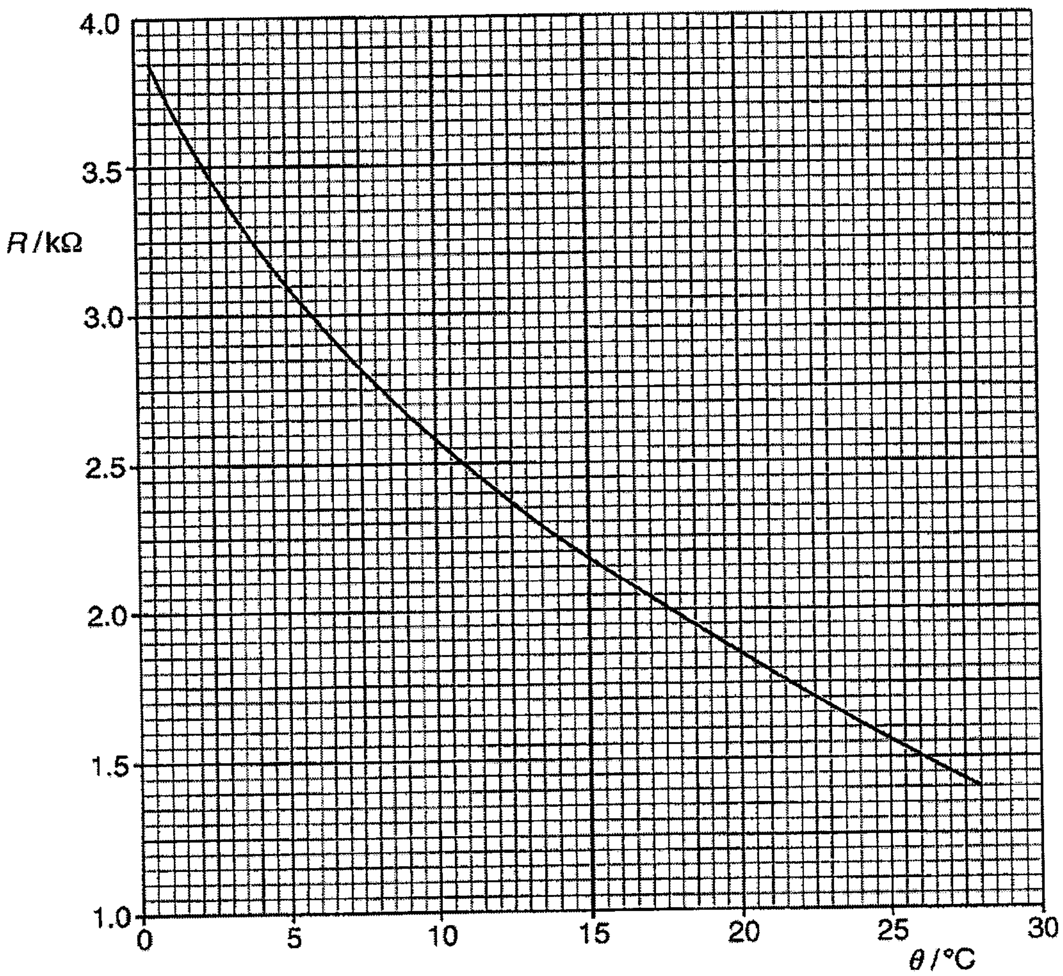


Fig. 4.2

The thermistor is immersed in a liquid maintained at a constant temperature of 5.0 °C. The energy delivered by the battery is 11.3 J for a duration of 10.0 min.

(a) **(i)** Determine the power delivered by the battery.

power = ... W [2]

(ii) Hence, determine the e.m.f. E of the battery.

E = ... V [3]

(b) The thermistor is removed and immersed in another liquid maintained at a constant temperature of 17.5 °C. The fixed resistor is replaced with another fixed resistor with a different resistance.

If the battery delivers the same power as before, determine the resistance of the fixed resistor.

resistance = ... Ω [3]

[Total: 8]

5 (a) Explain why a charge moving perpendicular to a magnetic field will follow a *uniform circular* path.

....

....

....

....

....

....[2]

(b) An electron (e_1) enters a uniform magnetic field of flux density 7.5 mT with a speed of 8.5×10^7 m s^{-1}. The magnetic field only exists within a square **MNOP** measuring 5.0 cm x 5.0 cm, as shown in Fig. 5.1 below.

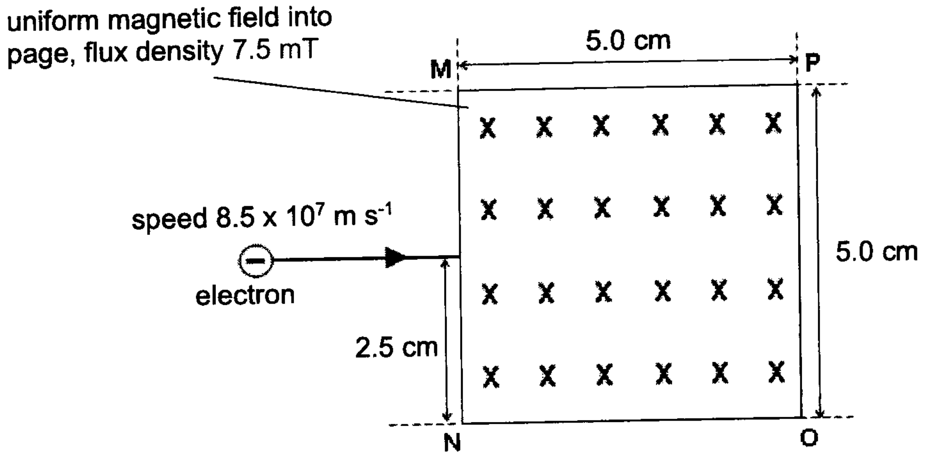


Fig. 5.1

(i) Calculate the radius of the path taken by the electron in the magnetic field.

radius = ...cm [2]

(ii) With reference to your answer in **(b)(i),** on Fig. 5.1, sketch the path of this electron as it passes through, and beyond the region of the magnetic field. [3]

(iii) Show that the period T (i.e. time to complete a circular path) of the motion of the electron when it is in the magnetic field is independent of its speed v and radius r of the path of the electron.

[1]

(iv) Another electron (e_2) moving with a **different** speed approaches the magnetic field along the same path as e_1. e_2 exits the field from side **MN**.

Hence, with reference to **(b)(iii),** explain which electron (i.e. e_1 or e_2), spends a longer time in the magnetic field.

....

....

....

....

....

....[2]

[Total: 10]

6 (a) Explain what is meant by the *activity* of a radioactive source.

....

....

.... [1]

(b) A sample of pure $^{235}_{92}U$ has a mass of 2.40 x 10^{-6} g has an activity of 0.1919 Bq.

(i) Determine the number of radioactive nuclei in this sample.

number of radioactive nuclei = ... [2]

(ii) Hence, calculate the decay constant of $^{235}_{92}U$.

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

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[Question continues next page.]

(c) The nuclide Potassium-42 $\left({}^{42}_{19}\text{K}\right)$ undergoes radioactive decay to become Calcium-42 $\left({}^{42}_{20}\text{Ca}\right)$.

A fresh sample of radioactive material contains N_o nuclei of Potassium-42 and no Calcium-42 at time t = 0. Fig. 6.2 shows the variation with time t of the ratio of the number N of nuclei of Potassium-42 to its original number N_o.

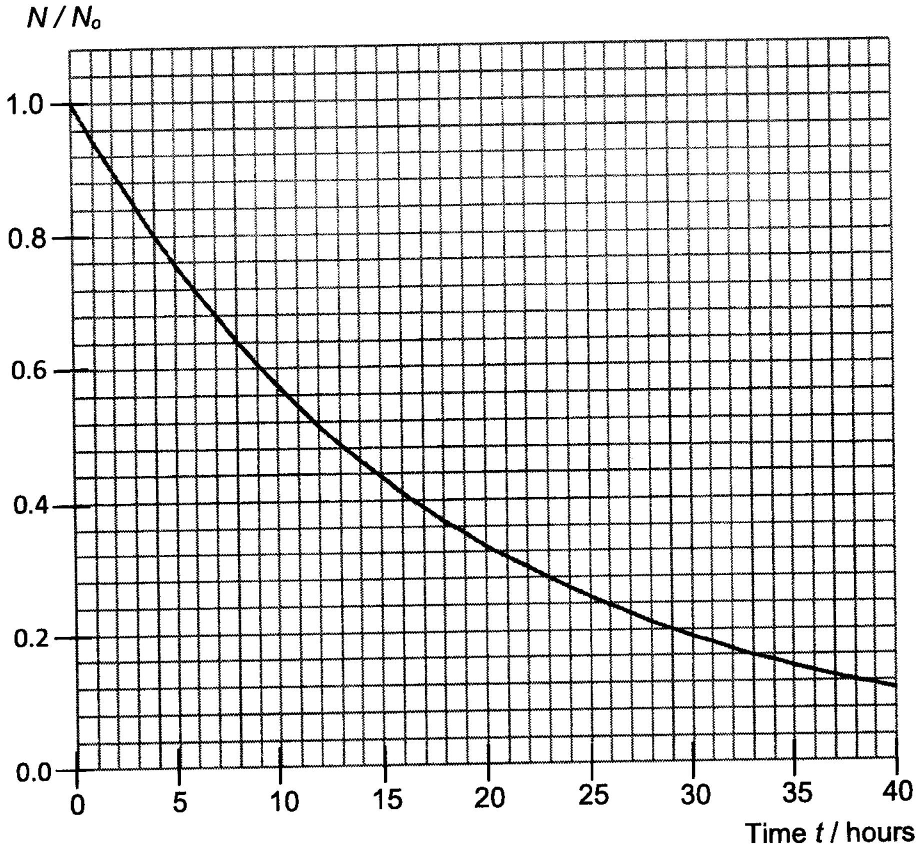

Fig. 6.2

(i) State the particles emitted in the radioactive decay of Potassium-42.

....[1]

(ii) Use Fig 6.2 to estimate the half-life of Potassium-42 in hours.

half-life = ...h [1]

(iii) Calcium-42 is stable. On Fig. 6.2, sketch a graph to show the variation with time t of the number of Calcium-42 atoms in the sample. [2]

(iv) Using Fig. 6.2, or otherwise, determine the age of the radioactive sample when the ratio $\frac{\text{Number of Calcium-42 atoms}}{\text{Number of Potassium-42 atoms}}$ is equal to 4.0.

age = ...h [2]

[Total: 11]

7 Read the passage below and answer the questions that follow.

Forces in Flight

Thrust, drag, lift, and weight are the four forces that act upon all aircraft in flight. Understanding how these forces work and knowing how to control them are essential to flight.

Lift is the upward force on the aircraft acting perpendicular to the wing. While an aircraft's weight is concentrated at the centre of gravity (CG), the lift occurs at the centre of pressure (CP). In the design of aircraft, the CG is fixed forward of the CP as shown in Fig. 7.1 in order to retain flight equilibrium. The tailplane of the aircraft helps to maintain the stability of the aircraft. It consists of a horizontal stabiliser with a fixed wing section and an elevator which could be adjusted to produce a vertical force acting on the rear of the aircraft's body. The vertical stabilizer consists of a rudder which could be maneuvered to produce a force to adjust the sideway movements of the aircraft.

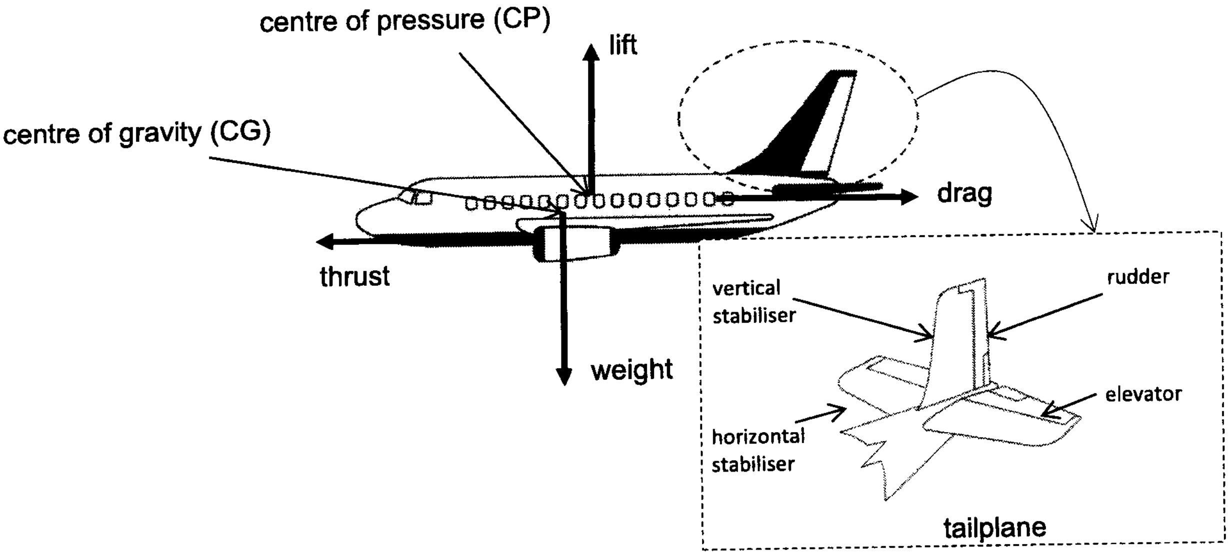

Fig. 7.1

The thrust is the forward force provided by a propulsion system of the plane – often the jet engines in a modern aircraft. A jet engine works by sucking air in the front, compressing it and then mixing and combusting the air with fuel before pushing it out at a much higher speed and higher pressure. Fig. 7.2 is a typical jet engine.

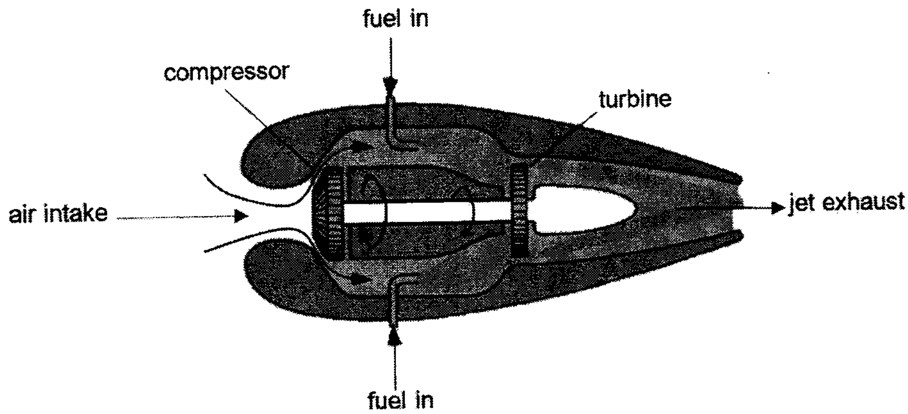

Fig. 7.2

Most of the lift of the aircraft is usually generated at the wings. The cross-section of the wings of the aircraft has a very special shape called an *aerofoil.* (Fig. 7.3(a)) The aerofoil looks like a teardrop that deflects the airflow downwards, increasing the velocity of the airflow on top and decreasing the velocity at the bottom. This effect produces a pressure difference between the top and the bottom of the wings which produces a net upward force known as the lift. By tilting the aerofoil at different angles with respect to the velocity of the air that flows through it, the lift force can also vary. This angle which the aerofoil makes with the velocity of the air that flows through it is known as the *angle of attack* α. (Fig. 7.3(b))

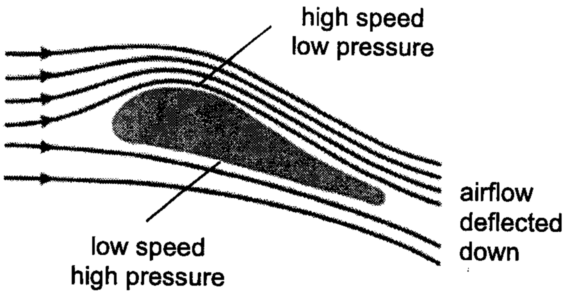

Fig. 7.3(a)

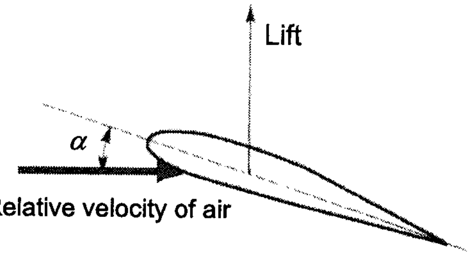

Fig. 7.3(b)

Although a lift force is generated by the wing when it moves through the air, due to the viscosity of air, a drag force is also generated as an inevitable product of the lift. Apart from the wings, all other parts of an aircraft's airframe also generate a drag force which acts in opposite direction to the flight.

Both the lift (L) and the drag (D) forces depend on factors such as the shape of the aerofoil, angle of attack and the relative velocity between the air and the aircraft. These factors are taken into consideration in the following *Lift* and *Drag Equations* used by pilots to determine L and D :

Lift Equation : $L=\frac{1}{2}C_L\rho v^2S$ and Drag Equation: $D=\frac{1}{2}C_D\rho v^2S$

where ρ is the density of the air, v is the relative speed between the aircraft and the wind and S the effective surface area of the wings. C_L and C_D are dimensionless constants known as the *lift coefficient* and the *drag coefficient* respectively. A dimensionless constant is one in which its unit is equal to one. Both C_L and C_D are dependent on the shape of the aerofoil and the angle of attack.

(a) An aircraft travels in a straight, level flight with a constant velocity as shown in Fig. 7.1. The total weight of the aircraft is 1.5×10^6 N, and the engines give it a forward thrust of 0.60×10^6 N.

(i) Determine the value of the lift and the drag.

lift = ... N

drag = ... N [2]

(ii) The horizontal separation of the lines of action of lift and weight is 0.75 m. Determine the vertical separation of the lines of action of thrust and drag.

vertical separation = ... m [2]

(iii) Due to the design of the aircraft, when the CG is forward of the CP, there is a natural tendency for the nose of the aircraft to tilt downwards when in flight.

Suggest how the tail stabiliser assists in maintaining the equilibrium of the plane.

....

....

....

....

.... [2]

(b) A simplified model of a jet engine of an aircraft is shown in Fig. 7.4.

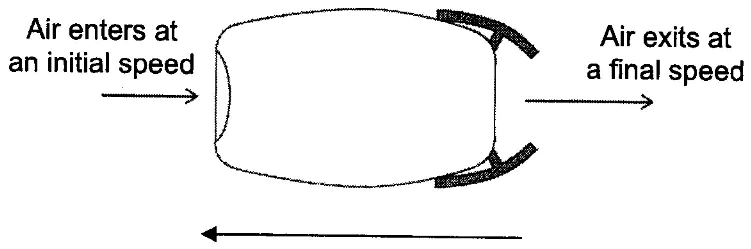

Fig. 7.4

(i) By using Newton's Laws of Motion, explain how the air is able to exert a forward thrust on the engine.

....

....

....

....

....

.... [2]

(ii) For a particular flight, the mass flow rate of the air that enters the jet engine is 210 kg s^{-1} and this mass of air increases speed by 580 m s^{-1} as it passes through the engine.

Calculate the thrust provided by the air on this jet engine.

thrust = ...N [2]

(iii) In reality, the actual thrust on the engine is different from the value calculated in **(ii)**. Suggest a possible physics related reason for the difference.

....

....[1]

(c) An aircraft has a mass of 2.85×10^5 kg and each wing has an area of 360 m^2. During level flight, the pressure on the lower wing surface is 7.00×10^4 Pa. Determine the pressure on the upper wing surface.

pressure = ...Pa [2]

(d) **(i)** Show that the coefficient of lift C_L is a dimensionless quantity.

[2]

(ii) To make a turn in flight, an aircraft often needs to do a tilt as shown in Fig. 7.5. Explain why the aircraft needs to tilt and increase in speed if it wishes to maintain the same altitude as before while making the turn.

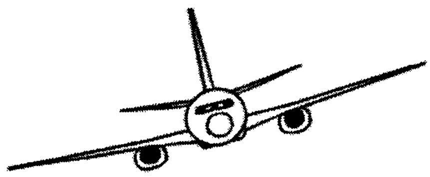

Fig. 7.5

....

....

....

....

....

....[2]

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[Question continues next page.]

(e) Both C_L and C_D are normally experimentally determined using a wind tunnel. Fig. 7.6 depicts the graphs of C_L and C_D with against the angle of attack α for a particular aerofoil wing; C_L is on the left axis and C_D is on the right axis. From these graph, the ratio of C_L to C_D can be found. This ratio is equal to the lift to drag ratio (L/D) which gives an indication of the efficiency of the performance of the plane in flight. A graph of some of the data showing the variation of L/D with α is shown in Fig. 7.7.

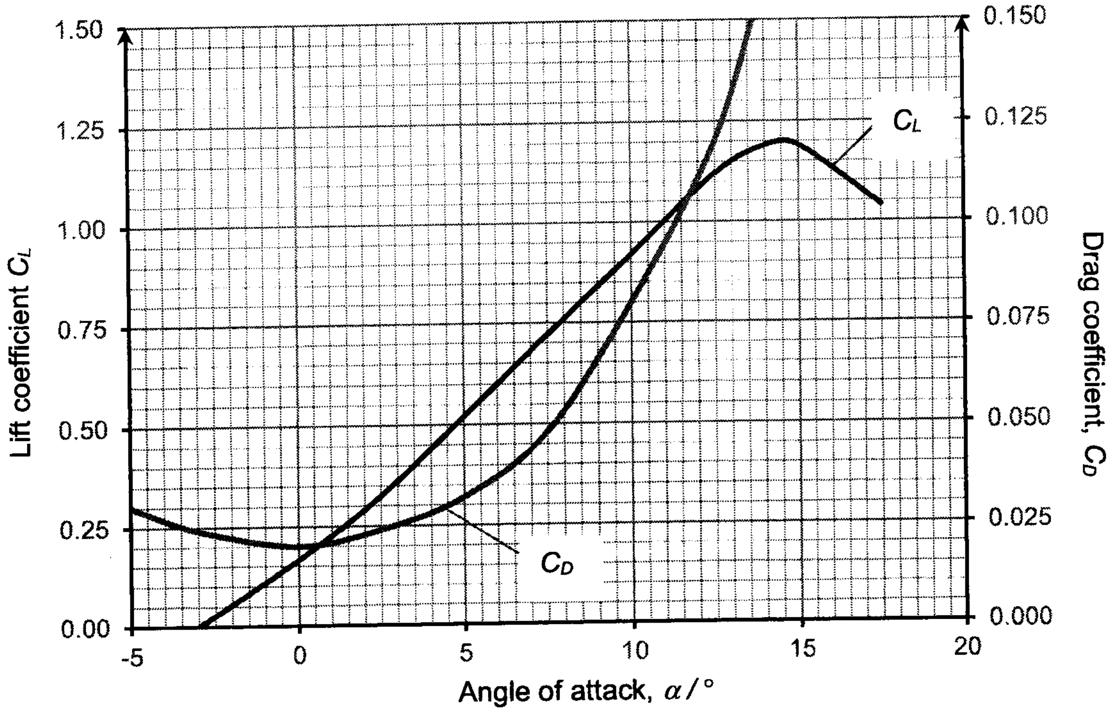

Fig. 7.6

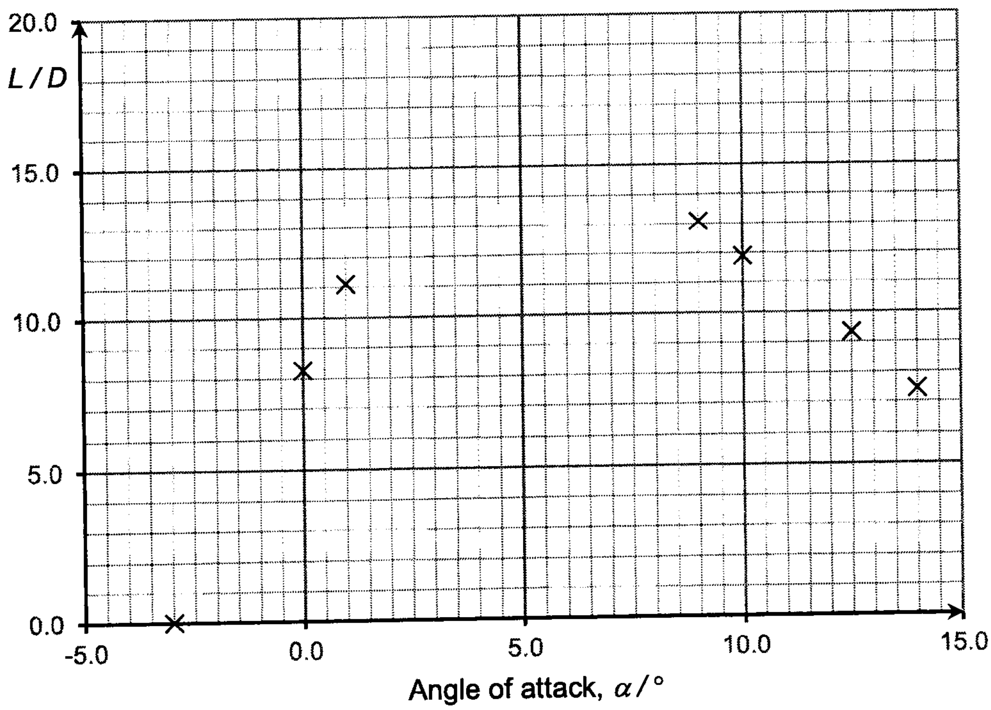

Fig. 7.7

(i) Using the *Lift* and *Drag Equations*, show that the ratio of C_L to C_D is equal to the lift to drag ratio *L/D*.

[1]

(ii) In most phases of flight, the generation of lift is a distinct benefit, while the generation of drag is a distinct disadvantage. When the aircraft is at level flight, the wing is said to be working most efficiently when the lift to drag ratio is a maximum. Suggest why this is so.

....

....

....

....[1]

(iii) For most conventional aerofoil wing, this greatest efficiency in **(e)(ii)** is achieved at an angle of attack at 4°.

1. Using Fig. 7.6, determine the lift to drag ratio at this angle of attack for the aerofoil.

L/D = ... [1]

2. Plot this point on Fig. 7.7 and sketch the best fit curve. [2]

[Total : 22 marks]

Acknowledgements:
1. Fig. 7.1. Source : (https://www.vectorstock.com/royalty-free-vector/aeroplane-side-view-vector-23448245)
2. Fig. 7.2. Source : (https://www.basicairdata.eu/knowledge-center/measurement/in-flight-angle-of-attack-usage/)
3. Key Reference 1 : Principles of Flight for PPL and Beyond, v. 5. Oxford Aviation Academy.

End of paper

HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		CT GROUP	21S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS

9749/03

Paper 3 Longer Structured Questions

15 September 2022

SECTION A BOOKLET

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **Centre number, index number, name** and **CT class** clearly 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, paperclips, highlighters, glue or correction fluid.

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

Section A

Answer **all** questions.

Section B

Answer **one** question only. **Circle** the question number on the cover page.

You are advised to spend one and a 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.

You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
Section A		
1		8
2		8
3		9
4		8
5		10
6		7
7		10
Section B		
8		20
9		20
Deductions		
P3		80

This paper consists of **17** printed pages.

Data

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permittivity of free space, $\varepsilon_o = 8.85 \times 10^{-12}$ F m^{-1} $\approx (1/(36\pi)) \times 10^{-9}$ F m^{-1}

elementary charge, $e = 1.60 \times 10^{-19}$ C

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molar gas constant, $R = 8.31$ J K^{-1} mol^{-1}

the Avogadro constant, $N_A = 6.02 \times 10^{23}$ mol^{-1}

the Boltzmann constant, $k = 1.38 \times 10^{-23}$ J K^{-1}

gravitational constant, $G = 6.67 \times 10^{-11}$ N m^2 kg^{-2}

acceleration of free fall, $g = 9.81$ m s^{-2}

Formulae

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pressure of an ideal gas	$P = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean kinetic energy of a molecule of an ideal gas	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$ $= \pm \omega \sqrt{(x_o^2 - x^2)}$
electric current	$I = Anvq$
resistors in series	$R = R_1 + R_2 + \ldots$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential	$V = \frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage	$x = x_o \sin \omega t$
magnetic flux density due to a long straight wire	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o n I$
radioactive decay	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 (a) (i) Define gravitational potential at a point.

....

....

....

.... [2]

(ii) Explain why gravitational potential is negative.

....

....

....

.... [2]

(b) A meteorite was observed to be traveling fast on a straight-line path inside a gravitational field. AB is a segment of this path, which occurs over a short period of time. The variation in the gravitational potential ϕ along AB is shown in Fig 1.1 where x is the displacement of the meteorite from A. The gravitational potential reaches a maximum value when $x = x_0$ at the point C.

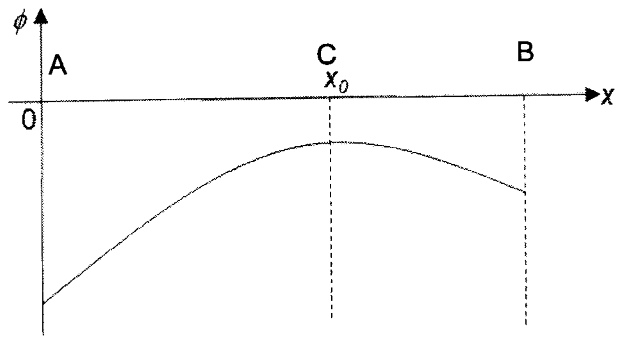


Fig 1.1

(i) Describe the variation in the gravitational force acting on the meteorite along the path AC.

....

....

....

.... [2]

(ii) On Fig 1.2, sketch the graph of the variation in the kinetic energy of the meteorite.

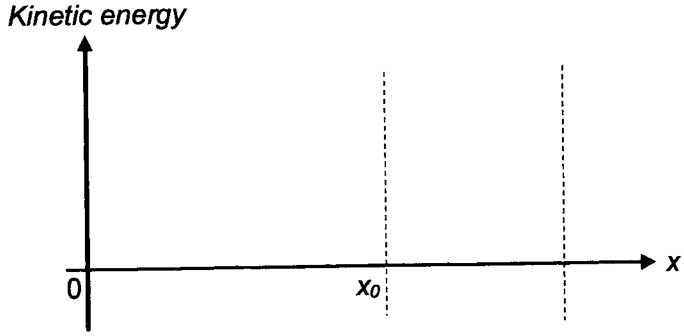


Fig 1.2 [2]

[Total: 8]

2 Fig. 2.1 shows a cylinder containing an ideal gas of pressure *P* and volume *V* enclosed by a movable piston. The cylinder is kept submerged in a large ice-water bath maintained at 0 °C.
The specific latent heat of fusion of the ice = 334 J g^{-1}.

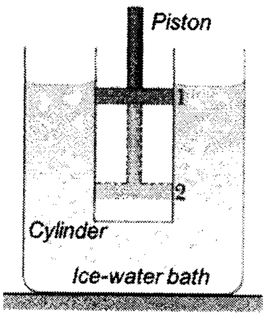


Fig. 2.1

The gas undergoes three processes in the following sequence:

Process A: Gas compressed quickly from position 1 to 2 (such that there is no heat transfer to and from gas).

Process B: Piston held at position 2 until the gas reaches the temperature of the ice-water bath.

Process C: Piston slowly raised back to position 1.

(a) The volume of gas when the piston is at position 1 and 2 are indicated as V_1 and V_2 respectively. The dot represents the state of gas in cylinder at the start of process A.
Sketch the 3 processes on the *P-V* diagram in Fig. 2.2. Label the processes clearly using A, B & C.

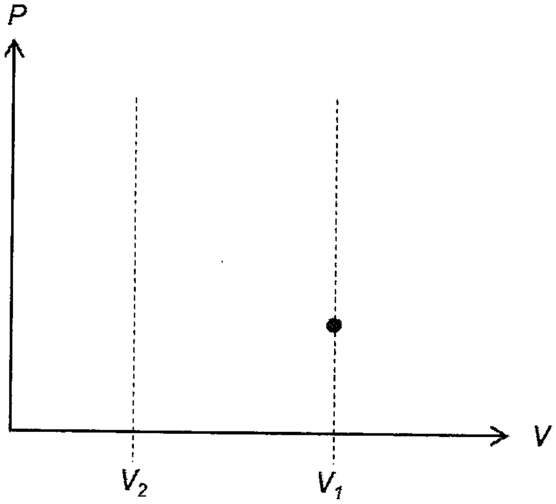


Fig. 2.2

[3]

(b) Identify process B.

.... [1]

(c) At the end of process C, 100 g of ice has melted. There is no heat transfer between the ice and environment.
State whether net heat is transferred into or out of the gas cylinder.

.... [1]

(d) Determine the net temperature change for the gas for one complete cycle.

net temperature change = ... K [1]

(e) Calculate the net work done on the gas.

net work done on the gas = ... J [2]

[Total: 8]

3 One end of a spring is fixed to a support. A block is attached to the other end of the spring and gently lowered to its equilibrium position, as shown in Fig. 3.1.

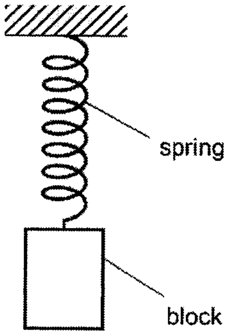


Fig. 3.1

Using two fingers, a student pushes down sharply on the block.
This immediately imparts some downward momentum to the block, causing it to oscillate.

(a) Theory suggests that the vertical acceleration a of the block is related to its vertical displacement y by the expression

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

where k is the spring constant and m is the mass of the block.

Explain why this expression leads to the conclusion that the block is performing simple harmonic motion.

....

....

....

.... [2]

(b) Fig. 3.2. shows some measurements obtained by the student.

Spring constant k / N m^{-1}	25
Mass of block / kg	0.15

Fig. 3.2

(i) Determine the angular frequency ω of the oscillation.

ω = ... rad s^{-1} [1]

(ii) The block has a maximum speed of 0.31 m s^{-1}. Damping effects can be neglected. **Using your result in (b)(i)**, calculate the amplitude y_0 of the oscillation.

y_0 = ... m [1]

(iii) Using your answers in **(b)(i)** and **(b)(ii)**, sketch on Fig. 3.3 the variation of velocity v of the oscillating system with the displacement y.

Indicate on your graph when the mass is at the start of its motion and when it first comes to rest. Label these points A and B respectively.

Take downwards as positive displacement.

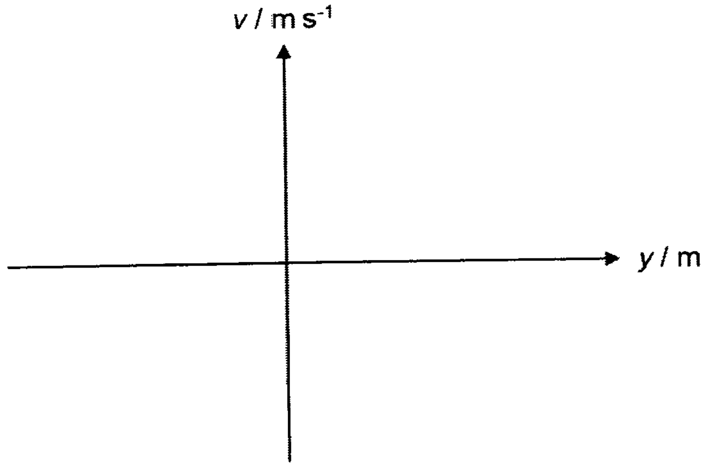


Fig. 3.3 [3]

(iv) Sketch two graphs on Fig. 3.4 to show the variation of kinetic energy (KE) and elastic potential energy (EPE) of the oscillating system as the block moves between the equilibrium position and the lowest position. Label each graph clearly.

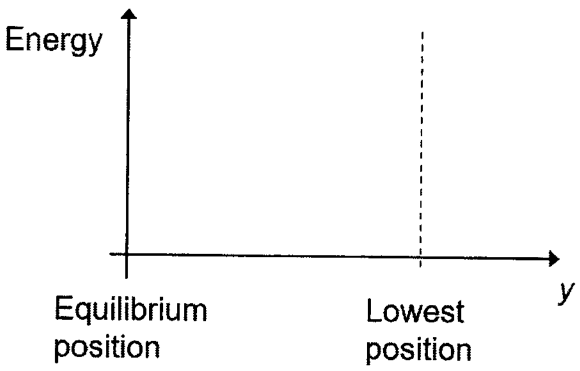


Fig. 3.4

[2]

[Total: 9]

4 A circuit is set up to determine the e.m.f. E and internal resistance r of an unknown cell as shown in Fig. 4.1. Initially, both switch S_1 and switch S_2 are opened.

An accumulator with a negligible internal resistance is connected in series to a resistor R_1 and a resistance wire. The resistance wire AB is 120.0 cm long. Both resistance wire and the external resistor R_1 has the same resistance. When the jockey J is placed at end point B, the potential difference across the resistor R_1 is 4.00 V. The resistance of the fixed resistor R_2 is 12.0 Ω.

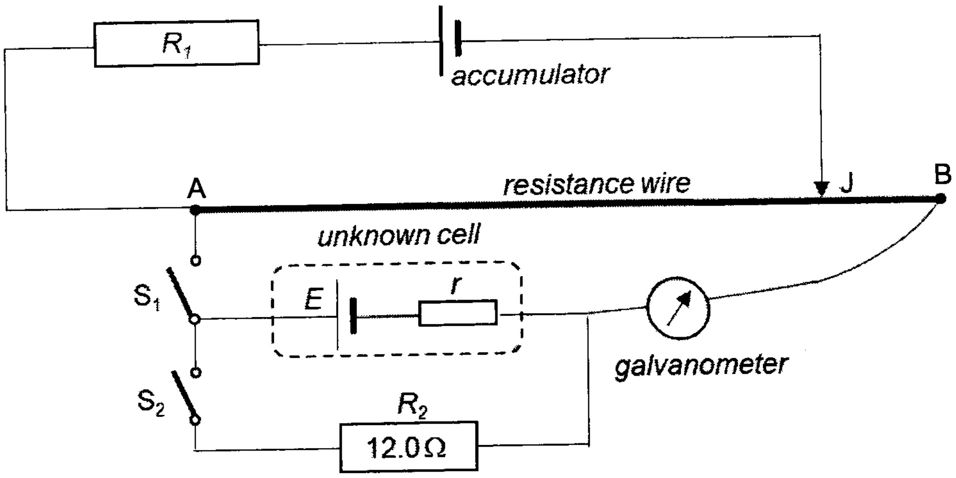


Fig. 4.1

(a) Determine the e.m.f. of the accumulator.

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

(b) The switch S_1 is closed. When the jockey J touches the point B on the resistance wire, the galvanometer shows null deflection. Determine the e.m.f. E and terminal potential difference of the unknown cell.

terminal potential difference = ... V

E = ... V [2]

(c) Both switches S_1 and S_2 are closed. When the jockey J is moved to a new point C on the resistance wire where it is at a distance of 72.0 cm from the point A, the galvanometer shows null deflection. Determine

(i) the potential difference between point A and point C.

potential difference = ... V [2]

(ii) the potential difference across the fixed resistance R_2.

potential difference = ... V [1]

(iii) the internal resistance *r* of the unknown cell.

r = ... Ω [2]

[Total: 8]

5 (a) The square loop ***abcd*** is placed in a region of uniform magnetic field of flux density B as shown in Fig. 5.1. The loop carries a steady current I in the direction as shown. Dotted lines CD, EF, GH and JK are axes of symmetry through the centre of the square loop.

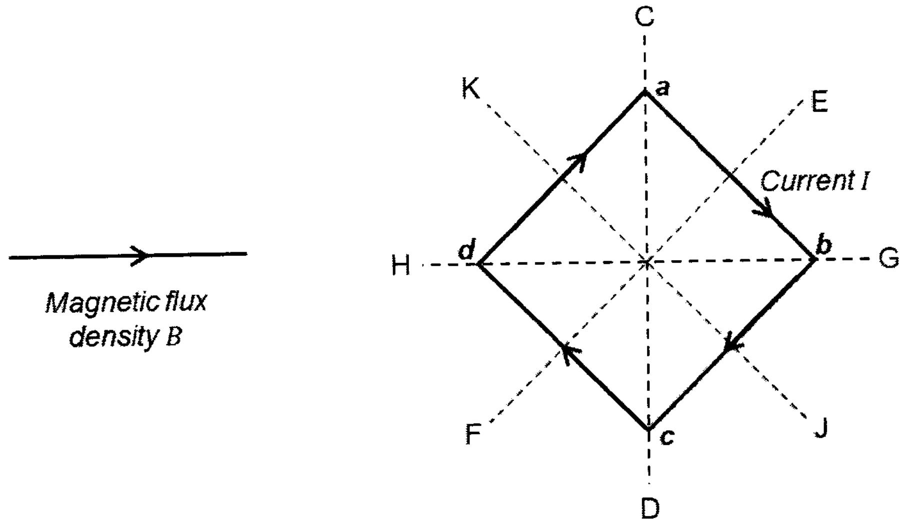


Fig. 5.1

(i) State the axis (CD, EF, GH or JK) about which the square loop will rotate.

.... [1]

(ii) State and explain the direction of rotation of the square loop about the axis you have identified in **(a)(i)**.

....

....

....

....

....

....

....

....

.... [4]

(b) The square loop in Fig. 5.2 is made of wires with total series resistance of 10.0 Ω. It is placed in a uniform magnetic field of magnetic flux density 0.100 T directed perpendicularly into the plane of the diagram.

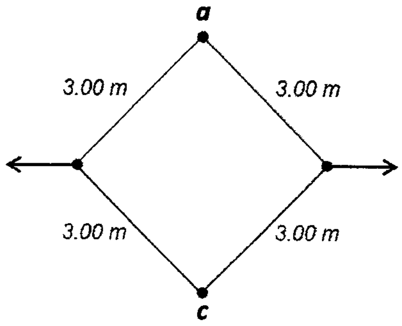


Fig. 5.2

The loop which is made of inextensible wires is hinged at each corner. In a time of 0.100 s, it is pulled in the directions as shown by the arrows until the separation between points ***a*** and ***c*** is 2.00 m.

(i) Determine the average induced e.m.f. in the loop.

average induced e.m.f. = ... V [4]

(ii) Hence, or otherwise, find the induced current in the loop.

induced current = ... A [1]

[Total: 10]

6 **(a)** The equation $V = 340 \sin(100\pi t)$ represents a sinusoidal alternating voltage for a household power supply, where V is in volts and t is in seconds. State the frequency, peak voltage and root-mean-square voltage for this alternating voltage.

(i)

frequency = ... Hz [1]

(ii)

peak voltage = ... V [1]

(iii)

root-mean-square voltage = ... V [1]

(b) Fig. 6 shows an ideal iron-cored transformer. The ratio of the secondary turns to the primary turns is 1:20.

A 240 V a.c. supply is connected to the primary coil and a 6.0 Ω resistor is connected to the secondary coil.

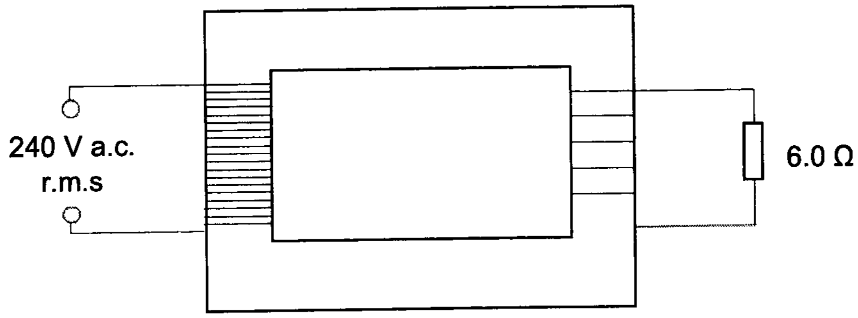


Fig. 6

(i) Determine the voltage across the 6.0 Ω resistor.

voltage = ... V [1]

(ii) Calculate the current in the primary coil.

current = ... A [3]

[Total: 7]

7 In an experiment, incident photons that enter a tube strike a metal surface, resulting in electrons being ejected. By counting the number of collected electrons, the number of incident photons can be determined.

(a) State the phenomenon where electrons are ejected from a metal irradiated with light.

.... [1]

(b) Determine the maximum kinetic energy of the ejected electrons if monochromatic light of wavelength 500 nm is incident on a metal of work function of 1.0 eV.

maximum kinetic energy = ... eV [2]

(c) Hence, calculate the maximum momentum of the ejected electrons.

maximum momentum = ... N s [2]

(d) A laser light of wavelength 500 nm and power 25×10^{-6} W is incident onto the metal. The probability of a photon ejecting an electron from the metal is 20%. Calculate the electron current produced, assuming all electrons are collected.

electron current = ... A [3]

(e) The metal chosen for this experiment is required to eject electrons when irradiated with light of all incident wavelengths throughout the visible light range (400 nm to 700 nm). Determine the maximum value for the work function of this metal.

maximum work function of metal = ... eV [2]

[Total: 10]

End of Paper 3 Section A

HWA CHONG INSTITUTION
JC2 Preliminary Examination
Higher 2

CANDIDATE NAME		CT GROUP	21S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS

9749/03

Paper 3 Longer Structured Questions

15 September 2022

SECTION B BOOKLET

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

INSTRUCTIONS TO CANDIDATES

Write your **Centre number, index number, name** and **CT class** clearly 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, paperclips, highlighters, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer **one** question only. **Circle** the question number on the cover page.

You are advised to spend one and a 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.

You are reminded of the need for good English and clear presentation in your answers.

For Examiner's Use		
SECTION B (circle 1 question)		
8		20
9		20
Deductions		

This document consists of **11** printed pages.

Data

speed of light in free space,
$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$

permeability of free space,
$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$

permittivity of free space,
$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
$\approx (1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$

elementary charge,
$e = 1.60 \times 10^{-19}\,\mathrm{C}$

the Planck constant,
$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$

unified atomic mass constant,
$u = 1.66 \times 10^{-27}\,\mathrm{kg}$

rest mass of electron,
$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$

rest mass of proton,
$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$

molar gas constant,
$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$

the Avogadro constant,
$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$

the Boltzmann constant,
$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$

gravitational constant,
$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$

acceleration of free fall,
$g = 9.81\,\mathrm{m\,s^{-2}}$

Formulae

uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on / by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\mathrm{K} = T/^{\circ}\mathrm{C} + 273.15$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section B

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

8 (a) (i) State the *principle of superposition*.

....

....

....

....

.... [2]

(ii) When two waves superpose, state three conditions necessary for a stable and observable interference pattern.

1. ....

....

....

2. ....

....

....

3. ....

....

....

[3]

(b) Two coherent transverse wave sources produce wavefronts as shown in Fig. 8.1. The sources S_1 and S_2 are 3.0 mm apart. The line CC is parallel to the line joining S_1 and S_2 and it is 1.00 m away from the sources. Fig. 8.1 is not drawn to scale.

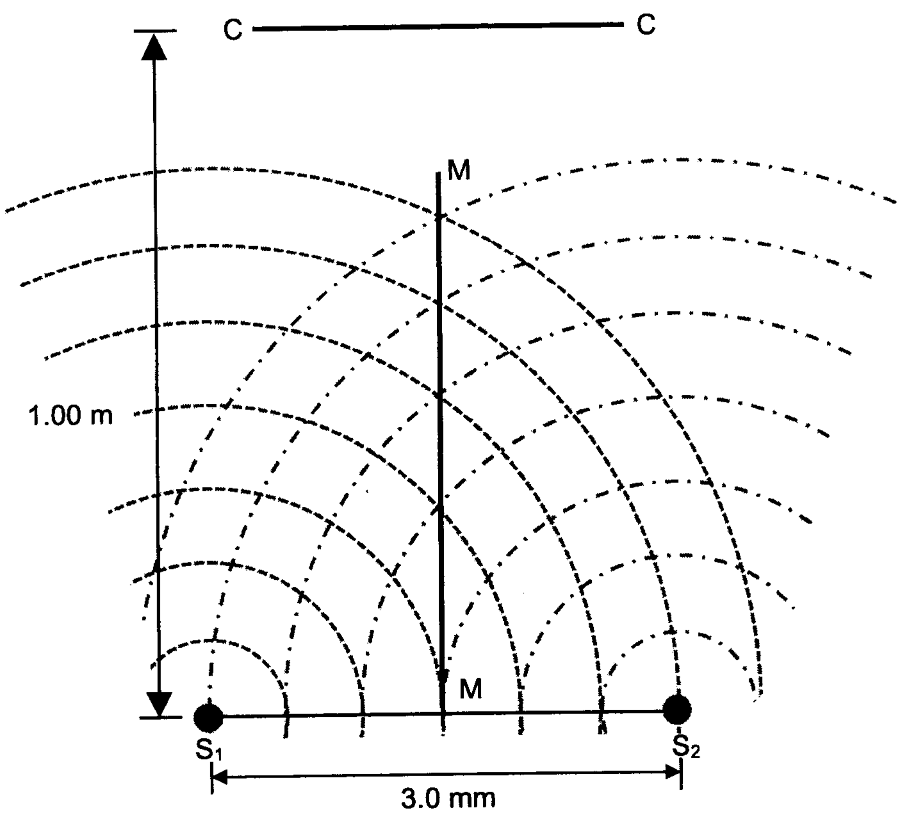


Fig. 8.1 (not to scale)

Lines where the amplitude of the resultant wave is minimum is known as a nodal line. Lines where the amplitude of the resultant wave is a maximum is known as an antinodal line.

(i) Line MM is a nodal line.
Hence, deduce the phase difference (in degrees) between the sources S_1 and S_2.

phase difference = ... ° [1]

(ii) On Fig. 8.1, draw a line where the path difference in terms of wavelength λ of the waves from the two sources is

1. 2 λ. Label this line EE. [1]
2. 0.5 λ. Label this line FF. [1]

(iii) State whether the line FF is a nodal or antinodal line.

Line FF: .... [1]

(iv) Identify the particular interference pattern detected along line S_1S_2.

.... [1]

(v) Show that the wavelength of the waves generated by the two sources is 0.5 mm.

[1]

(vi) Along line S_1S_2, determine the number of minimas (locations where the resultant wave has the smallest amplitude) detected between the two sources. Ignore what is detected at the sources.

number of minimas = ... [3]

(vii) Determine the distance between each maxima that can be detected along line CC.

distance between each maxima = ... m [2]

(viii) Describe how the new interference pattern detected along lines CC and S_1S_2 compares with the old pattern when the following changes are made separately.

1. The distance between S_1 and S_2 is increased.

CC: ....

....

....

S_1S_2: ....

....

....

[2]

2. The amplitude of waves from S_1 is smaller than the waves from S_2.

CC: ....

....

....

S_1S_2: ....

....

....

[2]

[Total: 20]

9 **(a)** State *Coulomb's Law.*

....

....

.... [1]

(b) In a simple model of the structure of an atom, a hydrogen atom can be thought of as consisting of an electron in circular orbit around a proton, as shown in Fig. 9.1.

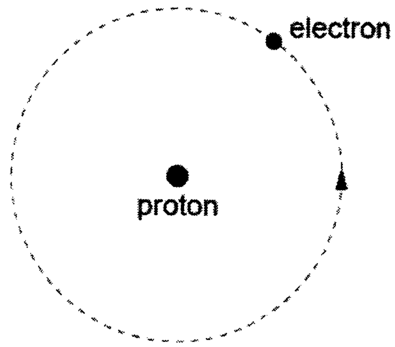


Fig. 9.1

(i) Show that the speed v of the electron is given by

$$v = \frac{e}{\sqrt{4\pi\varepsilon_0 mr}}$$

where e is the elementary charge, r is the radius of the orbit and m is the mass of the electron.

[2]

(ii) Hence, show that the total energy E_T of this system is given by

$$E_T = -\frac{e^2}{8\pi\varepsilon_0 r}$$

[2]

(iii) The ground state energy of an electron in a hydrogen atom is -13.6 eV.

Use the expression in **(b)(ii)** to show that the radius of orbit of an electron in its ground state in a hydrogen atom is approximately 5×10^{-11} m.

[2]

(c) Gravitational fields and electric fields are similar in that they can both be described as regions in which force is applied to an object. However, there are some differences between the two fields as well.

State, in words, a further *similarity* and a *difference* between gravitational and electric fields.

Similarity: ....

....

....

Difference: ....

....

....

[2]

(d) The table shows data relating to the Moon orbiting the Earth and an electron orbiting the nucleus of a hydrogen atom.

	Moon orbiting Earth	electron orbiting nucleus
mass / kg	7×10^{22}	9×10^{-31}
speed / m s^{-1}	1×10^{3}	2×10^{7}
orbital radius / m	4×10^{8}	5×10^{-11}

(i) Use the data in the table to determine

1. the de Broglie wavelength of the Moon orbiting the Earth,

wavelength = ... m [1]

2. the de Broglie wavelength of the electron orbiting the nucleus.

wavelength = ... m [1]

(ii) Use your answers to **(d)(i)** to explain why it is more reasonable to consider an electron in orbit around the nucleus as a wave while the Moon in orbit around the Earth as a particle.

....

....

.... [1]

(e) A mixture of 2 different powdered minerals can sometimes be separated in the laboratory by using an electric field.

The mixture to be separated is first placed in a vibrating tray in which the two types of powdered minerals become oppositely charged by friction. The tray has a small opening through which the minerals fall vertically from rest through a constant horizontal electric field set up between a pair of charged parallel plates. Fig. 9.2 shows a possible setup.

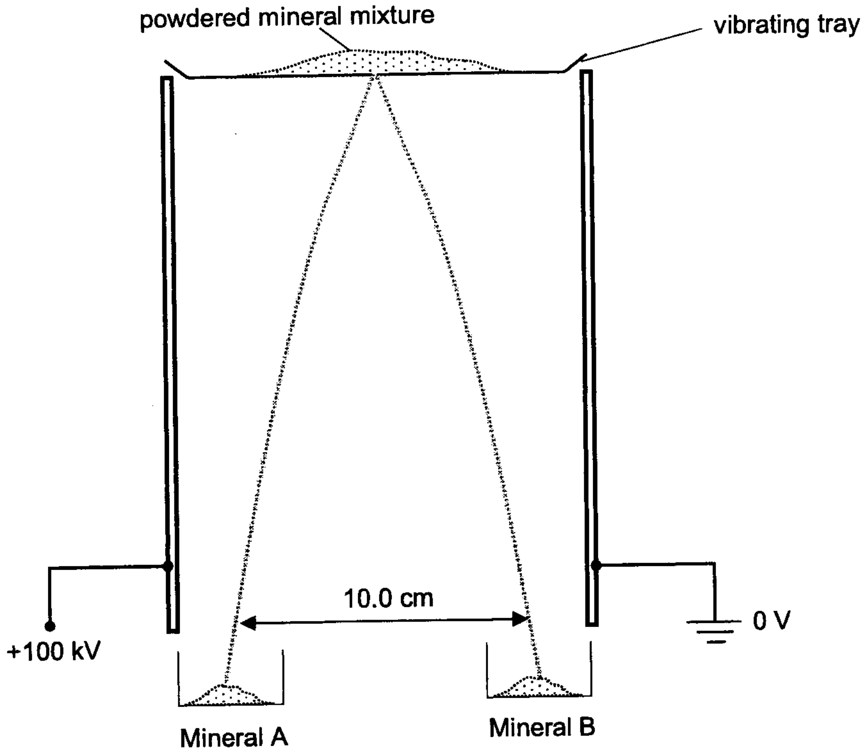


Fig. 9.2

In the above setup, a potential difference of 100 kV is maintained between the two large parallel plates which are separated horizontally by a distance of 15.0 cm. After falling through the plates, the minerals are separated by a horizontal distance of 10.0 cm.

The individual grains of the powdered minerals can be modelled as spheres of diameter 100 μm, each carrying a charge of magnitude 1.60×10^{-17} C.

(You may assume that air resistance and upthrust is negligible.)

(i) Determine the magnitude of the force on a grain due to the electric field produced by the two large parallel plates.

force = ... N [2]

(ii) With the support of an appropriate calculation, explain why the electrical force between two charged mineral grains that are adjacent to each other can be ignored when considering the motion of the grains in the electric field.

....

....

.... [3]

(iii) Given that the magnitude of charge per unit mass of the minerals is 2.00×10^{-6} C kg^{-1}, show that the horizontal acceleration of each mineral grain is 1.33 m s^{-2}.

[1]

(iv) Hence, determine the time taken for the minerals to pass out of the parallel plates.

time taken = ... s [2]

[Total: 20]

End of Paper 3 Section B

BP~561

HWA CHONG INSTITUTION
C2 Preliminary Examination
Higher 2

A

CANDIDATE NAME		CT GROUP	21S
CENTRE NUMBER		INDEX NUMBER	

PHYSICS

9749/04

Paper 4 Practical

22 August 2022

2 hours 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Answer **all** questions.

You will be allowed a maximum of one hour to work with the apparatus for Questions 1 and 2, and a maximum of one hour for Question 3. You are advised to spend approximately 30 minutes on Question 4.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

At the end of the examination, submit sets A, B and C separately.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift
Laboratory

For Examiner's Use	
1	/ 7
2	/ 15
3	/ 22
4	/ 11
Total	/ 55

Sets A, B, C consist of **18** printed pages.

1 **(a)** Measure 100 cm^3 of water using the measuring cylinder, and pour the water into the beaker provided. Heat the water using the Bunsen burner.

Switch off the Bunsen burner, observe the temperature of the water in the beaker and start the stopwatch when the temperature is about 80.0 °C.

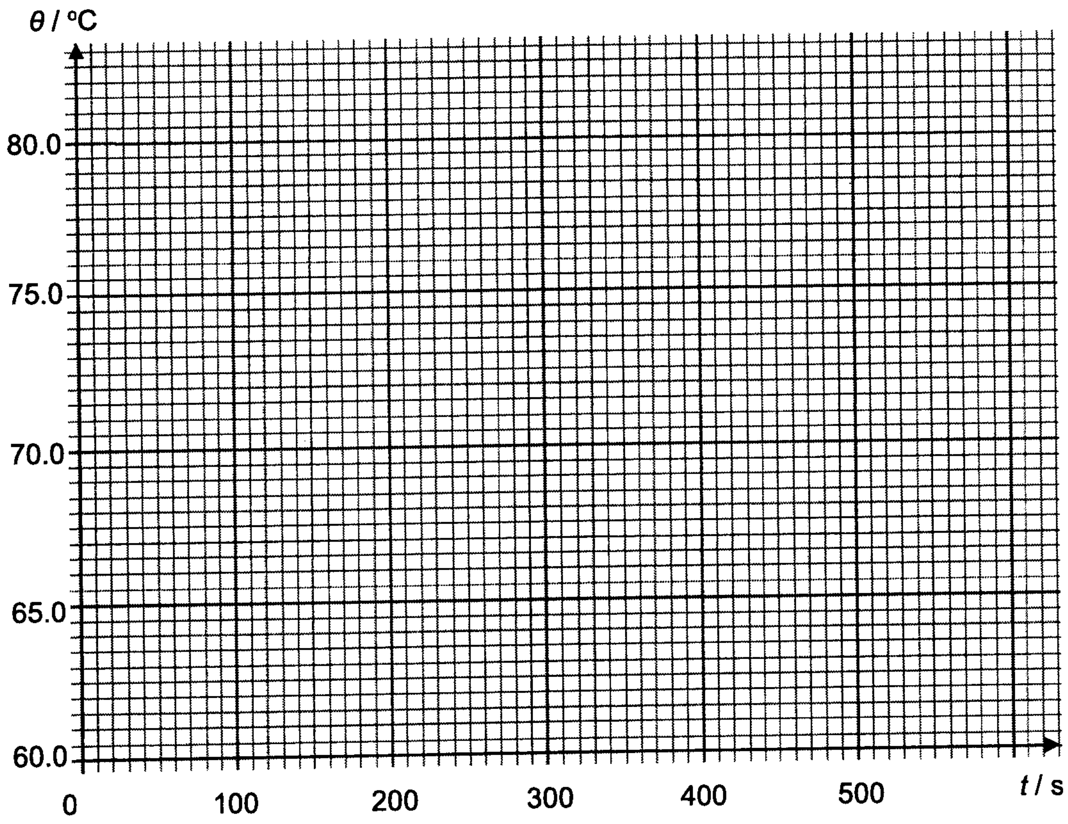
Record the time elapsed t when the water is at a temperature θ, for a total of 8 readings, until the water reaches a temperature of 60.0 °C.

Record your readings in the table below.

θ / °C	t / s

[2]

(b) Plot a graph of θ against time t. Draw a curve through your points. [2]



(c) Draw a tangent to the curve at θ = 70.0 °C. [1]

(d) Theory suggests that the rate of heat loss P from the water is given by

$$P = -mc\frac{d\theta}{dt}$$

where m is the mass of water and c is the specific heat capacity (c = 4.2 J g^{-1} K^{-1}). Assume that the density of water is 1.0 g cm^{-3}.

Determine the rate of heat loss P when θ = 70.0 °C.

P = ... J s^{-1} [2]

[Total: 7]

BLANK PAGE

2 In this experiment, you will investigate the current in an electrical circuit.

(a) You have been provided with two metre rules A and B, each with a resistance wire attached.

Take measurements to determine the resistance per unit length of each of the wires.

The resistance per unit length of the wire attached to rule A is R_A.
The resistance per unit length of the wire attached to rule B is R_B.

R_A = ...

R_B = ...
[2]

(b) Set up the circuit as shown in Fig. 2.1.

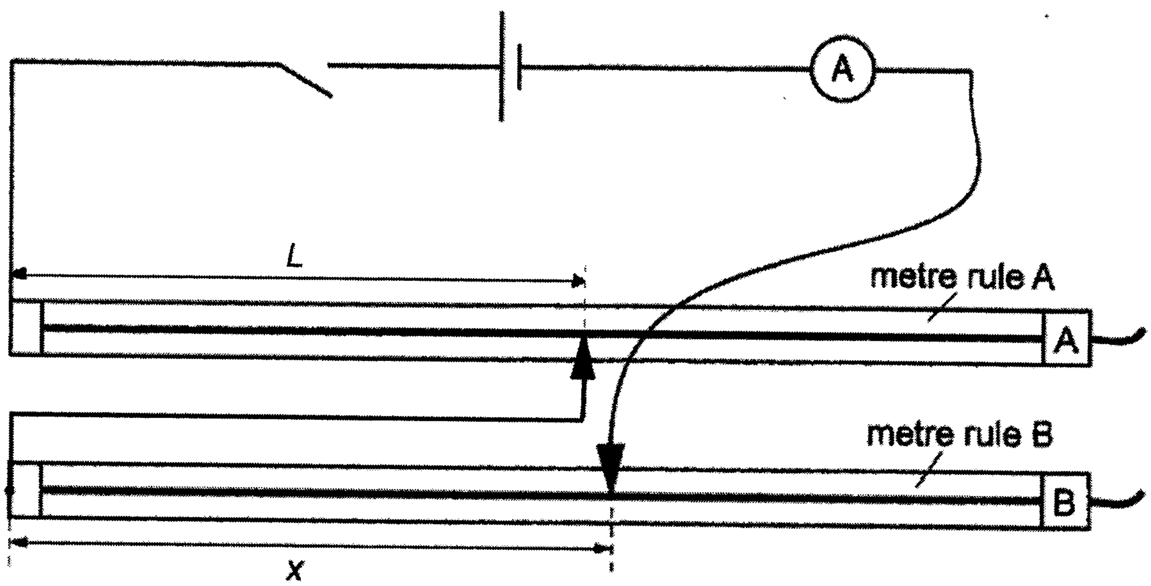


Fig. 2.1

L should be approximately half the length of the rule and *x* should be **greater** than *L*.

Close the switch.

Measure and record *L*, *x* and the ammeter reading *I*.

L = ...

x = ...

I = ...
[2]

(c) Vary x, obtaining a suitable range of values between 0 cm and 100 cm, and repeat **(b)**, keeping L constant throughout.

[3]

(d) It is suggested that I and x are related by the expression

$$E = IR_A L + IR_B x$$

where E is the electromotive force (e.m.f.) of the cell.

Plot a suitable graph to determine a value for E.

E = ... V [7]

(e) Without taking further readings, sketch a line on your graph grid to show the results you would expect if the experiment was repeated with x measured on metre rule A and the same L in **2(b)** measured on metre rule B.

Label this line W. [1]

[Total: 15]

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NAME ______________________ **CLASS** 21S ( ) **SCORE** ______ **B**

3 A ride in a playground consists of a plank of wood supported by two loops of rope.

In this experiment, you will investigate a model of this ride.

You have been provided with two sets of string loops and two half-meter rules.

(a) **(i)** Use the **shorter** loops of string to set up the apparatus as shown in Fig. 3.1.

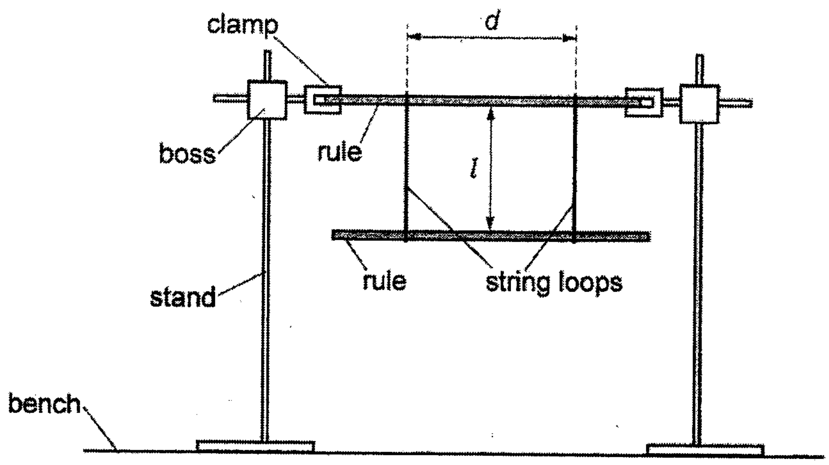

Fig. 3.1

Adjust the heights of the bosses until the top rule is parallel to the bench and both rules have their scales facing upwards.

The distance between the string loops is *d*.

Adjust the positions of the string loops until *d* is approximately 40 cm.

The string loops should be vertical and the same distance from the center of the bottom rule.

Measure and record *d*.

d = ... [1]

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

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

(iii) The distance between the bottom face of the top rule and the top face of the bottom rule is *l*, as shown in Fig. 3.1.

Measure and record *l*.

l = ... [1]

(iv) Estimate the percentage uncertainty in your value of *l*.

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

(b) Move one end of the bottom rule towards you. Move the other end of the rule away from you. Release the rule. The rule will oscillate about a vertical axis.

Determine the period *T* of these oscillations.

T = ... [1]

(c) Set up the apparatus using the **larger** loops of string and a **smaller** value of *d*. Repeat **(a)(i)**, **(a)(iii)** and **(b)**.

d = ...

l = ...

T = ...
[2]

(d) It is suggested that

$$T^2 = \frac{kl}{d^2}$$

where k is a constant.

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

first value of k = ...

second value of k = ...

[2]

(ii) State whether or not the results of your experiment support the suggested relationship. Justify your conclusion by referring to your values in **(a)(ii)** and **(a)(iv)**.

....

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.... [1]

(e) Using the **larger** loops of string, add two 50 g masses to the bottom rule, as shown in Fig. 3.2. Each mass represents a child on the ride.

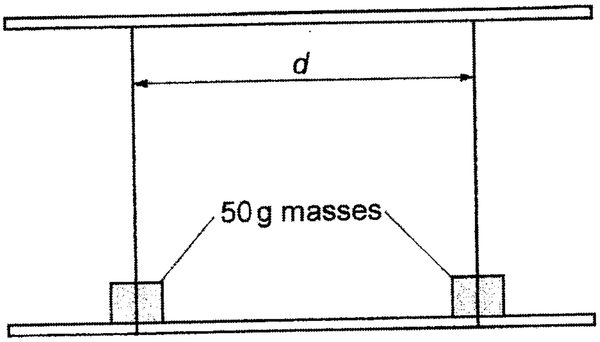

Fig. 3.2

Vary *d* and find values of *T* with and without the masses in place.

Present your results clearly.

Use your results to estimate a value for *d* where the value of *T* is the same with and without the masses.

d = ...

[4]

(f) You have been provided with some other masses. Use these masses to determine the effect on T of one or more children sitting at the **centre** of the ride while a child is seated at each string.

Present your results and conclusion clearly.

....

....

.... [3]

(g) The behaviour of the oscillating system depends on the length of the bottom plank.

It is suggested that the period *T* is directly proportional to the length *L* of the plank.

Explain how you investigate this relationship.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show direct proportionality
- why you might have difficulties using planks with very small lengths and very large lengths.

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.... [5]

[Total: 22]

NAME ____________________ CLASS 21S ( ) SCORE ______ **C**

4 A student investigates stationary sound waves in cylindrical tubes. Fig. 4.1 shows a stationary wave pattern in a tube which is open at both ends.

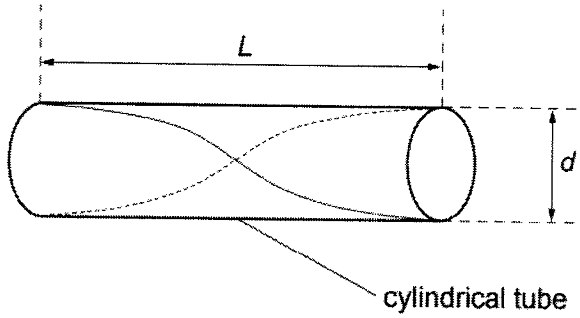

Fig. 4.1

The tube has length L and diameter d. The frequency of the sound for the stationary wave pattern shown is f.

It is suggested that the relationship between f, L and d is

$$\frac{1}{f} = aL + bd$$

where a and b are constants.

Design an experiment to determine the values of a and b.

You are provided with a number of different tubes of different lengths and diameters.

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

- the procedure to be followed
- the measurements to be taken
- the control of variables
- the analysis of the data
- any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

..........[11]

[Total: 11]

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