



MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 2

H2 Physics

9749/1

Paper 1 Multiple Choice

21 September 2017

1 hour

Candidate Name _____

Class Reg Number

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READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

There are **thirty** questions in this section. 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 Optical Mark Sheet (OMS).

Read very carefully the instructions on the OMS.

Write your name and class in the spaces provided on the OMS.

Shade your Index Number column using the following format:

- 1) first 2 digits is your index number in class
(e.g. 5th student is shaded as "05");
- 2) ignore the last row of alphabets.

Data

speed of light in free space
 permeability of free space
 permittivity of free space

elementary charge
 the Planck constant
 unified atomic mass constant
 rest mass of electron
 rest mass of proton
 molar gas constant
 the Avogadro constant
 the Boltzmann constant
 gravitational constant
 acceleration of free fall

$$\begin{aligned}
 c &= 3.00 \times 10^8 \text{ m s}^{-1} \\
 \mu_0 &= 4\pi \times 10^{-7} \text{ H m}^{-1} \\
 \epsilon_0 &= 8.85 \times 10^{-12} \text{ F m}^{-1} \\
 &\quad (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1} \\
 e &= 1.60 \times 10^{-19} \text{ C} \\
 h &= 6.63 \times 10^{-34} \text{ J s} \\
 u &= 1.66 \times 10^{-27} \text{ kg} \\
 m_e &= 9.11 \times 10^{-31} \text{ kg} \\
 m_p &= 1.67 \times 10^{-27} \text{ kg} \\
 R &= 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \\
 N_A &= 6.02 \times 10^{23} \text{ mol}^{-1} \\
 k &= 1.38 \times 10^{-23} \text{ J K}^{-1} \\
 G &= 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \\
 g &= 9.81 \text{ m s}^{-2}
 \end{aligned}$$

Formulae

uniformly accelerated motion

work done on/by a gas
 hydrostatic pressure
 gravitational potential
 temperature

pressure of an ideal gas

mean kinetic energy of a molecule of an ideal gas

displacement of particle in s.h.m.

velocity of particle in s.h.m.

electric current

resistors in series

resistors in parallel

electric potential

alternating current/voltage

magnetic flux density due to a long straight wire

magnetic flux density due to flat circular coil

magnetic flux density due to a long solenoid

radioactive decay

decay constant

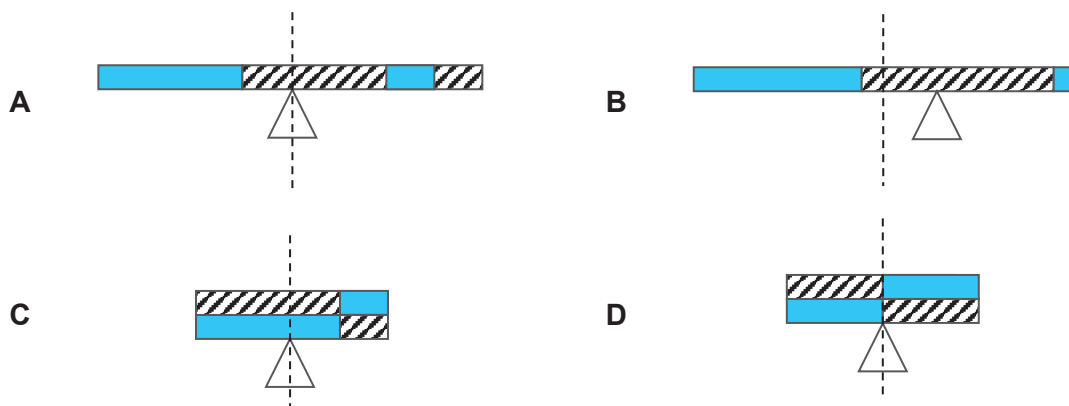
$$\begin{aligned}
 s &= ut + \frac{1}{2}at^2 \\
 v^2 &= u^2 + 2as \\
 W &= p\Delta V \\
 p &= \rho gh \\
 \phi &= -GM/r \\
 T/K &= T/^\circ\text{C} + 273.15 \\
 p &= \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle \\
 E &= \frac{3}{2} kT \\
 x &= x_0 \sin \omega t \\
 v &= v_0 \cos \omega t \\
 &= \pm \omega \sqrt{x_0^2 - x^2} \\
 I &= Anvq \\
 R &= R_1 + R_2 + \dots \\
 1/R &= 1/R_1 + 1/R_2 + \dots \\
 V &= \frac{Q}{4\pi\epsilon_0 r} \\
 x &= x_0 \sin \omega t \\
 B &= \frac{\mu_0 I}{2\pi d} \\
 B &= \frac{\mu_0 NI}{2r} \\
 B &= \mu_0 nI \\
 x &= x_0 \exp(-\lambda t) \\
 \lambda &= \frac{\ln 2}{t_{\frac{1}{2}}}
 \end{aligned}$$

Answer all 30 questions in this paper and shade your answers on the answer sheet provided.

- 1 Which estimate is realistic?
- A The kinetic energy of a bus traveling on an expressway is 30 000 J.
 - B The power of a domestic light is 300 W.
 - C The temperature of a hot oven is 300 K.
 - D The volume of air in a car tyre is 0.03 m³.
- 2 A car at rest at a traffic junction starts to accelerate at 2.0 m s⁻² when the traffic light turns green. At this moment, a truck travelling at a constant velocity of 14 m s⁻¹ passes the car.
- If the car is accelerating uniformly, how long will it take for the car to just overtake the truck?
- A 7.0 s B 14 s C 28 s D 56 s
- 3 Four different composite rods of uniform thickness are to be balanced horizontally on a knife-edge. Each rod is made up of 50% material A and 50% material B, where B is denser than A. The mid-point of each composite rod is indicated by a dotted vertical line.

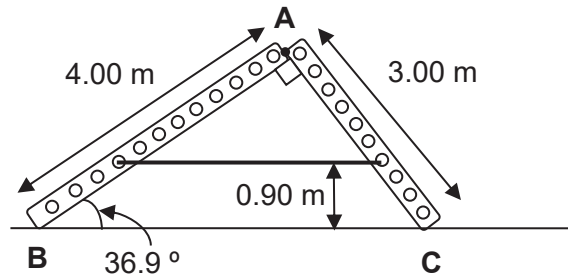


Which scenario is unlikely to occur?

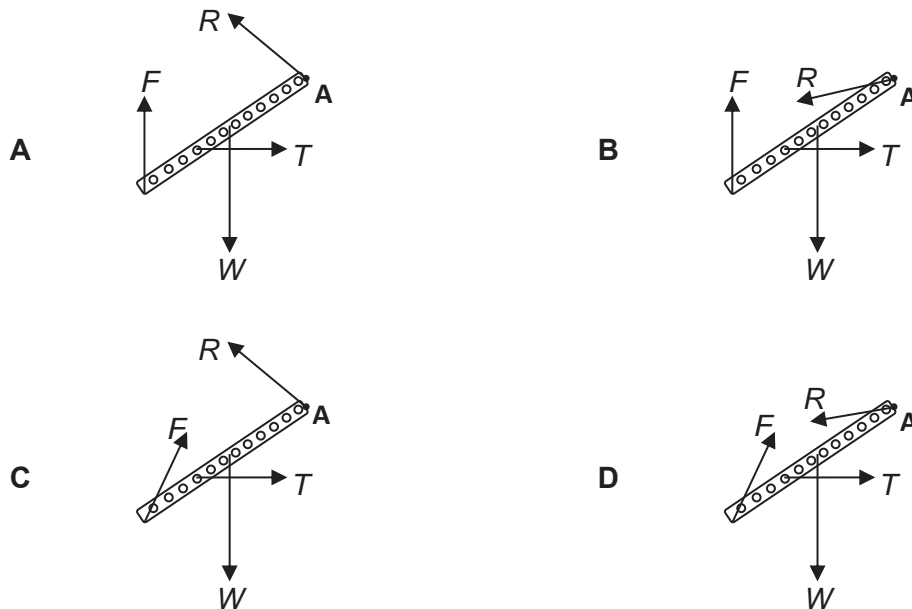


- 4 Two uniform ladders, 4.00 m and 3.00 m long, weighing 390 N and 290 N respectively are hinged at point **A** (90° apart) and tied together by a horizontal rope 0.90 m above the floor, as shown below. Assume the floor is freshly waxed and frictionless.

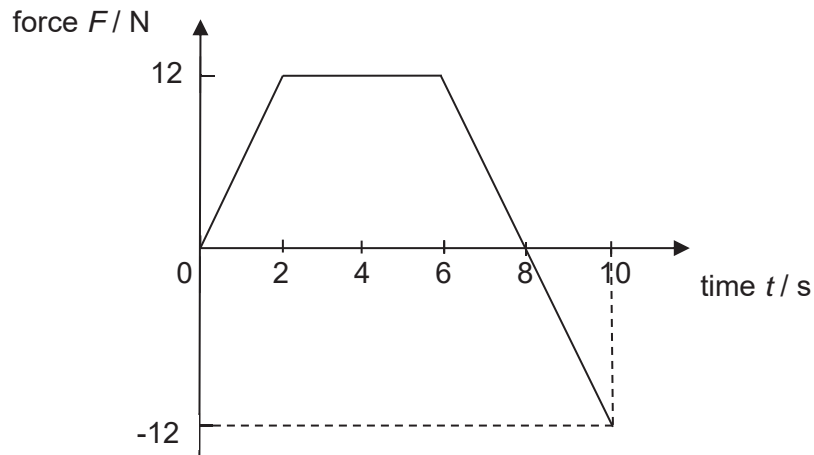
The contact force F at point **B** is 317 N.



Which of the following diagrams shows the correct forces F , weight W and tension of rope T and reaction force R acting at point **A** of the 4.00 m ladder?

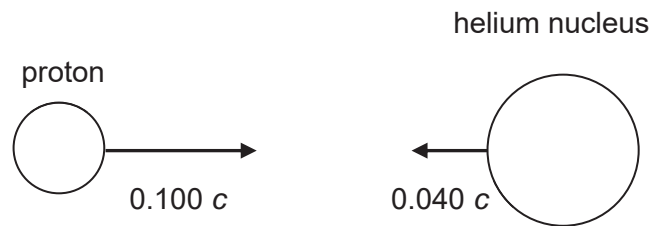


- 5 A body of mass 300 g initially at rest is acted on by a force F which varies with time t as shown in the diagram below.



What is the speed of the body at the 10th second?

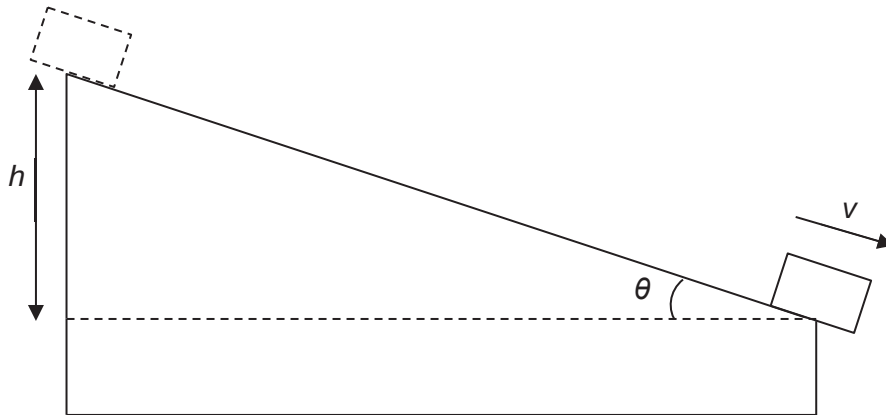
- A 200 m s⁻¹ B 240 m s⁻¹ C 260 m s⁻¹ D 280 m s⁻¹
- 6 A proton (mass 1 u) travelling with velocity $+0.100 c$ collides elastically head-on with a helium nucleus (mass 4 u) travelling with velocity $-0.040 c$.



What are the velocities of each particle after the collision?

	proton	helium nucleus
A	$+0.004 c$	$+0.064 c$
B	$-0.004 c$	$+0.064 c$
C	$+0.124 c$	$+0.016 c$
D	$-0.124 c$	$+0.016 c$

- 7 A box of mass m slides down a smooth ramp from rest. At time t , the box has slid down height h and is moving with speed v . The slope makes an angle θ with the horizontal, as shown in the diagram below.

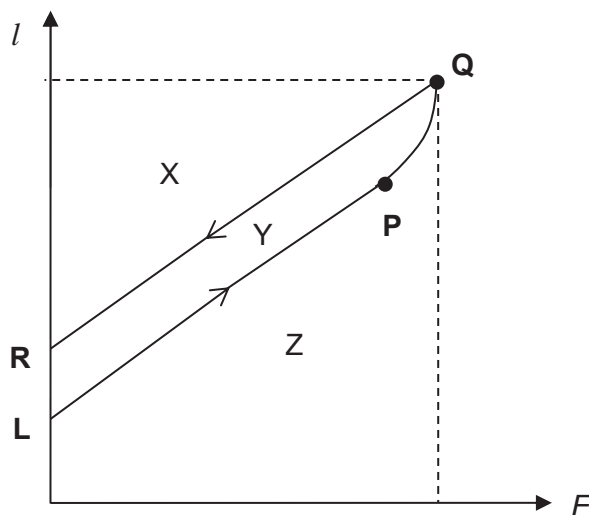


Which expression represents the rate of change of work done by gravitational force of the box at time t ?

- A mgv B $\frac{mgh + \frac{1}{2}mv^2}{t}$ C $mg\sin\theta\left(\frac{h}{t}\right)$ D $mg\sin\theta\sqrt{2gh}$

- 8 A spring is stretched by a varying force F , causing its length l to increase as shown by the line **LPQ** on the graph. The force is then gradually reduced to zero and the relationship between force and length is indicated by the line **QR**.

Which area represents the elastic potential energy stored in the spring at **Q**?



- A X B X + Y C Y + Z D Z

- 9 Javier noticed that his watch is inaccurate as the minute hand of his watch travels at an angular speed of $1.744 \times 10^{-3} \text{ rad s}^{-1}$. What is the time difference between his watch and an accurate clock 24 hours after he has synchronised it?
- A 0.55 seconds
B 1.1 seconds
C 66 seconds
D 130 seconds
- 10 A man is in a spacecraft that is orbiting around a planet.
Which of the following statements is true?
- A The man is on the ground of the spacecraft so as to provide for the centripetal force required for him to orbit the planet.
B The man is on the ground of the spacecraft as the gravitational force by the planet on the man attracts the man to the ground of the spacecraft.
C The man is floating in the spacecraft as the gravitational force by the planet on the man balances the centripetal force on the man.
D The man is floating in the spacecraft as the spacecraft and the man are experiencing the same centripetal acceleration.
- 11 Satellite A of mass m orbits a planet of radius R at a height R above the surface of the planet with kinetic energy, E_k .
What is the kinetic energy of satellite B of mass $2m$ that orbits the same planet at a height $2R$ above the surface of the planet?
- A E_k B $\frac{2}{3} E_k$ C $\frac{4}{3} E_k$ D $4 E_k$
- 12 A mass of 0.40 kg undergoing simple harmonic motion has a total energy of 5.0 J and amplitude 0.25 m. What is its period?
- A 0.016 s B 0.050 s C 0.31 s D 0.63 s
- 13 Which one of the following is an effect of an increase in damping in a forced oscillation?
- A amplitude at resonance increases
B the natural frequency at resonance increases
C the total energy of the system increases
D the period of the driven oscillator at resonance increases

- 14 A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

What is the lowest frequency of sound produced by a pipe of length 2 m?
(The speed of sound in the pipe is 320 m s^{-1} .)

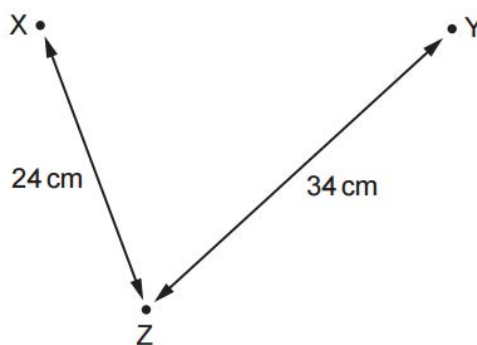
- A 20 Hz B 40 Hz C 80 Hz D 160 Hz

- 15 Diffraction can be observed when a wave passes an obstruction. The diffraction effect is greatest when the wavelength and the obstruction are similar in size.

For waves travelling through air, what is the combination of wave and obstruction that could best demonstrate diffraction?

- A visible light waves passing through an entrance of a classroom door
B sound waves passing through a human hair
C radio waves passing through a copper wire
D microwaves passing through a steel post

- 16 Wave generators at points X and Y produce waves of the same wavelength. At point Z, the waves from X have the same amplitude as the waves from Y. Distances XZ and YZ are as shown.

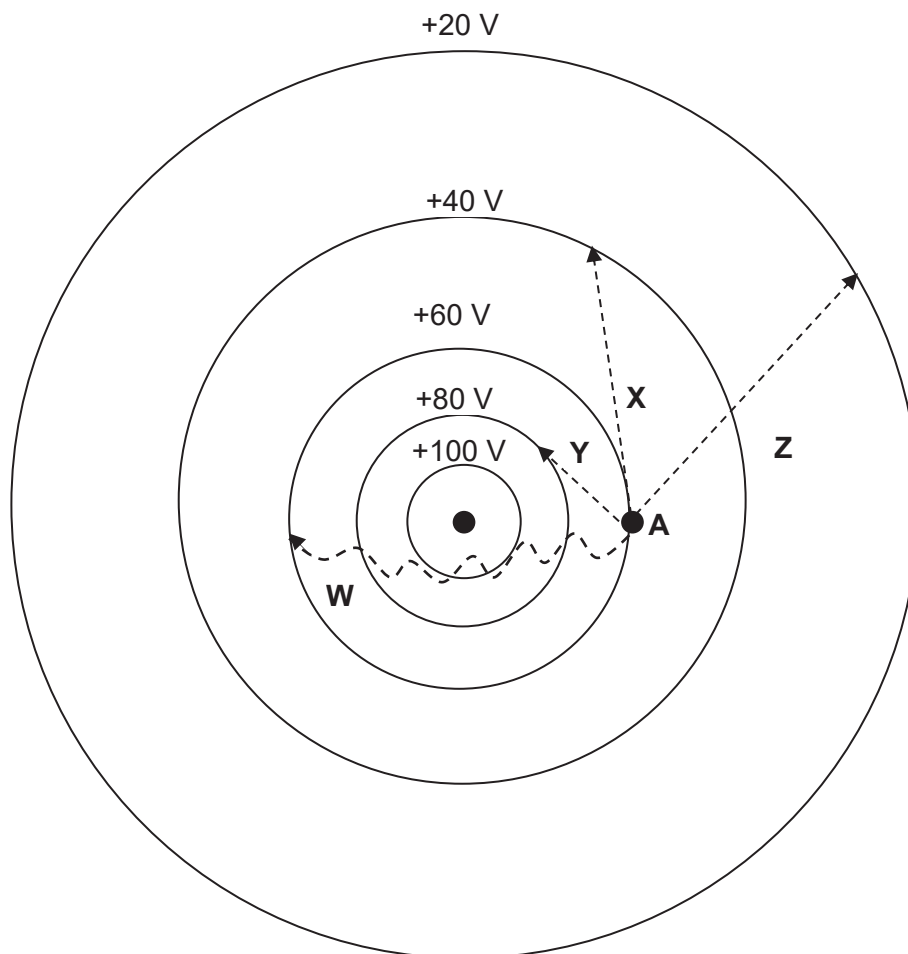


When the wave generators operate in phase, the amplitude of oscillation at Z is zero.

What could be the wavelength of the waves?

- A 2 cm B 3 cm C 4 cm D 6 cm

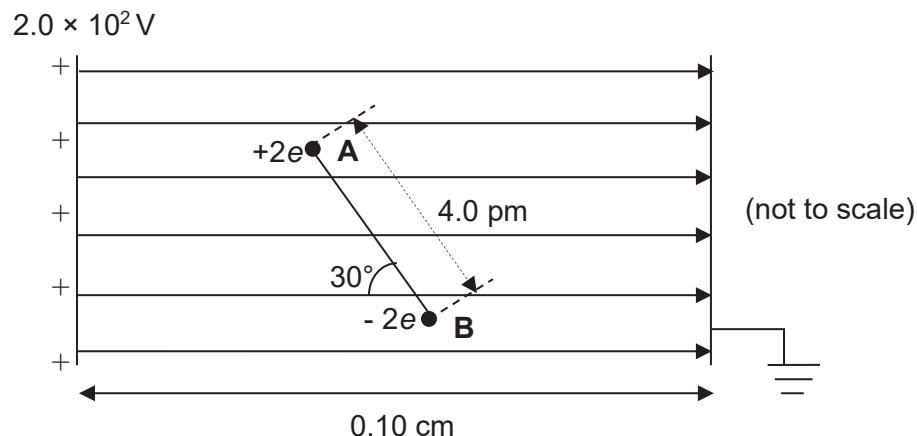
- 17 The diagram below shows the equipotential lines around a point charge. Another particle of charge $+2e$ was then brought from position **A** which lies on the equipotential line of $+60\text{ V}$ to other positions on other equipotential lines through various paths.



Which of the following statements is true?

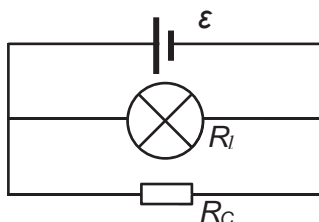
- A** The work done by the electric field in bringing the charge through path **W** is the greatest.
- B** The work done by the electric field in bringing the charge through paths **X** and **Y** are the same.
- C** The work done by the electric field in bringing the charge through path **Z** is the greatest.
- D** The work done by the electric field for all four paths are non-zero.

- 18 Two ions **A** and **B**, at a distance of 4.0 pm apart, are linked to form a molecule. They are situated between a pair of charged parallel plates placed a distance of 0.10 cm apart. The left plate has a potential of 2.0×10^2 V and the right plate is earthed. The line joining **A** and **B** is at an angle of 30° to the direction of the electric field as shown in the diagram below.



What is the torque on the molecule **AB**?

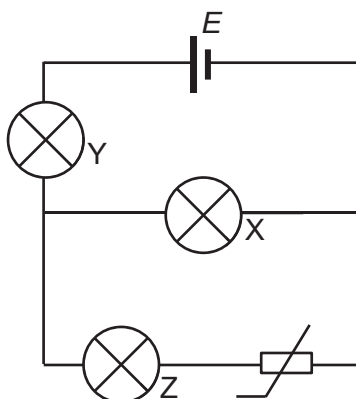
- A 2.2×10^{-25} N m B 1.3×10^{-25} N m C 2.6×10^{-25} N m D 5.1×10^{-25} N m
- 19 The figure below shows a lamp of resistance R_l and a device of resistance R_c being powered by an electrical source, ϵ .



Which expression gives the fraction of the total power delivered to the lamp?

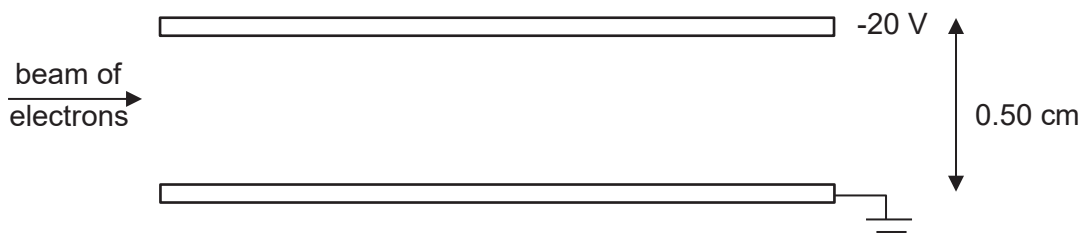
- A $\frac{R_c}{R_l + R_c}$ B $\frac{R_l}{R_l + R_c}$ C $\frac{R_c}{R_l}$ D $\frac{R_l}{R_c}$

- 20 A cell of e.m.f. E is connected to three identical lamps X, Y, and Z, and a negative temperature coefficient thermistor as shown in the figure below.



If the thermistor is heated up, which statement about the change in brightness of bulbs X and Y is true?

- A Both X and Y become brighter.
 B Both X and Y become dimmer.
 C Y becomes brighter, but X dims.
 D X becomes brighter, but Y dims.
- 21 A beam of electrons, travelling horizontally to the right with a speed, v , passes between two horizontal charged parallel metal plates separated by 0.50 cm. The potential of the upper plate is -20 V and the lower plate is earthed.

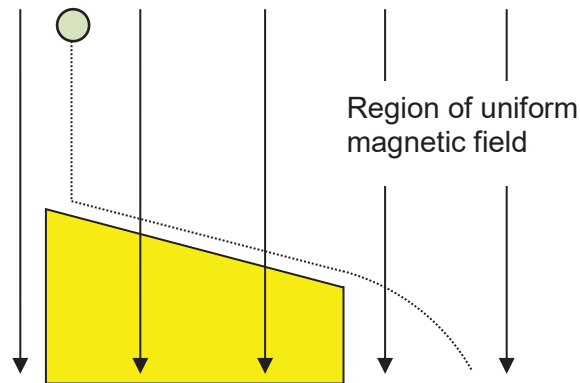


There is no deflection of the beam because of the presence of a uniform magnetic field in the region between the plates.

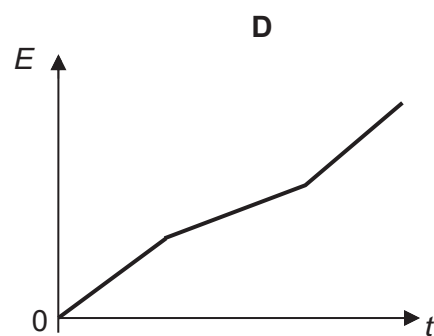
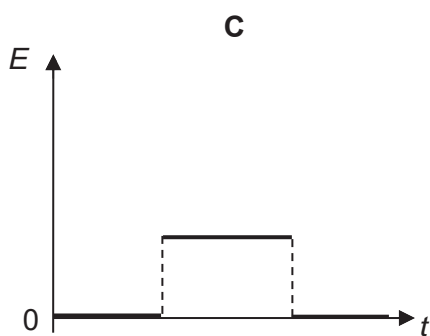
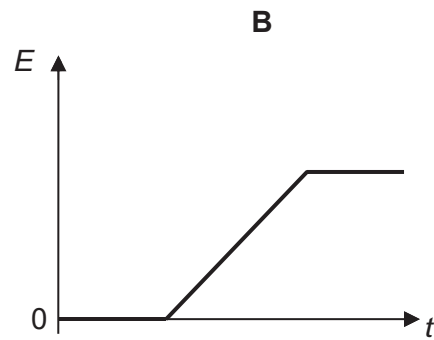
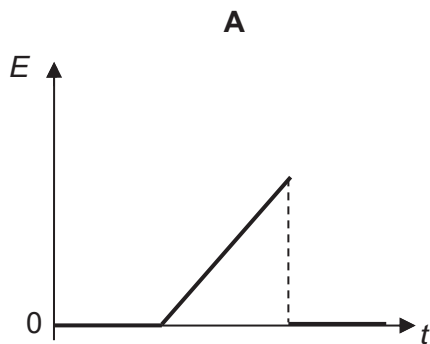
What is the magnitude of the magnetic field and in which direction must this magnetic field be?

	magnitude	direction
A	$4000 / v$	out of the paper
B	$4000 / v$	into the paper
C	$20 / v$	out of the paper
D	$20 / v$	into the paper

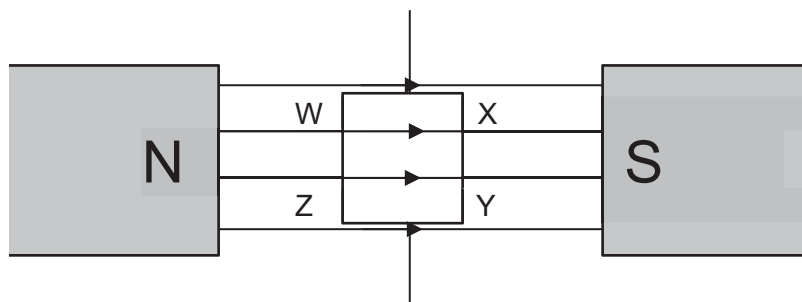
- 22 In a region of uniform magnetic field, a metal rod falls vertically from rest and lands on to a slope. It continues to roll down the slope and launches off the slope as shown in the diagram.



Which graph best shows the variation with time t of the e.m.f. E induced in the rod, from the time it is released?



- 23 In an electric motor, a rectangular coil WXYZ carrying current, I , has 20 turns and is in a uniform magnetic field of flux density 0.80 T.



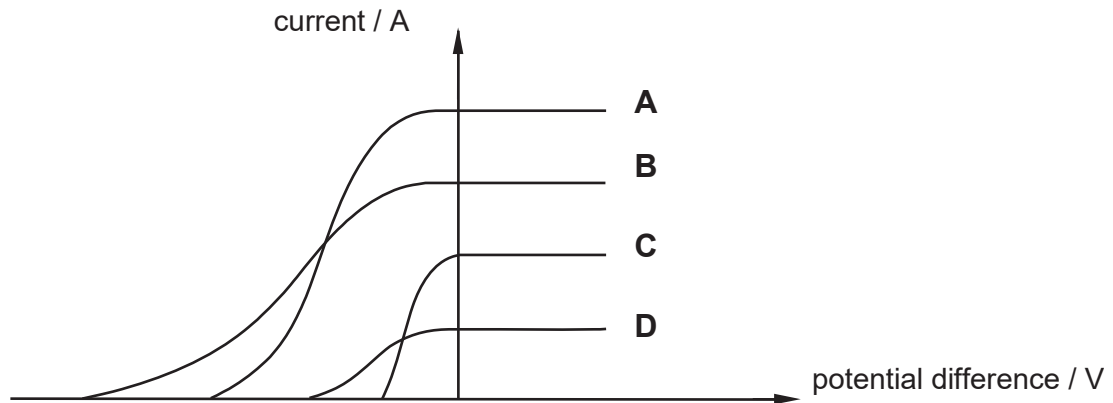
The lengths of sides XY and ZW are 0.17 m and of sides WX and YZ are 0.11 m. The maximum torque provided by the motor is 1.35 N m.

What is the current, I , in the rectangular coil?

- A** 4.5 A **B** 9.0 A **C** 45 A **D** 90 A
- 24 The secondary coil of an ideal transformer delivers a root-mean-square (r.m.s.) current of 2.5 A to a load resistor of resistance 8.0 Ω . The r.m.s. current in the primary coil is 10 A.
- What is the r.m.s. potential difference across the primary coil?
- A** 3.5 V **B** 5.0 V **C** 57 V **D** 80 V
- 25 A gas cylinder is fitted with a safety valve which releases a gas when the pressure inside the cylinder reaches 2.0×10^6 Pa. Given that the maximum mass of this gas the cylinder can hold at 10 $^{\circ}\text{C}$ is 15 kg, what would be the maximum mass at 30 $^{\circ}\text{C}$?
- A** 5 kg
B 14 kg
C 16 kg
D 45 kg
- 26 Which of the following statement about internal energy is correct?
- A** Internal energy of a system depends only on its temperature.
B When internal energy of the system increases, its temperature always rises.
C The internal energy of a system can be increased without transfer of energy by heating.
D When two systems have the same internal energy, they must be at the same temperature.

- 27 The figure below shows the currents observed in a photocell circuit as a function of the potential difference between the plates of the photocell when light beams **A**, **B**, **C** and **D** were each directed in turn at the cathode.

Which of the beams has the lowest wavelengths?



- 28 The uncertainty in the position of an electron is 50 nm. What is the minimum uncertainty in its velocity?
- A** 7.9 m s^{-1}
B 8.0 m s^{-1}
C $1.5 \times 10^3 \text{ m s}^{-1}$
D $1.5 \times 10^4 \text{ m s}^{-1}$
- 29 Which one of the following combinations of radioactive decay results in the formation of an isotope of the original nucleus?
- A** one alpha particle and four beta particles
B two alpha particles and one beta particle
C four alpha particles and one beta particle
D one alpha particle and two beta particles
- 30 A detector is used for monitoring an α -source and a reading of 300 counts is observed. After a time equal to the half-life of the α -source, the reading has fallen to 155 counts. If a 5 mm thick lead sheet is inserted between the α -source and the detector, the reading would probably be
- A** 0 counts **B** 5 counts **C** 10 counts **D** 20 counts

End of Paper



MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examination
Higher 2

H2 Physics

9749/2

Paper 2 Structured Questions

15 September 2017

2 hours

Class Reg Number

Candidate Name _____

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READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a 2B 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.

Answer **all** questions.

At the end of the examination, fasten all your work securely
together.

Examiner's Use	
Q1	/9
Q2	/10
Q3	/8
Q4	/12
Q5	/9
Q6	/12
Q7	/20
Deduction	
Total	/80

Data

speed of light in free space	c	=	$3.00 \times 10^8 \text{ m s}^{-1}$
permeability of free space	μ_0	=	$4\pi \times 10^{-7} \text{ H m}^{-1}$
permittivity of free space	ϵ_0	=	$8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
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 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-GM/r$
temperature	T/K	=	$T/^\circ\text{C} + 273.15$
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	=	$x_0 \sin \omega t$
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	=	$R_1 + R_2 + \dots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \dots$
electric potential	V	=	$\frac{Q}{4\pi\epsilon_0 r}$
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 flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

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

.....

 [3]

- (b) A small mass m and a heavy mass M are connected to the ends of an inextensible string. The string is threaded through a glass tube as shown in Fig. 1.1. The tube is then held by a student and is whirled so that the mass m rotates with a constant radius r at a frequency of 175 revolutions per minute. Given that $m = 0.30$ kg and $M = 0.90$ kg.

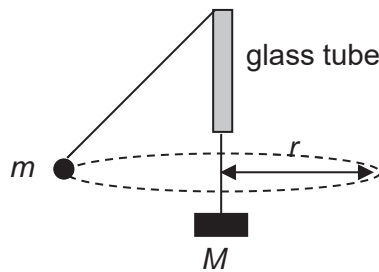


Fig. 1.1

- (i) Calculate the resultant force acting on the mass m .

resultant force = N [2]

- (ii) Hence, calculate the radius r of the circle.

$r =$ m [2]

(iii) Explain whether it is possible for the small mass m to be whirled in such a way that the string attached to it becomes horizontal.

.....

.....

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.....

.....

.....

..... [2]

2 (a) Define *gravitational potential* at a point.

.....

.....

..... [2]

(b) The Sun may be assumed to be an isolated uniform sphere with a mass M_S concentrated at its centre. The Earth of mass M_E orbits the Sun in a circular path of radius R as shown in Fig. 2.1.

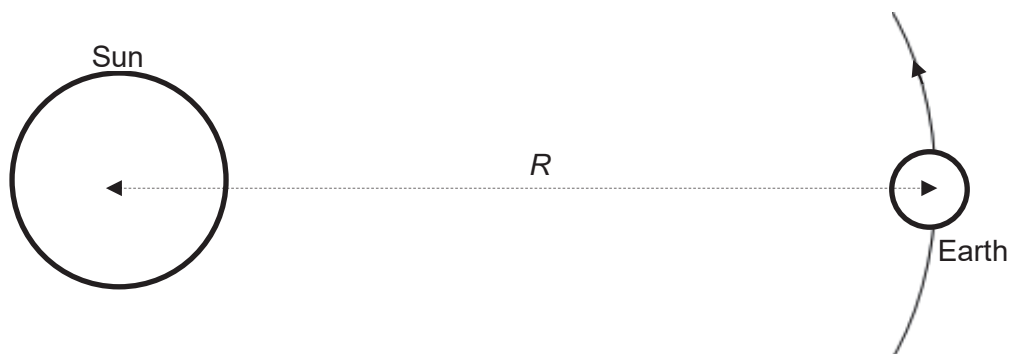


Fig. 2.1

- (i) For the Earth in orbit, derive an expression for its total energy in terms of M_S , M_E and R . Explain your working clearly. [4]

- (ii) Explain what does negative total energy imply about the system that comprises of the Sun and the Earth.

.....

 [2]

- (c) An unpowered artificial satellite is orbiting around the Sun along the same radial line from the Sun to the Earth as shown in Fig. 2.2.

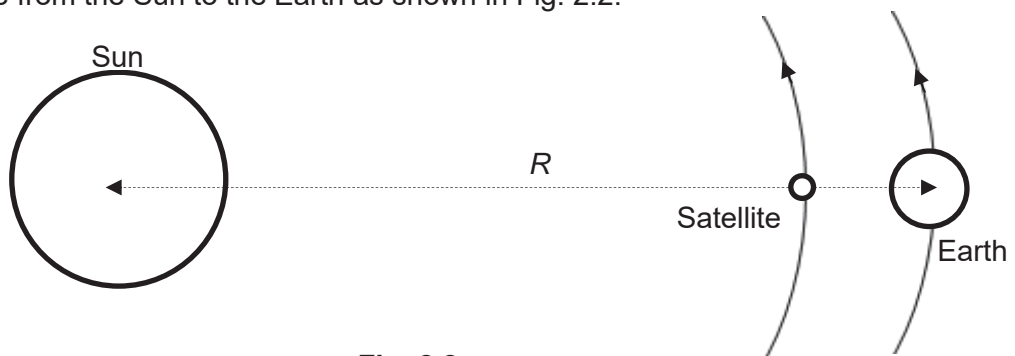


Fig. 2.2

Explain how it is possible for the satellite and the Earth to have the same orbital period but different orbital radius about the Sun.

.....

 [2]

- 3 (a) State the defining equation for simple harmonic motion and define any symbols used.

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

- (b) A frictionless trolley of mass m is held on a horizontal surface by means of two identical springs, each of spring constant k . The springs are attached to fixed points, as illustrated in Fig. 3.1.

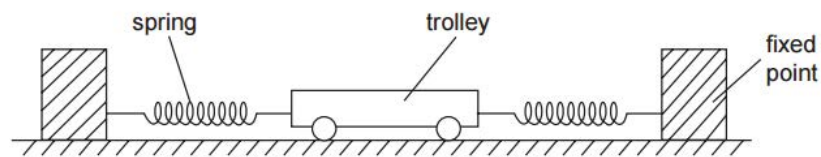


Fig. 3.1

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

The trolley is displaced a small distance x to the right along the axis of the springs. Both springs remain extended.

- (i) Show that the magnitude F of the restoring force acting on the trolley is given by

$$F = 2 kx \quad [2]$$

- (ii) The trolley is then released. Derive an expression for the acceleration a of the trolley in terms of k , x and m . Explain your working. [2]

- (iii) The mass m of the trolley is 1500 g and the spring constant k is 0.80 N cm^{-1} . Determine the frequency of oscillation of the trolley.

frequency = Hz [2]

- 4 (a) A rectangular coil is placed at the centre of the solenoid with its plane perpendicular to the axis of the solenoid as shown in Fig. 4.1.

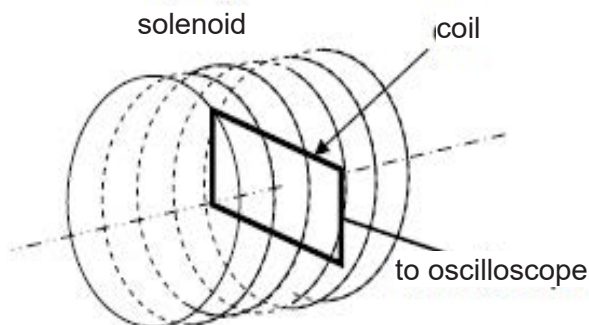


Fig. 4.1

The ends of the coil are connected to a cathode ray oscilloscope.

An alternating current is passed through the solenoid and its variation with time is shown in Fig. 4.2.

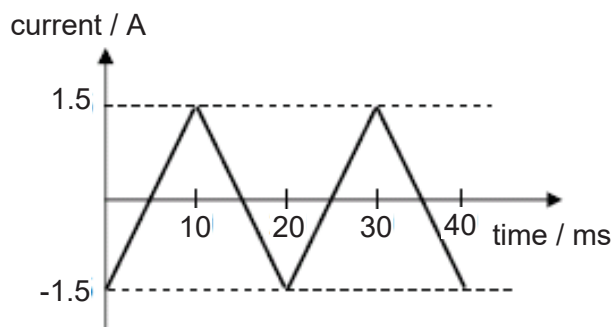


Fig. 4.2

- (i) State
- Faraday's law of electromagnetic induction,

.....

- Lenz's law.

.....

[2]

(ii) Hence, explain why there is an induced e.m.f. in the rectangular coil.

.....

.....

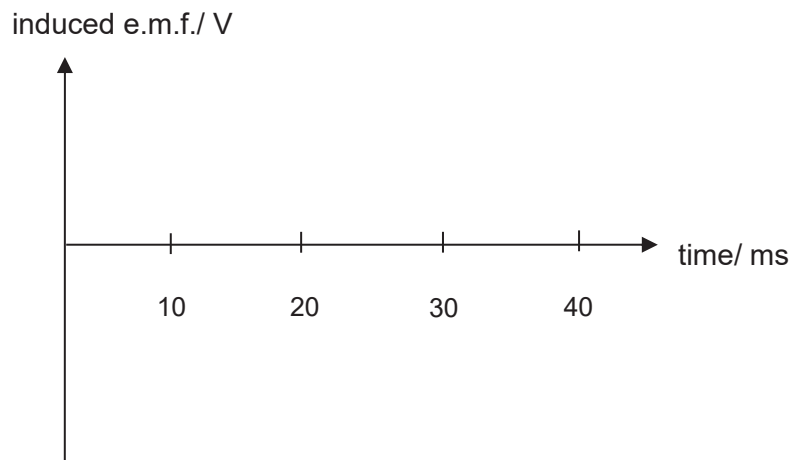
.....

..... [2]

(iii) The solenoid of length 0.50 m, has 400 turns and a cross-sectional area of $5.0 \times 10^{-3} \text{ m}^2$. The rectangular coil has 8 turns with dimensions 0.010 m by 0.020 m. Calculate the magnitude of the maximum induced e.m.f. in the coil.

e.m.f. =V [3]

(iv) Sketch the variation with time of the induced e.m.f. in the coil in the axes provided. [2]



-
- (v) A resistor of 2.0Ω is connected in parallel to the oscilloscope connected to the coil in Fig. 4.1. Calculate the maximum power across the resistor.

maximum power = W [2]

- (vi) Suggest one change to the set-up in Fig. 4.1 to increase the induced e.m.f in the coil.

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

- 5 (a) Explain one advantage of using alternating current when transmitting electrical energy.

.....

 [2]

- (b) An a.c. power supply is connected to a resistor R , a diode and a battery of e.m.f. 12.0 V as shown below in Fig. 5.1.

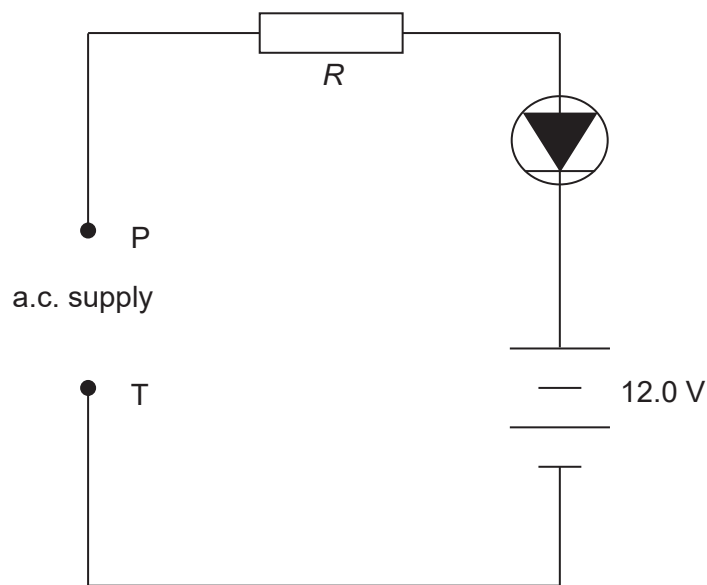


Fig. 5.1

The variation of the potential of P with respect to T, V_{PT} , is as shown in Fig. 5.2.

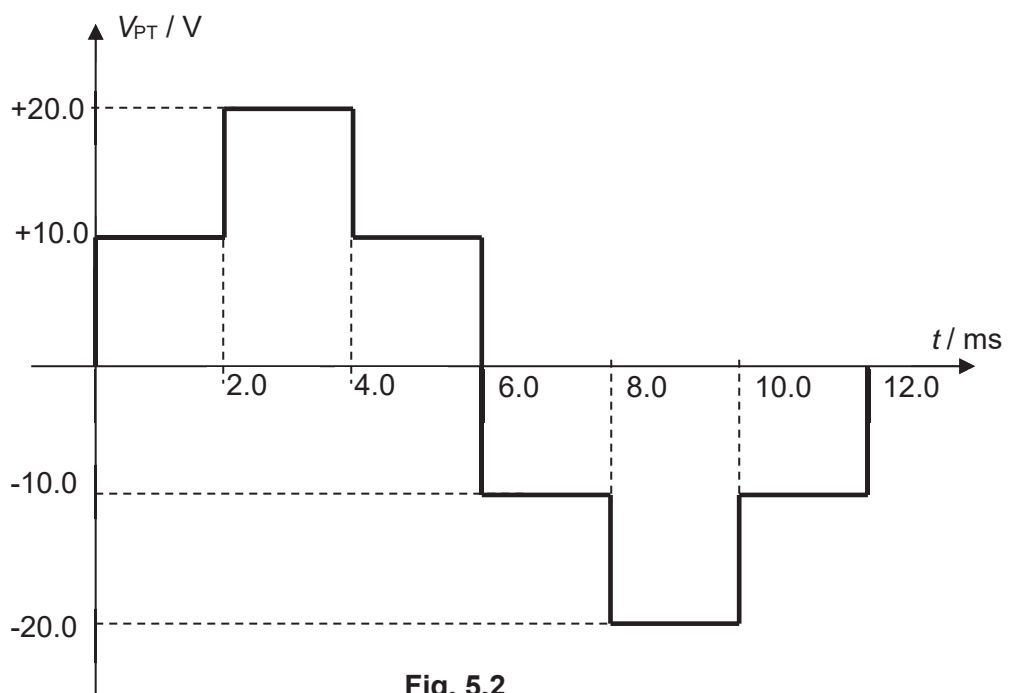


Fig. 5.2

- (i) Calculate the root-mean-square potential difference V_{rms} across points P and T.

$$V_{\text{rms}} = \dots\dots\dots \text{ V} \quad [2]$$

- (ii) Determine the potential difference across resistor R when

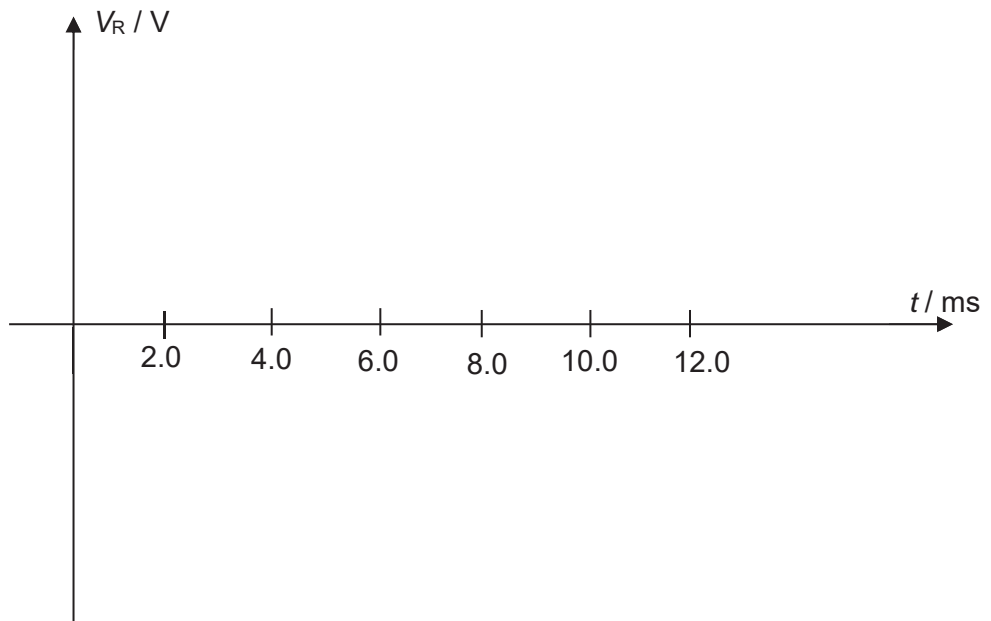
1. $V_{\text{PT}} = +10.0 \text{ V}$

potential difference = $\dots\dots\dots \text{ V} \quad [1]$

2. $V_{\text{PT}} = +20.0 \text{ V}$

potential difference = $\dots\dots\dots \text{ V} \quad [2]$

- (iii) Hence, sketch in the following axes the variation with time of the potential difference across R (V_R). [2]



- 6 (a)** Three constant pressure gas thermometers contain an identical type of gas at different pressures. These three thermometers are then used to determine the temperature T of an object as well as the temperature at triple point of water. The readings of each thermometer are tabulated in Fig. 6.1.

	Readings at temperature T		Readings at triple point of water	
	Pressure P / Pa	Volume V / cm ³	Pressure P / Pa	Volume V / cm ³
Thermometer 1	100 000	503.30	100 000	398.53
Thermometer 2	50 000	1006.20	50 000	798.19
Thermometer 3	10 000	5031.50	10 000	3997.20

Fig. 6.1

- (i) Determine the value of the unknown temperature T measured by Thermometer 1. Leave your answer to 5 significant figures.

temperature $T = \dots\dots\dots$ K [3]

- (ii) The values of T measured by Thermometer 2 and Thermometer 3 are 344.34 K and 343.84 K respectively. Explain why the values of T determined by the thermometers do not agree with each other.

.....

 [1]

- (iii) Explain how, by using a graph of the thermodynamic temperature T against pressure of the gas P of the constant pressure gas thermometers, the true value of T can be found.

Sketch the graph to illustrate your answer. Accurate plotting is not required.

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

- (b) (i) Based on the kinetic theory of ideal gas, explain how evaporation of perspiration helps to cool a person.

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

-
- (ii) A person expends about 350 W of power while running a marathon. Only 15% of that energy is delivered to the muscles and the remaining energy is mainly removed from the body through perspiration. The bodily fluid has a latent heat of vaporisation of $2.41 \times 10^6 \text{ J kg}^{-1}$.

Determine the volume of bodily fluid lost per hour.

volume of fluid lost per hour = $\text{m}^3 \text{ hr}^{-1}$ [3]

- 7 A deep foundation is a type of foundation which transfers the downward forces from a building to the earth further down from the surface. One type of deep foundation is pile foundations. Pile foundations are relatively long and slender members constructed by drilling-in tubes to the required depth – the tubes being filled with concrete before withdrawal. A sketch of how the column and piles system is shown in Fig. 7.1.

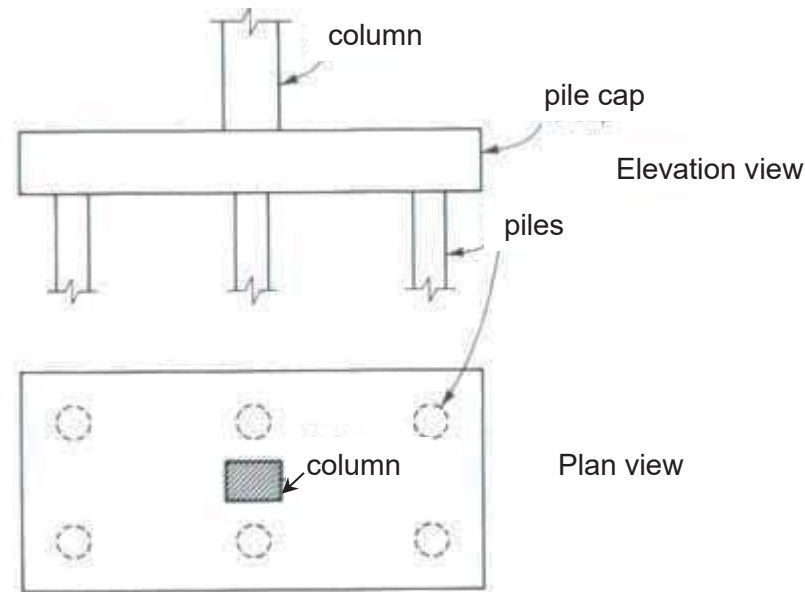


Fig. 7.1

In a construction site, some of the installed piles are selected to be tested to verify the designed soil parameter and design models.

- (a) One such test is called static pile load test as shown in Fig. 7.2. A jack pushes up on the loading platform. Reaction to the jack provides the force (actual load) acting on the test pile.

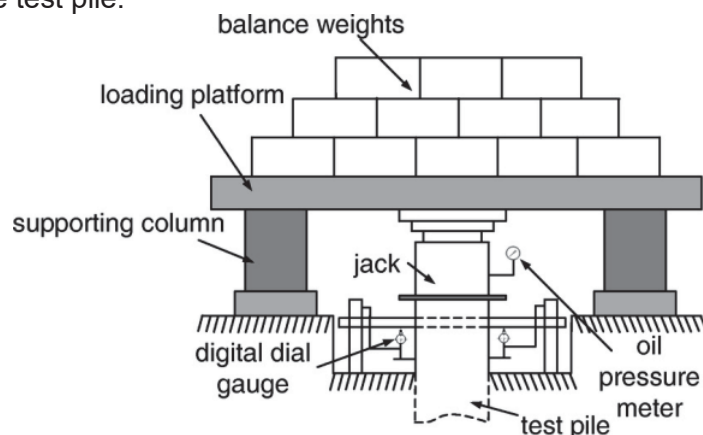


Fig. 7.2

The ultimate load-carrying capacity Q_u of a pile is designed and given by the equation (taking into consideration varying underground soil conditions):

$$Q_u = Q_p + Q_s$$

where Q_p = end (tip) resistance of the pile
 Q_s = shaft resistance of the pile (frictional resistance along the length of pile)

The results of one of the actual load tests are shown in Table 7.1. One ton is equivalent to 1000 kg of mass.

Actual Load (tons)	Q_p (tons)	Q_s (tons)	Elastic settlement (mm)	$\frac{Q_s}{\text{Actual load}}$ (%)
0	0	0	0	0
5	1.5	3.5	-1.08	70
10	2.0	8.0	-2.12	80
20	4.5	15.5	-4.08	
30	6.5	23.5	-6.58	
40	10.3	29.8	-10.36	74
50	16.0	34.0	-16.04	68
60	25.5	34.5	-25.51	58

Table 7.1

The load-settlement graph is expected to be a curve.

- (i) Fill in the blanks in Table 7.1. [1]
- (ii) Plot the remaining point in Fig. 7.3 and sketch the line of best fit for the actual load-settlement graph. [2]
- (iii) Estimate the settlement of the pile if the actual load is 55 tons.

settlement = mm [1]

- (iv) Estimate $\frac{Q_s}{\text{Actual load}}$ if the actual load is 55 tons. State your assumption/s made.

$$\frac{Q_s}{\text{Actual load}} = \dots\dots\dots\%$$

Assumption/s:

..... [2]

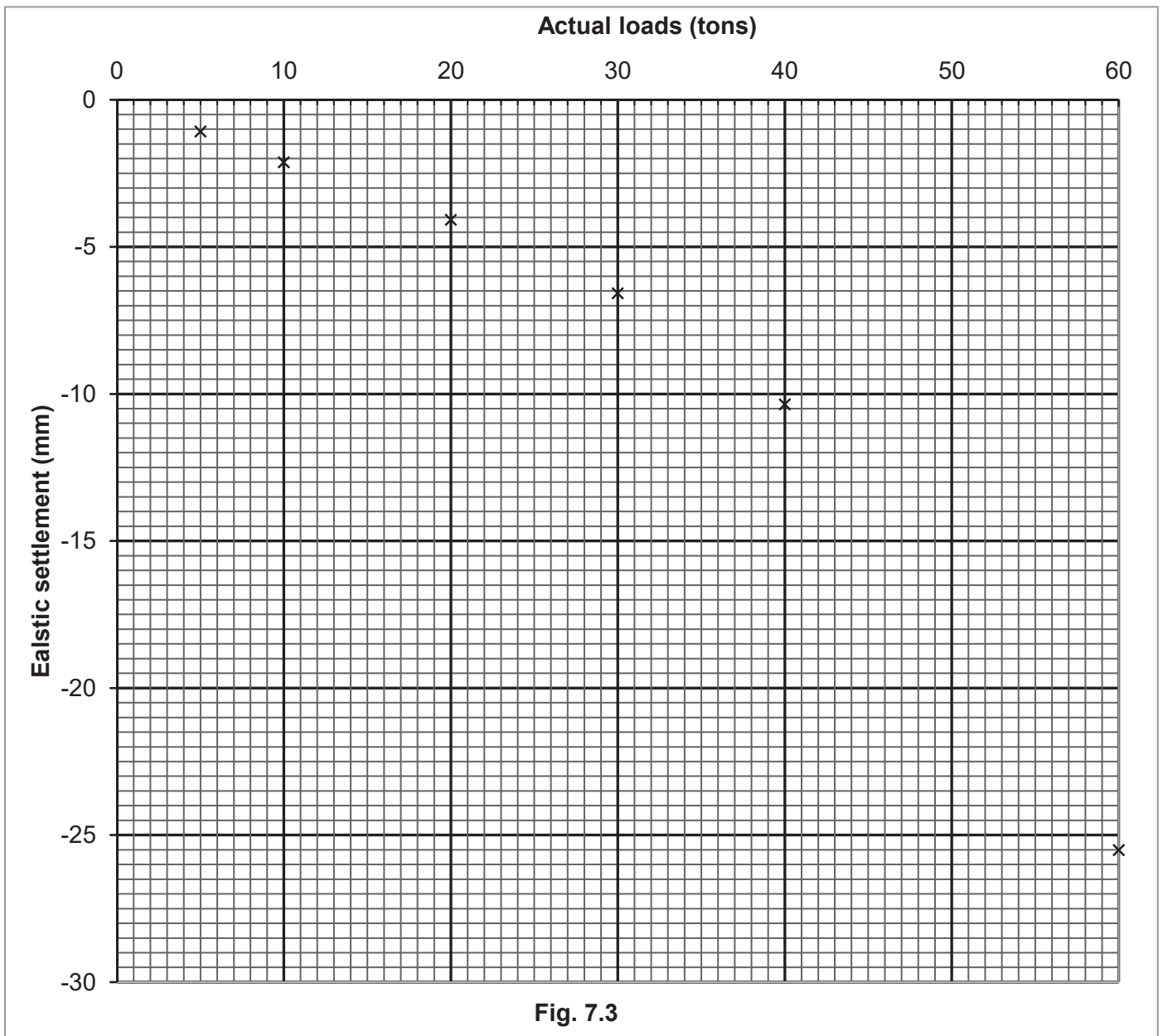
(v) Suggest what is meant by elastic settlement.

.....
 [1]

(vi) Using appropriate Newton's laws, explain how the actual load acts on the pile while the jack pushes up on the loading platform.

.....

 [2]



- (vii) Calculate the upthrust on the pile if the last 10 m of a 800 mm diameter pile is submerged in the underground water. The density of underground water is 1050 kg m^{-3} .

upthrust = N [2]

- (viii) A large factor of safety of 4.0 is considered in some pile design. For example, a 15-ton column is supported by a pile designed with a load carrying capacity of 60 tons. Suggest why such large factor of safety is considered.

.....

..... [1]

- (b) Another pile test, dynamic load pile test is also conducted. In this test, a dynamic load (a falling hammer) is applied to the pile head. The acceleration and strain on the pile head is recorded through connection cable to computer software to process the information so as to estimate the pile capacity in terms of shaft resistance and tip resistance of the pile. A typical setup is shown in Fig. 7.4.

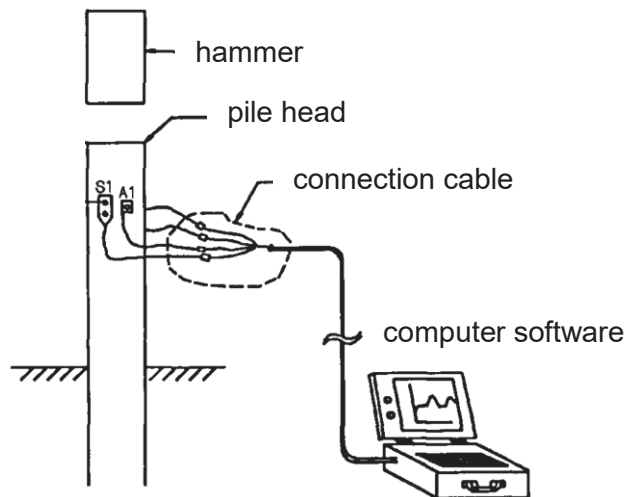


Fig. 7.4

-
- (i) A 600 kg hammer is dropped from rest at a height of 30.0 cm above the pile head. Calculate the energy input to the pile head as the hammer is dropped from rest.

energy input =J [2]

- (ii) After the hammer is dropped, a wave is sent down a 30.5 m deep pile and reflected back to the pile head. Calculate the theoretical time taken for the wave to travel down and up the pile when the velocity of the wave is 4000 m s^{-1} .

theoretical time taken = s [1]

- (iii) The recorded time taken was found to be smaller than that in (b)(ii). Suggest a possible reason for this.

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

(iv) Part of the information required for software analysis is the input of Young's modulus of the concrete pile, $E = \frac{\rho c^2}{k}$

where ρ is weight per unit volume of concrete = $(23.5 \pm 0.4) \text{ kN m}^{-3}$

c is the wavespeed = $(4000 \pm 400) \text{ m s}^{-1}$

k is the gravitational acceleration of 9.81 m s^{-2} .

Calculate E with its associated uncertainty. Include the unit with your answer.

$$E = \dots\dots\dots \pm \dots\dots\dots \quad [4]$$

End of Paper



H2 Physics

9749/3

Paper 3 Longer Structured Questions

18 September 2017

2 hours

Candidate Name _____

Class Reg Number

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READ THESE INSTRUCTIONS FIRST

Do not open this booklet until you are told to do so.

Write your name and class on all the work you hand in. Write in dark blue or black pen on both sides of the paper. You may use a 2B 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.

Section A

Answer **all** questions.

Section B

Answer **one** question only.

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

Write your answers on this question booklet in the blanks provided.

Examiner's Use		Percentage
Subtotal P1	/30	/15
Subtotal P2	/80	/30
Paper 3		
Q1	/8	
Q2	/4	
Q3	/10	
Q4	/5	
Q5	/7	
Q6	/12	
Q7	/14	
Q8	/20	
Q9	/20	
Deductions for P3		
Subtotal P3	/80	/35
Subtotal P4	/55	/20
Grand total		/100

Data

speed of light in free space
permeability of free space
permittivity of free space

elementary charge
the Planck constant
unified atomic mass constant
rest mass of electron
rest mass of proton
molar gas constant
the Avogadro constant
the Boltzmann constant
gravitational constant
acceleration of free fall

$$\begin{aligned}
 c &= 3.00 \times 10^8 \text{ m s}^{-1} \\
 \mu_0 &= 4\pi \times 10^{-7} \text{ H m}^{-1} \\
 \epsilon_0 &= 8.85 \times 10^{-12} \text{ F m}^{-1} \\
 &\quad (1/(36\pi)) \times 10^{-9} \text{ F m}^{-1} \\
 e &= 1.60 \times 10^{-19} \text{ C} \\
 h &= 6.63 \times 10^{-34} \text{ J s} \\
 u &= 1.66 \times 10^{-27} \text{ kg} \\
 m_e &= 9.11 \times 10^{-31} \text{ kg} \\
 m_p &= 1.67 \times 10^{-27} \text{ kg} \\
 R &= 8.31 \text{ J K}^{-1} \text{ mol}^{-1} \\
 N_A &= 6.02 \times 10^{23} \text{ mol}^{-1} \\
 k &= 1.38 \times 10^{-23} \text{ J K}^{-1} \\
 G &= 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2} \\
 g &= 9.81 \text{ m s}^{-2}
 \end{aligned}$$

Formulae

uniformly accelerated motion

work done on/by a gas
hydrostatic pressure
gravitational potential
temperature

pressure of an ideal gas

mean kinetic energy of a molecule of an ideal gas

displacement of particle in s.h.m.

velocity of particle in s.h.m.

electric current

resistors in series

resistors in parallel

electric potential

alternating current/voltage

magnetic flux density due to a long straight wire

magnetic flux density due to flat circular coil

magnetic flux density due to a long solenoid

radioactive decay

decay constant

$$\begin{aligned}
 s &= ut + \frac{1}{2}at^2 \\
 v^2 &= u^2 + 2as \\
 W &= p\Delta V \\
 p &= \rho gh \\
 \phi &= -GM/r \\
 T/K &= T/^\circ\text{C} + 273.15 \\
 p &= \frac{1}{3} \frac{Nm}{V} \langle c^2 \rangle \\
 E &= \frac{3}{2} kT \\
 x &= x_0 \sin \omega t \\
 v &= v_0 \cos \omega t \\
 &= \pm \omega \sqrt{x_0^2 - x^2} \\
 I &= Anvq \\
 R &= R_1 + R_2 + \dots \\
 1/R &= 1/R_1 + 1/R_2 + \dots \\
 V &= \frac{Q}{4\pi\epsilon_0 r} \\
 x &= x_0 \sin \omega t \\
 B &= \frac{\mu_0 I}{2\pi d} \\
 B &= \frac{\mu_0 NI}{2r} \\
 B &= \mu_0 nI \\
 x &= x_0 \exp(-\lambda t) \\
 \lambda &= \frac{\ln 2}{t_{\frac{1}{2}}}
 \end{aligned}$$

Section A

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

- 1 (a) One equation used in theory for gas flowing through small diameter tubes at low pressures is

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

where k is a dimensionless constant,
 r is the radius of the tube,
 p_1 and p_2 are the pressures at each end of the tube of length l ,
 M is the molar mass of the gas (unit: kg mol^{-1}),
 T is the thermodynamic temperature.

Determine the base units of Q .

base units of $Q = \dots\dots\dots$ [3]

- (b) A cylindrical thermos flask is used to store hot water. The internal diameter and depth of the thermos flask are measured to be (8.40 ± 0.01) cm and (21.5 ± 0.1) cm respectively.

- (i) State the instrument used to measure its diameter and a systematic error that can occur with the use of this instrument.

.....
 [2]

- (ii) Determine the volume of the thermos flask with its associated uncertainty.

volume = \pm cm^3 [3]

2 (a) Define the following:

(i) *pressure* ;

.....
.....

(ii) *density of a substance*.

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

(b) Hence, from the above definitions, derive an equation for the pressure p exerted by a fluid of density ρ_f at a depth h in the fluid, in terms of ρ_f , h and the acceleration of freefall g . Define any other symbols which you may use in your derivation. [3]

3 (a) State the property of a body that resists change in motion.

..... [1]

(b) Define *impulse*.

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

- (c) A soldier, together with his machine gun and bullets, has a combined mass of 90 kg. He stands at rest on a pair of ice skating blades and fires 10 bullets horizontally within 2.0 s in the forward direction. Each bullet has a mass of 10 g and leaves the gun with a speed of 750 m s^{-1} .

Assume there is no friction between the blades and the ground.

- (i) Calculate the soldier's speed just after he fired the 10th bullet.

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

- (ii) Calculate the average force exerted on the soldier and his machine gun.

average force =N [2]

- (iii) One of the bullets hits a stationary block on a horizontal platform. The impact causes the block to slide along the platform with the bullet embedded in it. The block experiences a constant frictional force throughout its motion and comes to a complete stop after a distance x .

1. State the type of collision between the bullet and the block.

..... [1]

2. State and explain how x changes if the platform is inclined upwards.

.....

.....

..... [2]

-
- 4 (a)** Unpolarised light with an intensity of $I_0 = 32 \text{ W m}^{-2}$ is incident on a pair of polarisers. The first polariser has its polarising axis aligned at 50° clockwise from the vertical. The second polariser has its polarising axis aligned at 20° clockwise from the vertical.

- (i)** State the intensity of the light when it emerges from the first polariser.

intensity = W m^{-2} [1]

- (ii)** Calculate the intensity of the light when it emerges from the second polariser.

intensity = W m^{-2} [2]

- (b)** Some recently released films have enabled viewing in three dimensions (3D). This can be done using two superimposed polarised images on the screen. One of the images is the scene as viewed by a left eye and the other as viewed by a right eye.

Explain how the images on the screen need to be polarised and how the spectacles of the cinema-goer also need to be polarised.

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

5 (a) State the Principle of Superposition.

.....

 [1]

(b) A laser is placed in front of two slits as shown in Fig. 5.1.

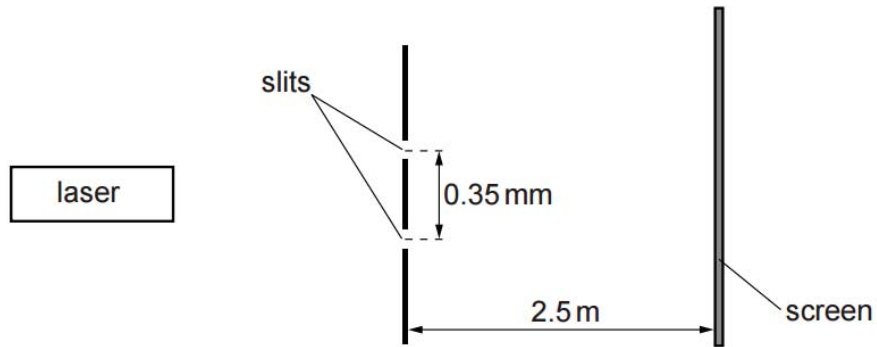


Fig. 5.1 (not to scale)

The laser emits light of wavelength 4.5×10^{-7} m. The distance from the slits to the screen is 2.5 m. The separation of the slits is 0.35 mm. The width of each slit is 2.0×10^{-6} m.

An interference pattern of maxima and minima is observed on the screen.

(i) Explain why an interference pattern is observed on the screen.

.....

 [2]

- (ii) One of the slits is now covered with an opaque object.

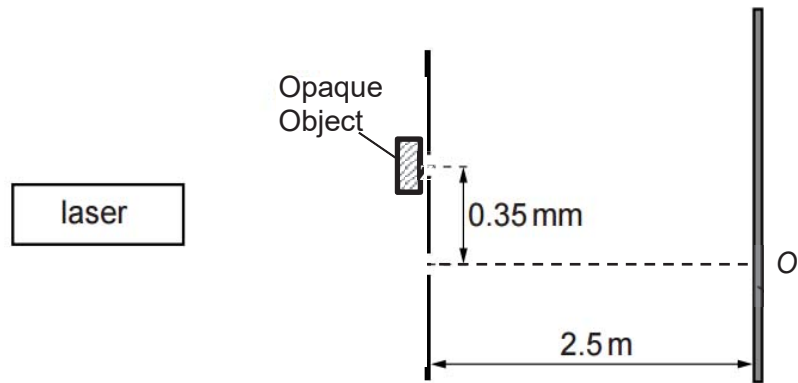


Fig. 5.2

1. On Fig. 5.3, sketch the variation with position of the intensity for the image observed on the screen. Your sketch should show at least 3 maxima. [2]

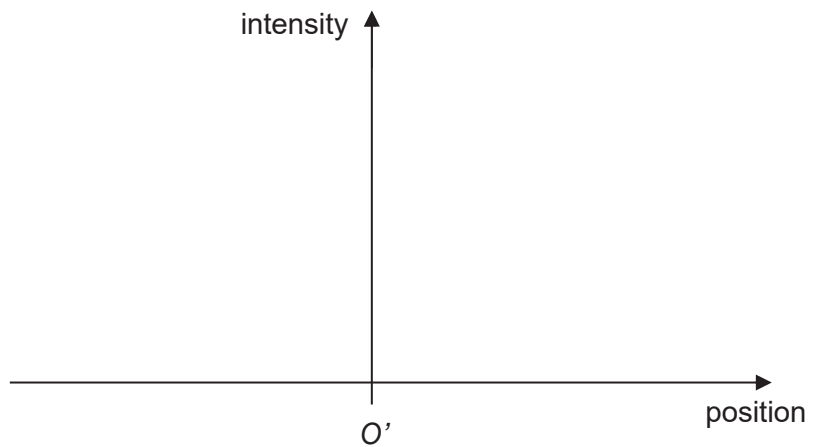


Fig. 5.3

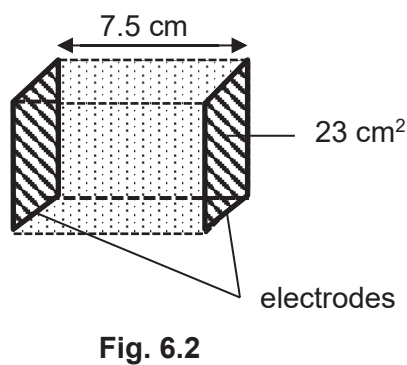
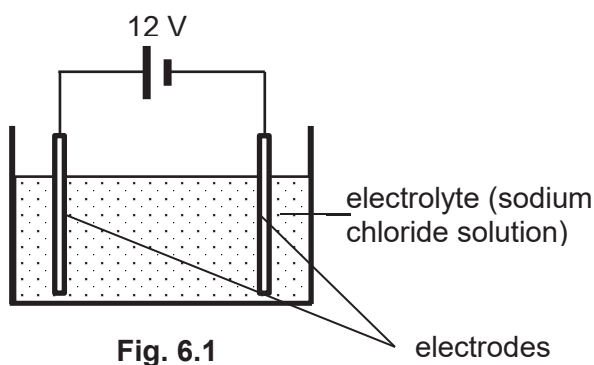
2. Calculate O'Y, the distance from O' at which the first minima occurs.

O'Y = m [2]

- 6 Fig. 6.1 shows a set up for the electrolysis of sodium chloride solution using a 12 V cell. When dissolved in water, each sodium chloride yields a pair of oppositely charged ions; a positively charged sodium ion (Na^+) and a negatively charged chloride ion (Cl^-), both with a charge of e .

Fig. 6.2 shows the portion of the electrodes immersed in the solution. The electrodes are 7.5 cm apart and the immersed area parallel to each other is 23 cm^2 . The resistivity of the given sodium chloride solution is $9.0 \ \Omega \text{ cm}$.

You can assume that Na^+ and Cl^- are the only charge carriers.



- (a) Calculate the current I passing through the sodium chloride solution.

$I = \dots\dots\dots \text{ A} \quad [3]$

- (b) With reference to Fig. 6.1, state the direction of the net motion of sodium and chloride ions.

sodium ion =

chloride ion = [1]

- (c) To prepare the sodium chloride solution, 1.7 mol of sodium chloride was fully dissolved in 1000 cm^3 of water. Calculate the number density n of the chloride ions.

$$n = \dots\dots\dots \text{ cm}^{-3} \quad [2]$$

- (d) By assuming that the flow of chloride ions contributes to half the current, calculate the drift velocity v of the chloride ions in the solution.

$$v = \dots\dots\dots \text{ cm s}^{-1} \quad [2]$$

- (e) Chloride ions forms chlorine gas as the electrolysis process progresses.

State and explain the changes to following.

- (i) the current, and

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

- (ii) the drift velocity of the chloride ions.

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

- 7 (a) Fig. 7.1 shows a high voltage supply set up to produce energetic electrons to bombard the cool sodium gas in the discharge tube, giving rise to a line spectrum through a diffraction grating. Fig. 7.2 shows some electron energy levels of a sodium atom.

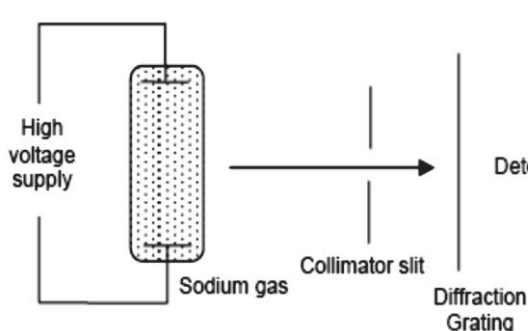


Fig. 7.1

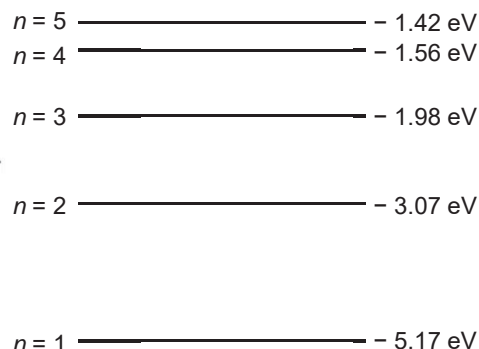


Fig. 7.2

- (i) The bombardment of the electrons caused the sodium gas to be excited up to the $n = 3$ energy level. Sketch the relative positions of the lines on the spectrum observed in Fig. 7.3 below. Label the corresponding transition for each line. [2]

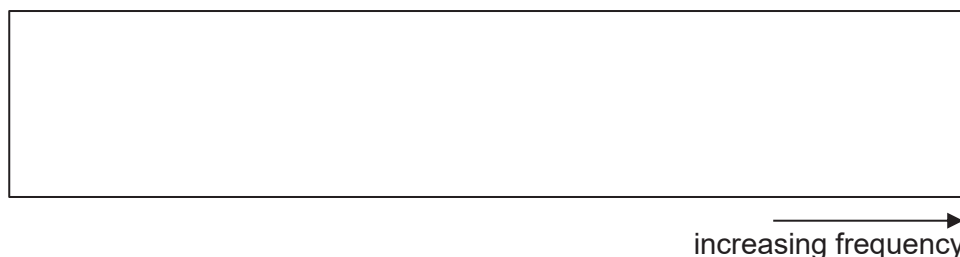


Fig. 7.3

- (ii) It is observed that the minimum kinetic energy of the recoil electrons is 0.24 eV. Determine the incident kinetic energy of the electrons that bombard the sodium gas.

incident kinetic energy = eV [2]

- (iii) Another cool gas with energy levels as shown in Fig. 7.4 is now placed between the discharge tube and the collimator slit in the set up in Fig. 7.1.

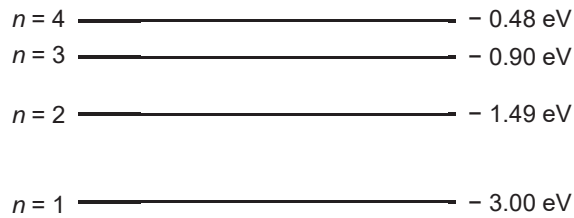


Fig. 7.4

Three faint spectral lines and two bright spectral lines are now detected at the detector. Explain this observation.

.....

.....

.....

.....

.....

.....

..... [3]

- (b) In another experiment, an electron beam is accelerated towards a barrier with two slits in it as shown in Fig. 7.5. The two slits has a separation of 272 nm. After passing through the double slit, a pattern was detected using a suitable fluorescent screen placed 240 mm away from the barrier.

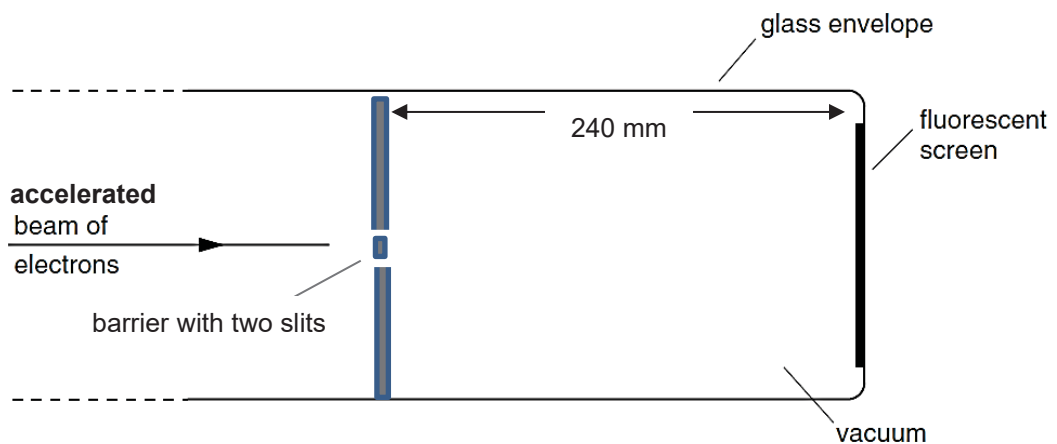


Fig. 7.5

The resulting pattern (not drawn to scale) observed after several hours is shown in Fig. 7.6.

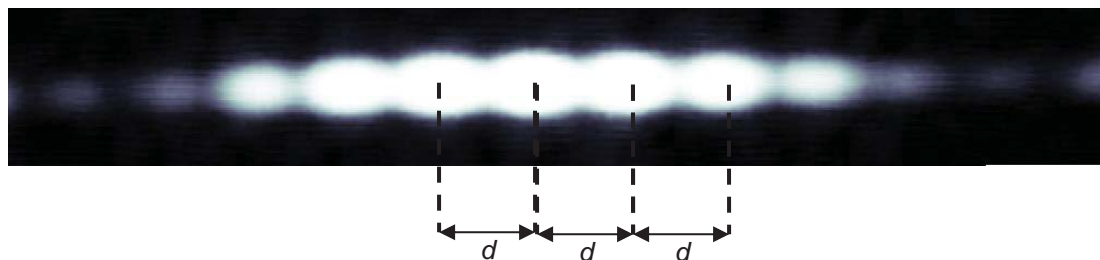


Fig. 7.6

d is the separation between the centres of adjacent bright spots.

- (i) Suggest the significance of the observed pattern in Fig. 7.6, on the nature of the electrons.

.....
 [1]

- (ii) If the electrons are initially accelerated across a potential difference of 600 V to reach the two slits in the barrier, calculate d , the separation between the centres of adjacent bright spots observed on the screen.

$d = \dots\dots\dots \text{ m} \quad [4]$

- (iii) State and explain a change, if any, which is observed in the pattern on the screen if the electrons are accelerated by a larger potential difference.

.....
 [2]

Section B

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

8 (a) Define *electric field strength*.

.....
 [1]

(b) Fig. 8.1 shows two parallel metal plates with a separation of 0.50 cm and the centre of the plates is situated 20 cm from a screen as shown.

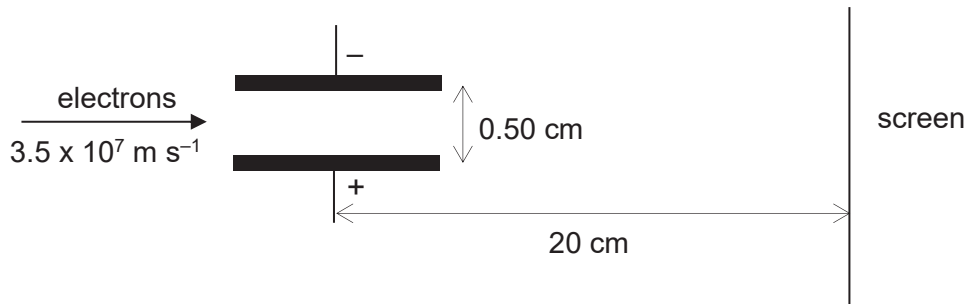


Fig. 8.1

A potential difference of 100 V is applied to the plates such that a uniform electric field is created in the region between the plates. Electrons of speed $3.5 \times 10^7 \text{ m s}^{-1}$ enter this region horizontally, mid-way between the plates.

(i) Calculate the acceleration of an electron within the plates.

acceleration = m s^{-2} [2]

(ii) The vertical component of the velocity of an electron at the moment when it exits the plates is $2.3 \times 10^6 \text{ m s}^{-1}$. Determine the time that the electron takes to pass between the plates.

time =s [2]

- (iii) A magnetic field is then applied in the region between the plates such that the electrons emerge un-deflected. State and explain the direction of the magnetic field to be applied.

.....

 [2]

- (iv) The magnetic field is now removed. The potential difference, V , across the plates is now changed and is given by the following equation

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

The r.m.s value of the potential difference is 60 V.

1. Determine the period of the potential difference across the plates.

period =s [1]

2. On Fig. 8.2, sketch the variation of potential with time, the trace of the deflected beam of electrons for one period. On the vertical scale, 1.0 cm represents 50 V. On the horizontal axis, 1.0 cm represents 5.0 ms.

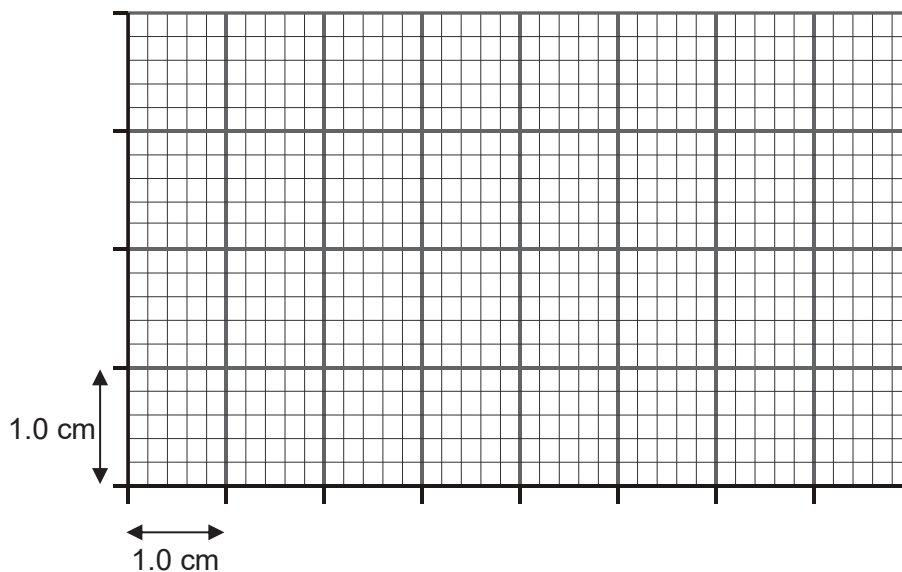


Fig. 8.2

[2]

- 8 (c) Two conductors, **A** and **B**, each of length 0.20 m and carrying current of 5.0 A are placed at right angles to the plane of the magnetic field of magnitude 3.2 mT created by a pair of magnets as shown in Fig. 8.3. Conductor **A** carries current out of the plane of the paper while conductor **B** carries current into the plane of the paper.

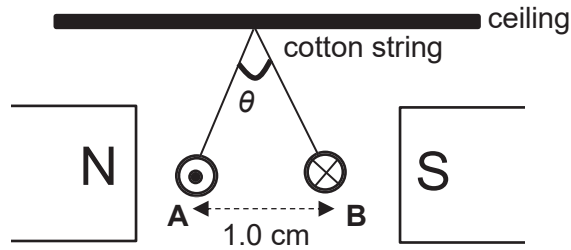


Fig. 8.3

The conductors are hung to the ceiling by cotton strings of equal tensions. At equilibrium, the two conductors make an angle of θ with each other and are separated by 1.0 cm.

You may assume that the entire length of conductors **A** and **B** lie in the magnetic field of the pair of magnets.

- (i) Fig 8.4 shows two forces that are acting on conductor **A**. Draw on the same diagram, two other forces that are acting on conductor **A**. Label all forces drawn.

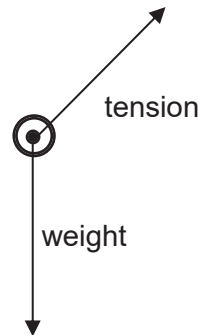


Fig. 8.4

[2]

- (ii) Calculate the magnetic force experienced by conductor **A** due to the pair of magnets.

force =N [2]

-
- (iii) The mass of conductor **A** is 0.35 g. Determine the tension in the cotton string and the angle, θ .

tension = N

$\theta = \dots\dots\dots^\circ$ [4]

- (iv) A student claims that since the tension in each of the strings are equal, the conductors have equal masses. State and explain if the claim is valid.

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

- 9 (a) The table below shows some of the properties of the ionising radiations alpha, beta and gamma.

Complete the table. [3]

	alpha	beta	gamma
mass		$1/1840 u$	
nature	particle		
penetrating ability		Stopped by few mm of aluminium	

- (b) In the early years of the last century, Madame Curie drew an illustration similar to the one in Fig. 9.1 which indicated how the three radiations travelled in air in a uniform magnetic field. Fig. 9.1 is not drawn to scale.

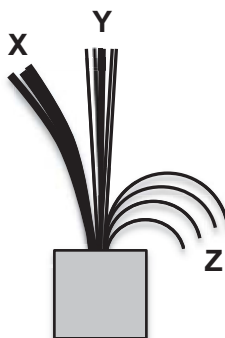


Fig. 9.1

- (i) Identify the radiations X, Y and Z.
- X:
- Y:
- Z: [2]

- (ii) State what can be deduced from the following observations:

1. The lines for X all have approximately the same length.
-
- [1]

2. The lines for Z have different curvatures.
-
- [1]

- (iii) A student claimed that the nuclear radioactive decay process that produces radiation **Z** produces only two products: a daughter nucleus and radiation **Z**.

Explain, with reference to your answer in (b)(ii)2., why the student's claim is not true.

.....

.....

.....

..... [2]

- (c) Define the following terms:

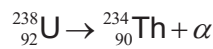
- 1. *activity*;

..... [1]

- 2. *half-life*.

..... [1]

- (d) The equation below



represents the decay of a uranium nucleus by alpha emission. You may assume that ${}_{92}^{238}\text{U}$ is initially stationary.

- (i) The half-life of ${}_{92}^{238}\text{U}$ is 1.42×10^{19} s. Determine the mass of ${}_{92}^{238}\text{U}$ that will give an emission of two α - particles per second.

mass of ${}_{92}^{238}\text{U} = \dots\dots\dots$ g [4]

-
- (ii) The alpha particle has kinetic energy KE_{α} of 4.18 MeV. Determine the energy released during one decay process.

energy released = MeV [3]

- (e) One common use of radioactivity is to check for cracks in the structure of underground water pipelines.

State two characteristics of a radioactive nuclide that would be ideal for this use.

.....

..... [2]

End of Paper



H2 Physics

9749/4

Paper 4 Practical

12 September 2017

2 hours 30 minutes

Candidate Name: _____

Class Reg Number

--	--

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number 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** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in 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, Question 1&2, Question 3, Question 4 are to be submitted separately.

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

Shift
Laboratory

Examiner's Use	
1	
2	
3	
4	
Total	/55

1 In this experiment, you will investigate the equilibrium of a wooden rule.

(a) (i) Attach masses to the apparatus as shown in Fig. 1.1.

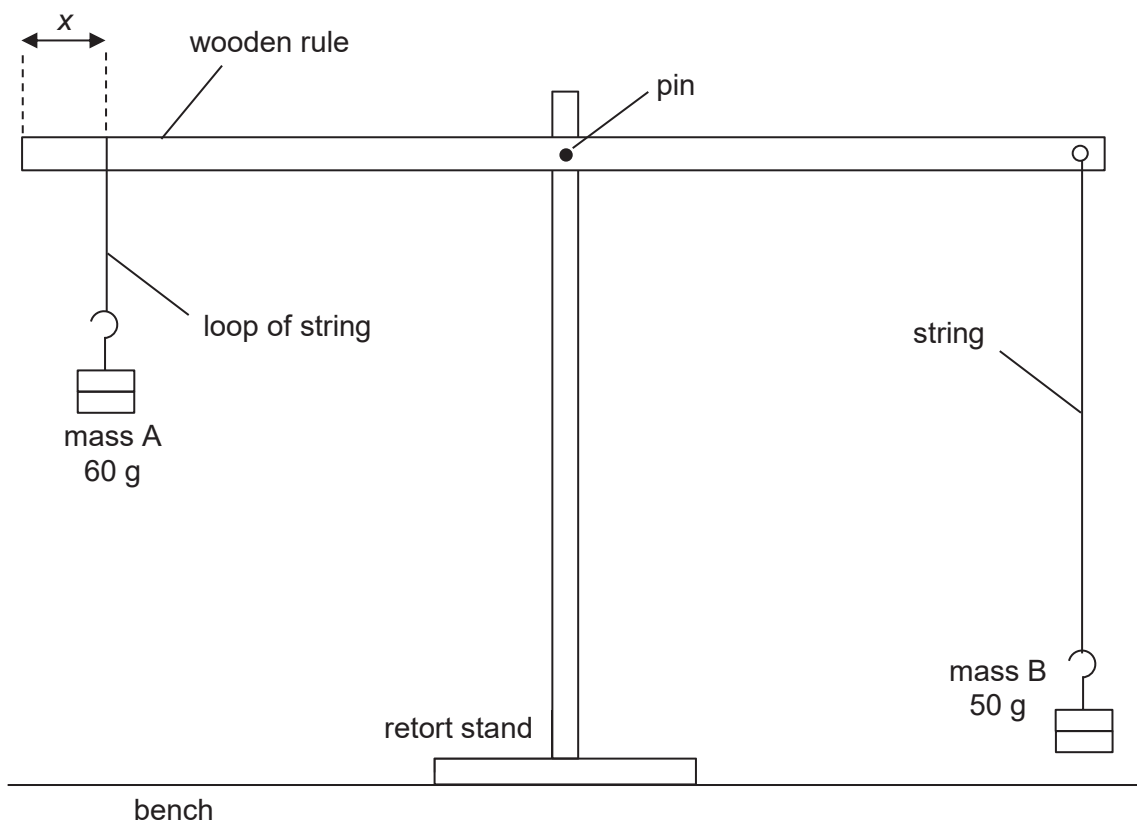


Fig. 1.1

Mass A is suspended from the wooden rule using a loop of string. The distance between the loop of string and the nearest end of the wooden rule is x .

(ii) Change x until the wooden rule is balanced and approximately parallel to the bench. Measure and record x .

$x = \dots\dots\dots$ [1]

- (b) (i) Remove both masses. Clamp the pulley to the retort stand using two wooden blocks.
- Thread the string for mass B over the pulley, and then attach the masses again, as shown in Fig. 1.2.

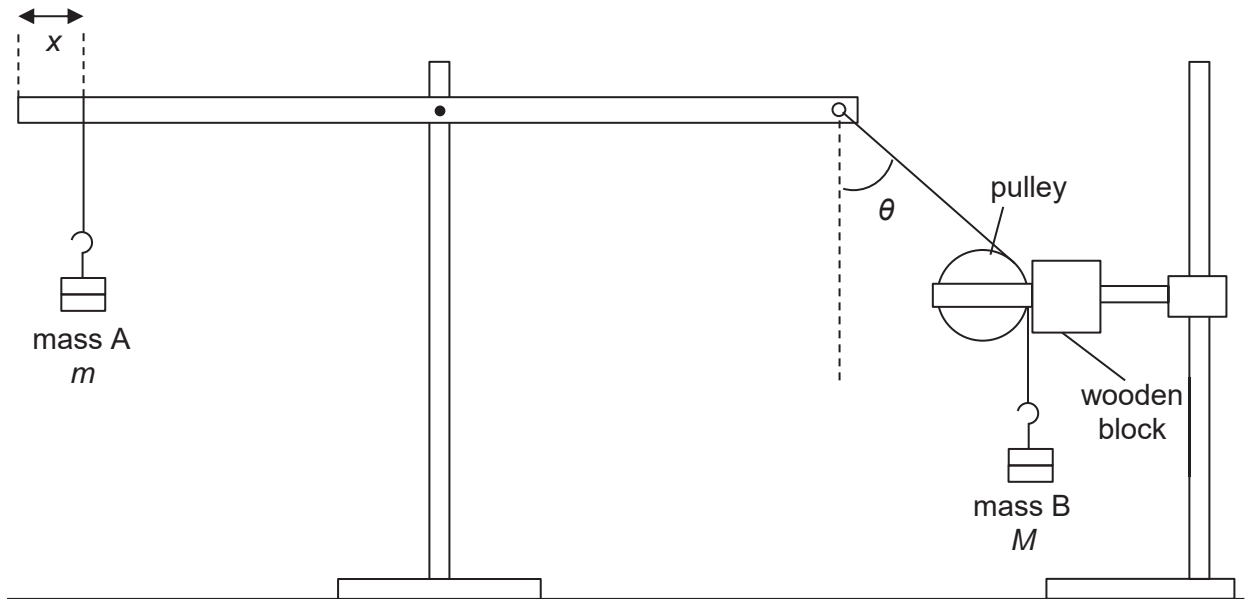


Fig. 1.2

- (ii) Transfer 10 g from mass A to mass B.
- (iii) With x at the same value as (a)(ii), adjust the position of the pulley until the wooden rule is approximately parallel to the bench.

Measure and record the angle θ that the string for mass B makes with the vertical, as shown in Fig. 1.2.

$\theta = \dots\dots\dots$ [1]

- (iv) Estimate the percentage uncertainty in your value of θ .

percentage uncertainty = $\dots\dots\dots$ [1]

(v) Record the mass m of mass A and mass M of mass B.

$m = \dots\dots\dots$

$M = \dots\dots\dots$ [1]

(vi) Calculate the value of $\frac{m}{M}$.

$\frac{m}{M} = \dots\dots\dots$ [1]

(c) It is suggested that the $\cos \theta$ is directly proportional to $\frac{m}{M}$.

Take further measurements to investigate this suggestion and explain whether your results support the suggested relationship.

Present your measurements and calculated results clearly.

.....

.....

.....

.....

.....

..... [4]

[Total: 9 marks]

- 2 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

- (a) (i) Connect the circuit shown in Fig. 2.1. The light-emitting diode (LED) should be connected the right way round so that light is emitted.

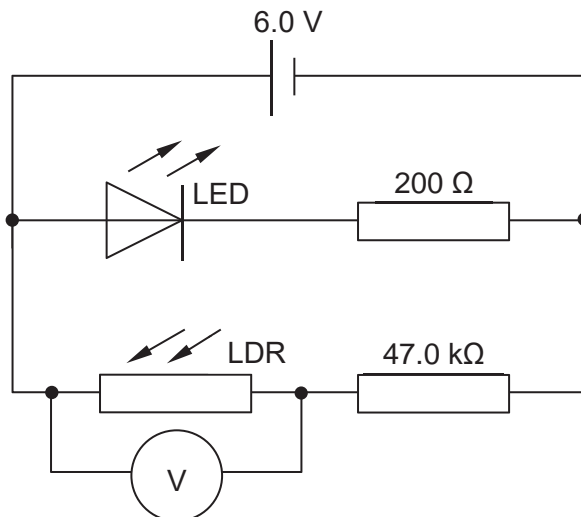


Fig. 2.1

- (ii) You are provided with a black straw of approximate length of 4 cm.
 (iii) Use the straw and clear adhesive tape to make a cylinder that fits neatly over the LDR and LED.

Cut the cylinder into two halves of approximately 2 cm each and fit the 2 cylinders over the LDR and LED, as shown in Fig. 2.2.

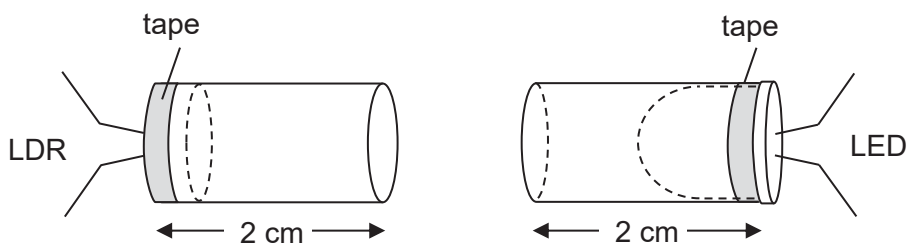


Fig. 2.2

- (b) Place the cylinders together, as shown in Fig. 2.3.

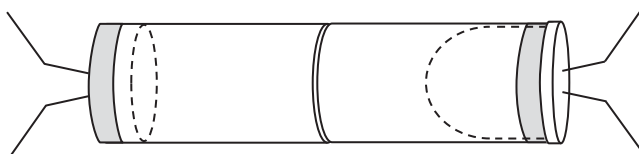


Fig. 2.3

Record the voltmeter reading V_0 .

$V_0 = \dots\dots\dots$ [2]

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

(i) Measure and record the thickness of these 16 layers.

thickness of 16 layers = [1]

(ii) Determine the thickness t of one layer of tracing paper.

t = [1]

(iii) Estimate the percentage uncertainty in your value of t .

percentage uncertainty = [1]

(d) (i) Place four layers of tracing paper between the LED and the LDR as shown in Fig. 2.4.

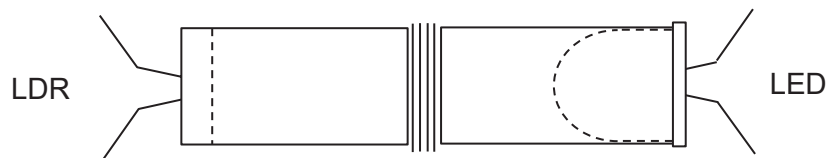


Fig. 2.4

Record the voltmeter reading V .

V = [1]

(ii) Repeat (d)(i) using eight layers of tracing paper.

V = [1]

(e) (i) State and explain two significant sources of error or limitations of the procedures for this experiment.

- 1.
.....
- 2.
..... [2]

(ii) Suggest two improvements that could be made to the experiment and explain how this addresses the errors identified in (e)(i). You may suggest the use of other apparatus or a different procedure.

- 1.
.....
- 2.
..... [2]

(f) Suggest changes that could be made to the experiment to investigate how the light detected by a LDR depends on the angle between the polarising axes of a pair of polarizing filters.

You may assume that a pair of *unmarked* polarizing filters is available.

You may draw a diagram to show how the apparatus would be arranged.

-
-
-
-
-
- [3]

[Total: 14 marks]

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Turn over for Question 3

Candidate Name: _____ () Class: _____

- 3 In this experiment you will investigate the relationship between the current in a copper wire and the orientation of a magnet suspended near to the copper wire. The magnet (with a pointer attached) has been suspended as shown in Fig. 3.1.

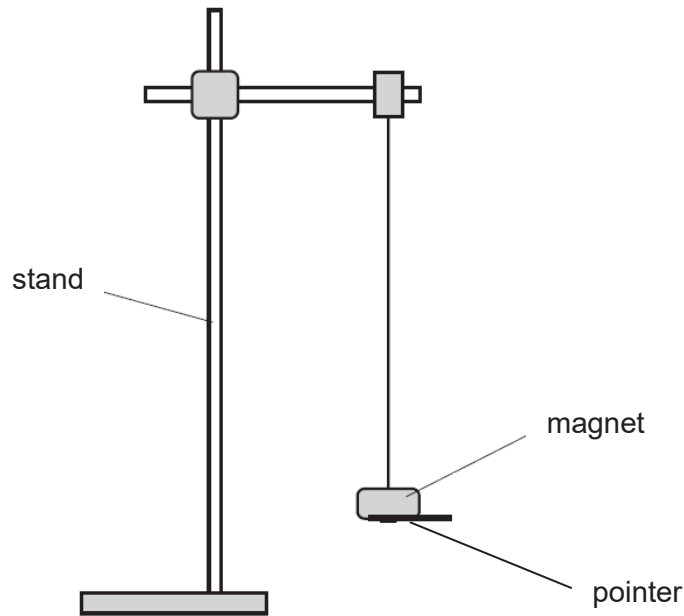


Fig. 3.1

A piece of straight copper wire has been taped to one edge of a 50 cm rule and a protractor attached to the centre of the rule. You should not disturb the copper wire or the protractor from their positions on the rule during the course of the experiment.

- (a) (i) Set up the circuit shown in Fig. 3.2.

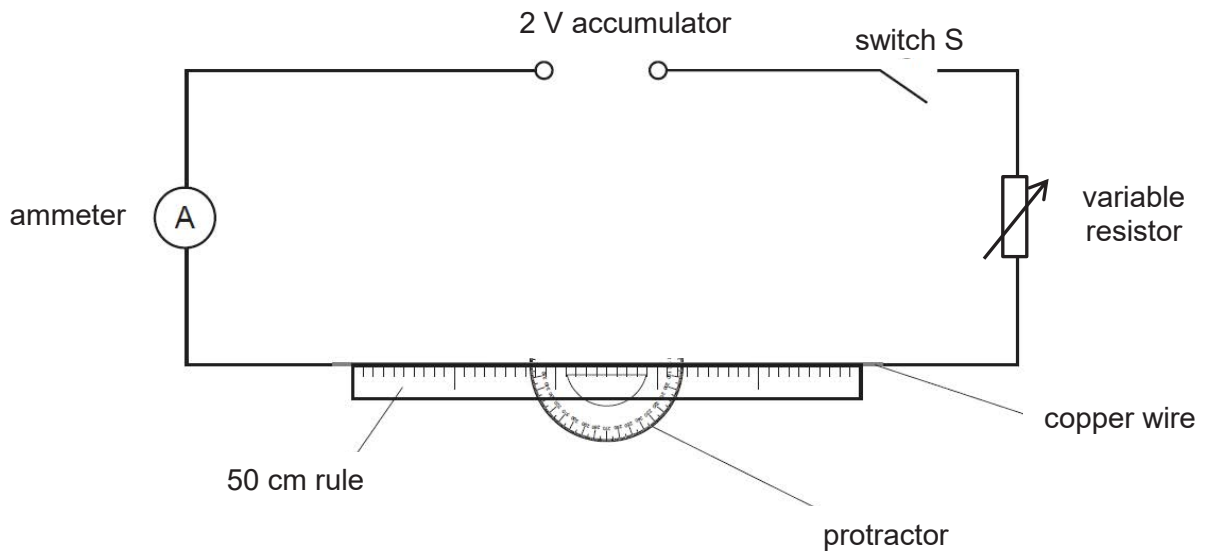


Fig. 3.2

- (ii) Place the rule just below the magnet such that the pointer is at most 5 mm above the top of protractor. The pointer should be perpendicular to the wire and the centre of the protractor directly below the point of suspension. The arrangement is shown in Fig. 3.3.

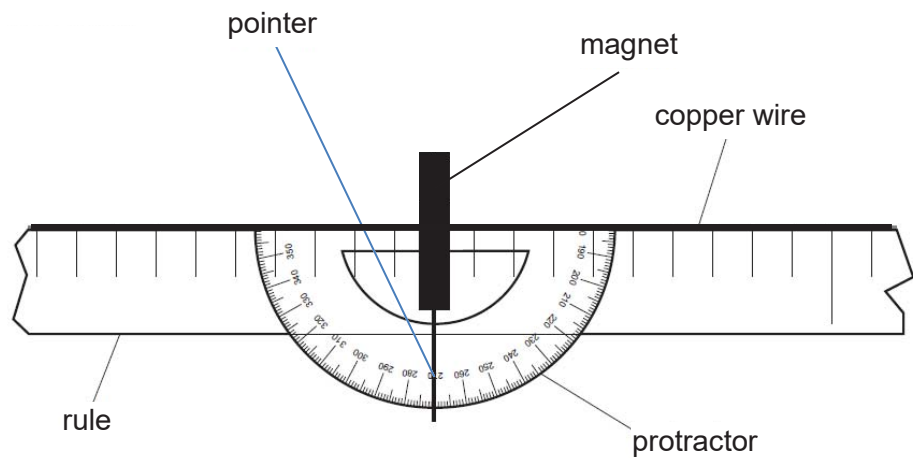


Fig. 3.3 (top view)

- (iii) Close switch S.
- (iv) Adjust the current until the pointer shows a measurable deflection. Slow down the motion of the magnet by touching it. When the pointer is steady, measure and record the angle of deflection θ and the current I .

$\theta = \dots\dots\dots$

$I = \dots\dots\dots$ [1]

- (v) Estimate the percentage uncertainty of θ .

percentage uncertainty of $\theta = \dots\dots\dots$ [1]

- (vi) Vary the resistance of the variable resistor and repeat (iv) to obtain further sets of readings for θ and I . The current should not exceed about 4 A.

[7]

(vii) Open switch S.

- (b) The formula which relates θ and I is

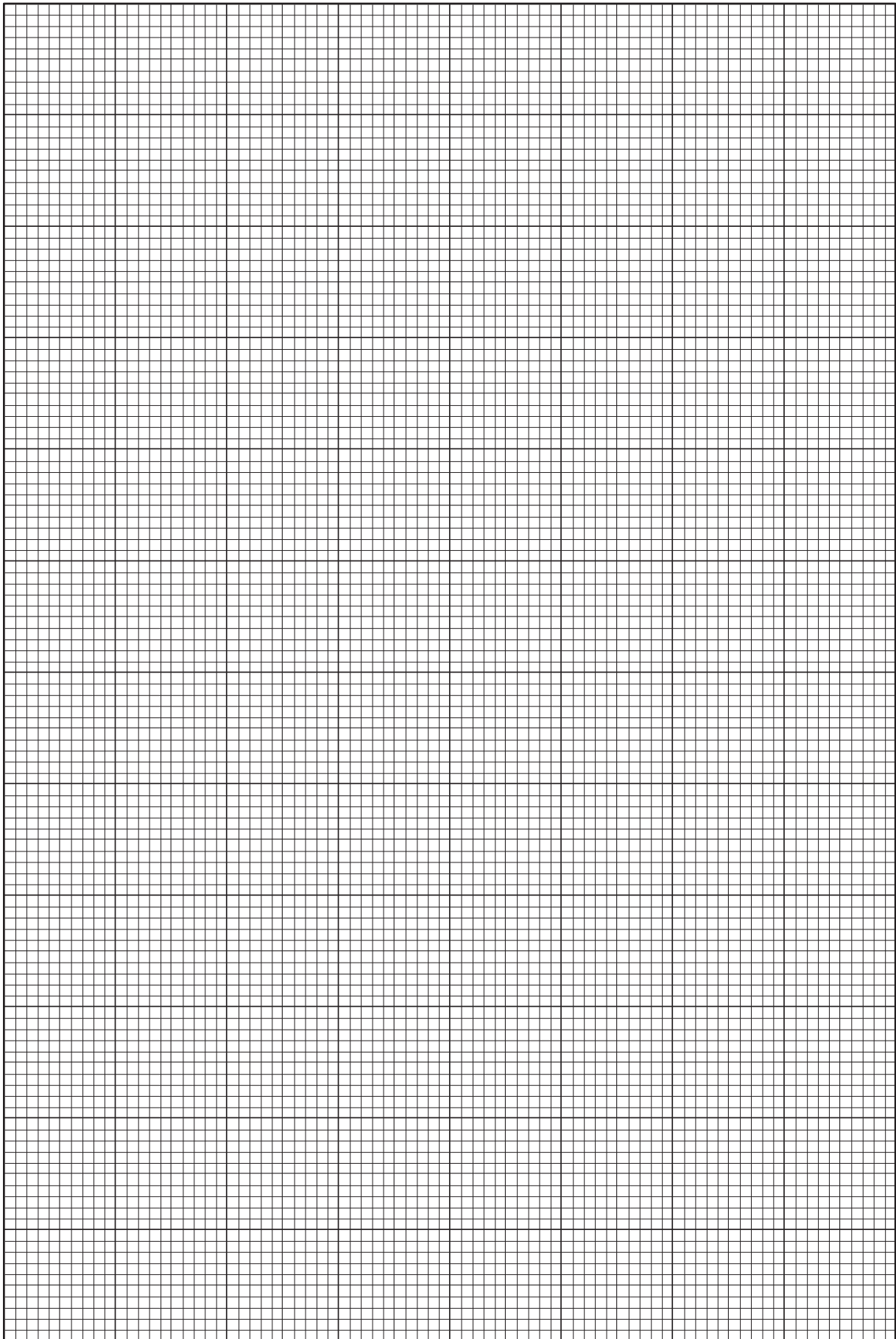
$$\tan \theta = A I + B$$

where A and B are constants.

Plot a graph to determine the values of A and B.

A =

B = [4]



[3]

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

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

(d) (i) Use the results from your experiment to calculate a value for θ when the current in the copper wire is 15 A.

$\theta = \dots\dots\dots$ [1]

(ii) Give one reason why it may be difficult to verify this experimentally.

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

(e) It is known that constant A is affected by the magnetic flux density due to the wire. On the graph grid on page 12, sketch a second graph to represent the results if distance between the magnet and the wire is increased. Label this graph Z. [1]

[Total: 20 marks]

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Turn over for Question 4

Candidate Name: _____ () Class: _____

- 4 Each of the propellers on a drone consists of two or more blades connected to a motor shaft. As the motor rotates air is drawn through the blades. This results in a thrust on the propeller, hence lifting the drone. Fig. 4.1 shows a propeller used in a drone. The speed of rotation of the motor is determined by the power supply it is connected to.

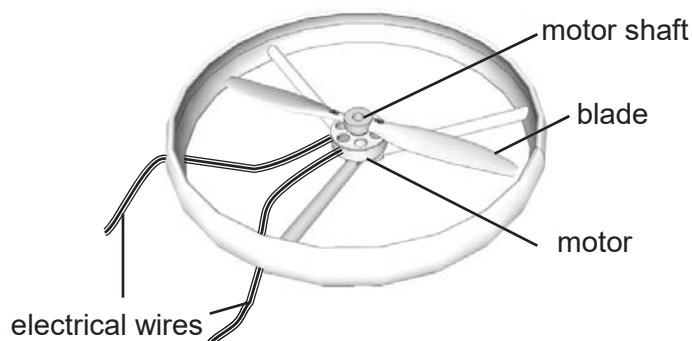


Fig. 4.1

A student suggests that the average thrust T on the propeller depends on the rotational speed ω of the blade, the blade angle θ , and the density of air.

The relation between the average thrust T , ω , and θ may be written in the form

$$T = k\omega^a \sin^b \theta$$

where k , a , b are constants.

You are provided with the following apparatus.

- a number of propellers with different blade angles indicated,
- tachometer (an instrument that measures the rotational speed of a shaft)
- electronic balance

You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine the values of k , a , b .

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

- (a) the identification and control of variables,
- (b) the equipment you would use,
- (c) the procedures to be followed,
- (d) how the values of k , a and b are determined from your readings,
- (e) any precautions that would be taken to improve the accuracy and safety of the experiment.

[Total: 12 marks]

Diagram

.....

.....

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.....

.....

2017 H2 P1 Preliminary Examination

1 **Ans: D**

A: Typical bus mass = 3000 kg, speed = 60 km/h $\approx 17 \text{ m s}^{-1}$, so KE $\approx 400\,000 \text{ J}$

B: Typical power of domestic light = 10 to 90 W

C: 300 K is 27 °C, too low for hot oven

D: Typical tyre is 60 cm radius, 20 cm width, 4 cm breadth \Rightarrow volume $\approx 0.03 \text{ m}^3$

2 **Ans: B**

$$s_{car} = 0 + 0.5(2)t^2$$

$$s_{truck} = (14)t$$

$$s_{car} = s_{truck}$$

$$t = 14 \text{ s}$$

3 **Ans: A**

To create rotational equilibrium, the sum of moments exerted by the weight of each material about the knife-edge must be equal. Another way is to use visual inspection to estimate the location of the centre of gravity (CG) for the composite rod. The knife-edge must be below the CG for rotational equilibrium.

For C and D, the CG lies in the middle of the rod so knife-edge is placed correctly below the CG.

For B, the CG is off-centre to the right as material B is concentrated to the right. The knife-edge is also positioned more to the right (from centre) There is a chance that rotational equilibrium can be established.

For A, the CG is also off-centre to the right since material B is concentrated to the right, but the knife-edge is at the centre. Hence, rotational equilibrium cannot be established.

4 **Ans: A**

Since the floor is frictionless, contact force at point B is only the normal contact force.

At equilibrium,

At point A, there is an upward vertical force (magnitude of $390 - 317 = 73 \text{ N}$) to ensure net vertical forces is zero.

At point A, there is a leftward force to counter the rightward tension force.

Hence, reaction force at A is pointing as shown in diagram A.

5 Ans: A

Change in momentum = area under F-t graph

Area under F-t graph from 0 to 10 seconds = $0.5 \times (8+4) \times 12 + [(-0.5) \times (2) \times (12)] = 60 \text{ N s}$

Change in momentum = final momentum – initial momentum

$$60 = mv - 0$$

$$v = 200 \text{ m s}^{-1}$$

6 Ans: D

Using relative speed of approach = relative speed of separation

$$u_1 - u_2 = v_2 - v_1$$

$$0.100c - (-0.040c) = v_2 - v_1$$

$$v_2 = 0.140c + v_1 \quad \text{-----(1)}$$

Using conservation of momentum

$$1u \times 0.100c - 4u \times 0.040c = 1u \times v_1 + 4u \times v_2$$

$$0.100c - 0.160c = v_1 + 4v_2 \quad \text{----- (2)}$$

Substitute eqn (1) into (2)

$$-0.060c = v_1 + 4 \times (0.140c + v_1)$$

$$v_1 = -0.124c$$

$$v_2 = +0.016c$$

7 Ans: D

The constant force pulling the object down the slope, $F = mg \sin \theta$

Instantaneous power, $P = Fv = mg \sin \theta v$

Loss in GPE = gain in KE

$$mgh = \frac{1}{2} m(v^2 - 0^2)$$

$$v = \sqrt{2gh}$$

$$\therefore P = mg \sin \theta \sqrt{2gh}$$

8 Ans: A

EPE is equal to the area under the force-extension graph. In this case, a stretched length vs force graph is plotted, hence we consider the area that Q makes with the vertical axis.

Note that at point Q, the spring has undergone plastic deformation, hence some energy has been released as heat (represented by area Y).

9 **Ans: C**

$$\text{Angular velocity of accurate clock} = \frac{2\pi}{60 \times 60} = 1.745329 \times 10^{-3} \text{ rad s}^{-1}$$

Javier watch behind by

$$(1.745329 - 1.744) \times 10^{-3} \times 24 \times 3600 = 0.114847372 \text{ rad}$$

$$\frac{0.114847372}{1.745329 \times 10^{-3}} = 66 \text{ s}$$

10 **Ans: D**

For the man (where m is the mass of the man),

$$g - \frac{N}{m} = r\omega^2$$

For the spacecraft, (where M is the mass of the man),

$$g + \frac{N}{M} = r\omega^2$$

Since both the man and the spacecraft are at the same distance away from the planet and orbits the planet with the same angular velocity, hence N (normal contact force between the man and the spacecraft) is zero. The man is floating in the spacecraft.

OR

Consider both the man and the spacecraft as a system with total mass M_T ,

$$M_T g = M_T r \omega^2$$

$$g = r \omega^2$$

For the man, (where

$$g - \frac{N}{m} = r \omega^2 = g$$

$$\therefore \frac{N}{m} = 0$$

11 **Ans: C**

For Satellite A, gravitational force provides for centripetal force, (M is the mass of the planet, m_A is the mass of Satellite A and r is the distance between Satellite A and the planet)

$$\frac{GMm_A}{r^2} = m_A \frac{v^2}{r}$$

Kinetic energy, $E_k = \frac{1}{2} m_A v^2$

$$\frac{1}{2} m_A v^2 = \frac{GMm_A}{2r} = \frac{GMm_A}{2(2R)} \text{ (Since Satellite A is } 2R \text{ away from the centre of the planet)}$$

For satellite B, (M is the mass of the planet, m_B is the mass of Satellite B and r is the distance between Satellite B and the planet)

$$\frac{1}{2} m_B v^2 = \frac{GMm_B}{2r} = \frac{GM2m_A}{2(3R)} = \frac{4}{3} E_k$$

12 **Ans: C**
reasoning:

$$\text{Total Energy} = \frac{1}{2} m \omega^2 x_0^2$$

$$5 = \frac{1}{2} (0.4) \left(\frac{2\pi}{T} \right)^2 (0.25)^2$$

$$T = 0.31 \text{ s}$$

13 **Ans: D**
reasoning:

Increased damping, it will take longer to complete an oscillation. Hence period increases and natural frequency at resonance decreases.

14 **Ans: B**
reasoning:

For a closed pipe, the fundamental frequency occurs at 0.25λ

Length of pipe = 2 m = 0.25λ ,

Hence,

$$f = v/\lambda = 320 / 20 = 40 \text{ Hz}$$

15 **Ans: D**
reasoning:

Wave	Approx Size	Obstacle	Obstacle Size	Conclusion
microwaves	0.1 cm – 10 cm	Steel post	10^{-1} m	Most similar in order of magnitude
radiowaves	1 m – 10 m	Copper wire	10^{-3} m	
sound waves	1.7 cm – 17 m	Human hair	10^{-5} m	
visible light wave	400-700nm	Opening of classroom	2 m	

16 **Ans: C**
reasoning:

Path difference is 10 cm

For point Z to be at destructive interference, it needs to be in multiples of $(n+1/2) \lambda$

Trial and error for all 4 options

If $\lambda = 2\text{cm}$, PD = 5λ (CI)

If $\lambda = 3\text{cm}$, PD = 3.33λ (no complete cancellation)

If $\lambda = 4\text{cm}$, PD = 2.5λ (DI)

If $\lambda = 26\text{cm}$, PD = 1.67λ (no complete cancellation)

17 **Ans: C**

A is incorrect. There is no work done for path **W** as the change in potential is zero.

B is incorrect. Positive work (path **X**) is done when the positive particle is brought to a point of lower potential while negative work (path **Y**) is done when the positive particle is brought to a point of higher potential.

C is correct. Positive work is done by the electric field when the positively charged particle is brought from a position of higher potential to a position of lower potential (path **Z**) and the change in potential is the largest.

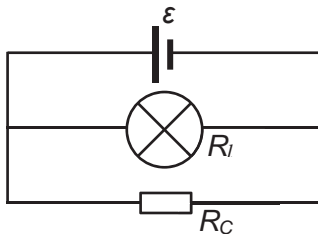
D is incorrect. Work done is zero for path **W** as the change in potential is zero.

18 **Ans: B**

$$\tau = qE \times d = (2 \times 1.6 \times 10^{-19}) \left(\frac{2.0 \times 10^2}{0.001} \right) (4.0 \times 10^{-12} \sin 30^\circ)$$

$$= 1.3 \times 10^{-25} \text{ Nm}$$

19 **Ans: A**



The same potential difference across both the lamp and the resistor.

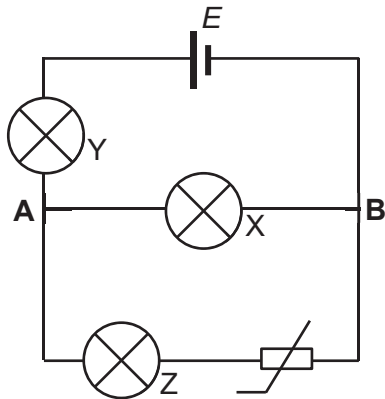
$$P_{lamp} = \frac{\epsilon^2}{R_l} \quad = \quad P_{resistor} = \frac{\epsilon^2}{R_C}$$

Fraction of power delivered to lamp

$$= \frac{P_{out}}{P_{in}} = \frac{\frac{\epsilon^2}{R_l}}{\frac{\epsilon^2}{R_l} + \frac{\epsilon^2}{R_C}} = \frac{R_C}{R_l + R_C}$$

20 Ans: C

When heated up, resistance of an NTC thermistor decreases.



Effective resistance across points **AB** decreases. Hence V_{AB} decreases and p.d. across Y increases. Y will become brighter and X dims.

21 Ans: A

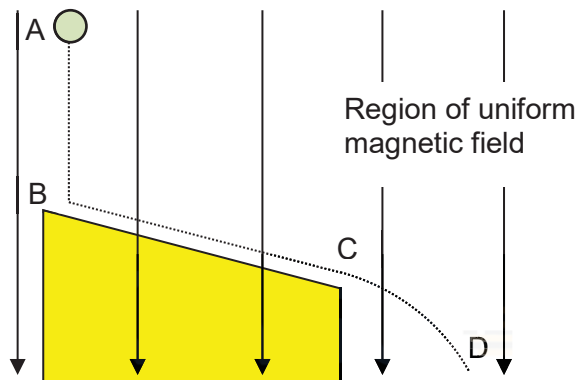
Electric force on the electrons is downwards. Hence magnetic force on electrons is upwards. Using Fleming's LHR, the magnetic field is pointing out of the paper.

$$F_E = F_B$$

$$qE = Bqv$$

$$B = \frac{E}{v} = \frac{20 / 0.005}{v} = \frac{4000}{v}$$

22 Ans: B



$E = Blv$, where v is the horizontal component of the rod's velocity. From Point A to B, the rod is moving vertically and E is zero. From B to C, as the rod rolls down the slope, the component of its weight parallel to the slope caused its velocity to increase. Hence, Its horizontal velocity increases at a constant rate and E increases linearly. From C to D, the rod is moving in projectile motion. Its horizontal velocity is constant and E remains constant.

23 **Ans: A**

The forces acting on XY and ZW have the same magnitude in opposite directions. These two forces form a couple with a torque as follow:

$$\tau = NBIL \times d = (20)(0.80)(I)(0.17) \times (0.11) = 1.35$$

$$I = 4.5 \text{ A}$$

24 **Ans: B**

reasoning:

$$\text{r.m.s potential difference in secondary coil} = 8.0 \times 2.5 = 20 \text{ V}$$

$$\text{r.m.s potential difference in primary coil} = 20 \div 4 = 5.0 \text{ V}$$

(This is a step-up transformer with a 1:4 turn ratio).

25 **Ans: B**

reasoning:

$$\text{From } pV = nRT$$

$$n_1RT_1 = n_2RT_2$$

$$\frac{m_1}{M_R} RT_1 = \frac{m_2}{M_R} RT_2$$

$$m_2 = \frac{(273.15 + 10)(15)}{(273.15 + 30)} = 14.0 \text{ kg}$$

26 **Ans: C**

reasoning:

A is incorrect as this is only true if the system is an ideal gas system.

B is incorrect as during change of state, internal energy can increase but temperature will remain the same.

D is incorrect as it is possible for a system with lower temperature to have the same amount of internal energy as another system if the system with lower temperature have much more particles.

C is correct as internal energy of a system can be increased by simply doing work on the system while keeping the heat transfer process zero.

27 **Ans: B**

B has the lowest wavelength/ highest frequency as it has the largest stopping potential.

Stopping potential is a measure of the maximum KE of the photoelectrons which is dependent on the frequency of the radiation.

28 **Ans: D**

$$\Delta x \Delta p \geq h \quad , \quad \Delta p = m \Delta v$$

$$\therefore \Delta v = \frac{h}{\Delta x \cdot m} = \frac{6.63 \times 10^{-34}}{50 \times 10^{-9} \times 9.1 \times 10^{-31}} \left(\frac{1}{50 \times 10^{-9} \times 9.1 \times 10^{-31}} \right)$$

$$\Delta v = 1.5 \times 10^4 \text{ m s}^{-1}$$

29 **Ans: D**

reasoning:

To form back the same isotope, mass number need not be the same but atomic number must be the same.

Ejecting an alpha particle causes the mass number and atomic number to decrease by 4 and 2 respectively.

Releasing two beta particles will cause no change in the mass number but atomic number will increase by 2, hence return back to the original atomic number.

30 **Ans: C**

reasoning:

Let C be original number of counts due to the α -source.

Let B be the background count.

$$C + B = 300 \quad (1)$$

$$0.5C + B = 155 \quad (2)$$

$$\text{Solving, } C = 290$$

Lead would block all the counts due to the α -source.

Hence, only background count of 10 is detected.

H2 P2 Prelim Solutions

- 1 (a) In a uniform circular motion, although the linear speed remains unchanged, its direction changes with time [B1], hence the velocity is always changing. So the motion is accelerated. By Newton's second law, a resultant force [B1] must be acting on it. Since the change in velocity is directed towards the centre of the circle [B1], the acceleration, and hence the resultant force is directed towards the centre of the circle. [3]
- (b) (i) $T = Mg = 0.90 \times 9.81 = 9.829 \text{ N}$
 Resultant force
 $= \sqrt{T^2 - (mg)^2}$
 $= \sqrt{(8.829)^2 - (0.30 \times 9.81)^2}$ [1]
 $= 8.32 \text{ N}$ [1]
- (ii) Resultant force = $mr\omega^2$
 $9.76 = mr(2\pi f)^2$ [1]
 $r = \frac{8.324}{0.30 \left(2\pi \left(\frac{175}{60} \right) \right)^2} = 0.0826 \text{ m}$ [1]
- (iii) It would not be possible [A1] for the string to be horizontal because the string needs to make an angle with the horizontal such that there is a vertical component of the tension to balance the weight [M1]. [2]
- 2 (a) (i) The **gravitational potential**, ϕ , at a point in a gravitational field [B2] created by a mass M , is the work done per unit mass, by an external force in bringing a small test mass from infinity to that point without a change in kinetic energy.
- (b) (i) Gravitational force provides for centripetal force [B1]

$$F_g = \frac{M_E v^2}{R}$$

$$\frac{GM_S M_E}{R^2} = \frac{M_E v^2}{R}$$

$$E_k = \frac{1}{2} M_E v^2 = \frac{GM_S M_E}{2R}$$
 [B1]

$$E_p = \frac{-GM_E M_S}{R}$$
 [B1]

$$E_T = E_p + E_k$$

$$E_T = \frac{-GM_E M_S}{R} + \frac{GM_E M_S}{2R} = \frac{-GM_E M_S}{2R}$$
 [B1]
- (ii) Since total energy at infinity is zero, when total energy is negative, [B1] it implies that the system is bounded / the Earth is being attracted to the Sun / work needs to be done in order to move the Earth out [B1] of the gravitational field of the Sun.

(c) Due to the presence of the Earth, the resultant gravitational force experienced by the satellite is less than the gravitational force the Sun exerts on it. [B1]

Hence as g field strength experienced by satellite is weakened, it results in a smaller orbital radius for the same period. [B1]

3 (a) Defining equation is $a = -\omega^2 x$. [B1]

Where a is the acceleration of the system

ω is the angular frequency / angular velocity of system

x is the displacement of the system from the equilibrium [B1]

(b) (i)



$$F_1 = k(e + x) \quad [M1]$$

$$F_2 = k(e - x)$$

Resultant force

$$= F_1 - F_2$$

$$= k(e + x) - k(e - x) \quad [M1]$$

$$= 2kx \quad [A0]$$

(ii) Explanation of negative sign (any one of the following)

- Since net force and displacement are in opposite direction

- Since displacement is to the right and restoring force is to the left [M1]

By Newton's 2nd Law, $F_{net} = ma$

$$\underline{-2kx = ma} \quad [M0]$$

$$\text{Hence, } a = -\frac{2kx}{m} \quad [A1]$$

(iii) $\frac{2kx}{m} = \omega^2 x$

$$\frac{2k}{m} = (2\pi f)^2$$

$$\frac{2(80)}{1.500} = (2\pi f)^2 \quad [M1]$$

$$f = 1.6 \text{ Hz} \quad [A1]$$

- 4 (a) (i) Faraday's Law of Electromagnetic Induction states that the induced e.m.f ε is directly proportional to the rate of change of magnetic flux linkage Φ or the rate of cutting of magnetic flux. [B1]

Lenz's law states that the induced e.m.f. will be directed such that the current which it (e.m.f.) causes to flow opposes the changes that is producing it (e.m.f.). [B1]

- (ii) Alternating current in the solenoid produces an alternating magnetic flux density. [B1]

This causes a changing magnetic flux linkage in the coil, and by Faraday's law the rate of change of magnetic flux linkage through the coil induces an e.m.f. [B1]

- (iii) $B = \mu_0 nI$
 $= 4\pi \times 10^{-7} (400/0.50)(1.5)$

[C1] Correctly substituting values for $B = \mu_0 nI$ or $\varepsilon = NA \frac{dB}{dt}$

Induced e.m.f =

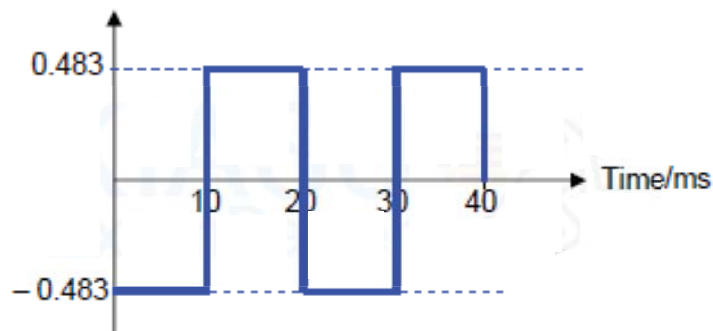
$$\frac{dNBA}{dt}$$

$$= NA \frac{dB}{dt}$$

$$= (8)(0.01 \times 0.02) \frac{4\pi \times 10^{-7} (400 / 0.50)(1.5 - (-1.5))}{10 \times 10^{-3}} \quad [M1]$$

$$= 4.83 \times 10^{-4} \text{ V} \quad [A1]$$

- (iv) Induced e.m.f /mV



[B2] – correct profile with correct labels

OR

[B1] – correct profile but wrong/missing labels

(v)
$$\text{Max Power} = \frac{(4.83 \times 10^{-4})^2}{2.0} \quad [\text{M1}]$$

$$= 1.17 \times 10^{-7} \text{ W} \quad [\text{A1}]$$

- (vi) Any one below: [B1]
 Increase the current in the solenoid
 Increase number of turns per unit length of the solenoid
 Increase the frequency of the A.C. current through solenoid
 Increase the number of turns in the rectangular wire
 Increase cross sectional area of rectangular wire
 Adding an iron core inside rectangular coil

- 5 (a) By transmitting electrical power in a.c. mode, the transmission voltage can be stepped up. [B1]

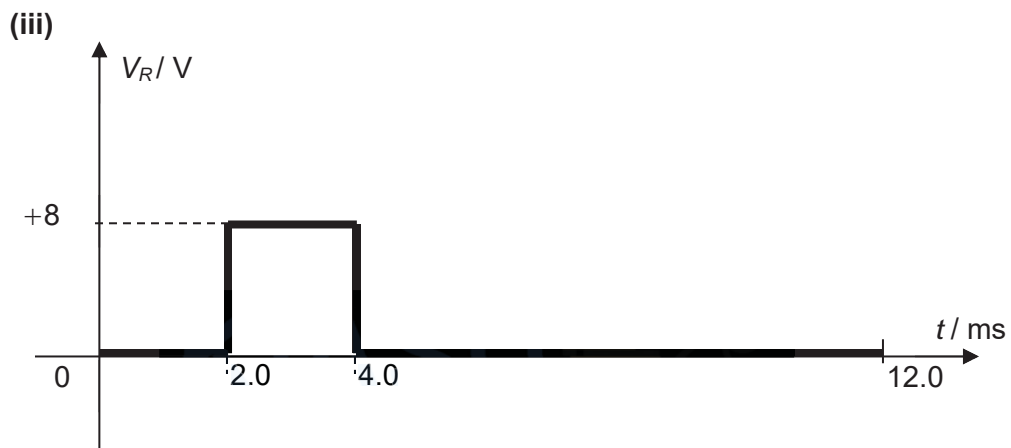
This will reduce power loss in the cables due to a smaller transmission current. [B1]

(b) (i)
$$V_{\text{rms}} = \sqrt{\frac{2(10.0)^2(2.0) + (20.0)^2(2.0) + 2(10.0)^2(2.0) + (20.0)^2(2.0)}{12.0}} \quad [\text{M1}]$$

$$= 14 \text{ V} \quad [\text{A1}]$$

(ii) 1. 0 V [A1]

(ii) 2. p.d. across resistor $R = 20 - 12$ [M1]
 $= 8.0 \text{ V}$ [A1]



1 mark for shape of graph.
 1 mark for labelled axes (if graph is correct)

6 (a) (i) using Ideal Gas Equation $PV = nRT$, at constant P ,

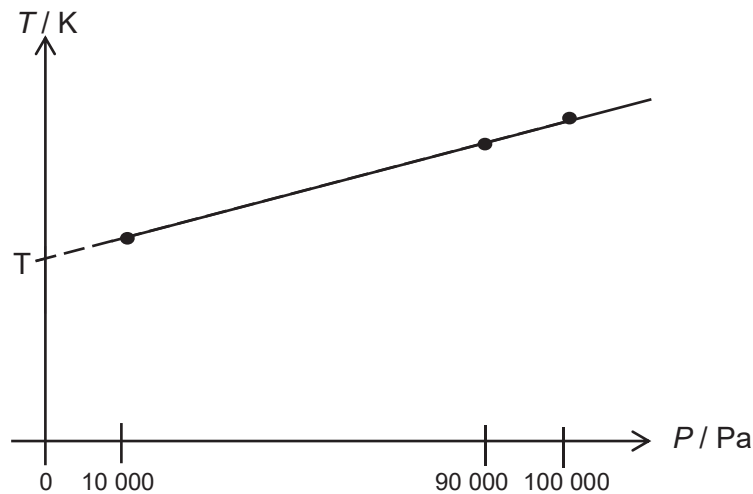
$$T = \frac{V_r}{V_{Tr}} \times T_{Tr} \quad [\text{M1}]$$

$$T_{Tr} = 273.16 \text{ K} \quad [\text{M1}]$$

$$T = \frac{(100000)(503.30)}{(100000)(398.53)} \times T_{Tr}$$
$$= 344.97 \text{ K (5 s.f.)} \quad [\text{A1}]$$

(ii) The gas in the pressure gas thermometer is not ideal. [A1]

(iii)



Plotting straight line graph and extrapolating to vertical axis (not origin) – [B1]

Labelling T correctly – [B1]

Real gas approaches ideal gas behavior at low pressures. [B1]

(b) (i) During evaporation, the more energetic water molecules have sufficient energy to escape from the body surface. [B1]

Hence, the average energy of the molecules left behind will be lower and temperature falls. [B1]

(ii) Power removed by sweating
 $= 0.85 \times 350 = 297.5 \text{ W}$ [M1]

$$P = \frac{Ml}{t} = \frac{\rho V l}{t} \quad [M1]$$

$$\frac{V}{t} = \frac{P}{\rho l}$$

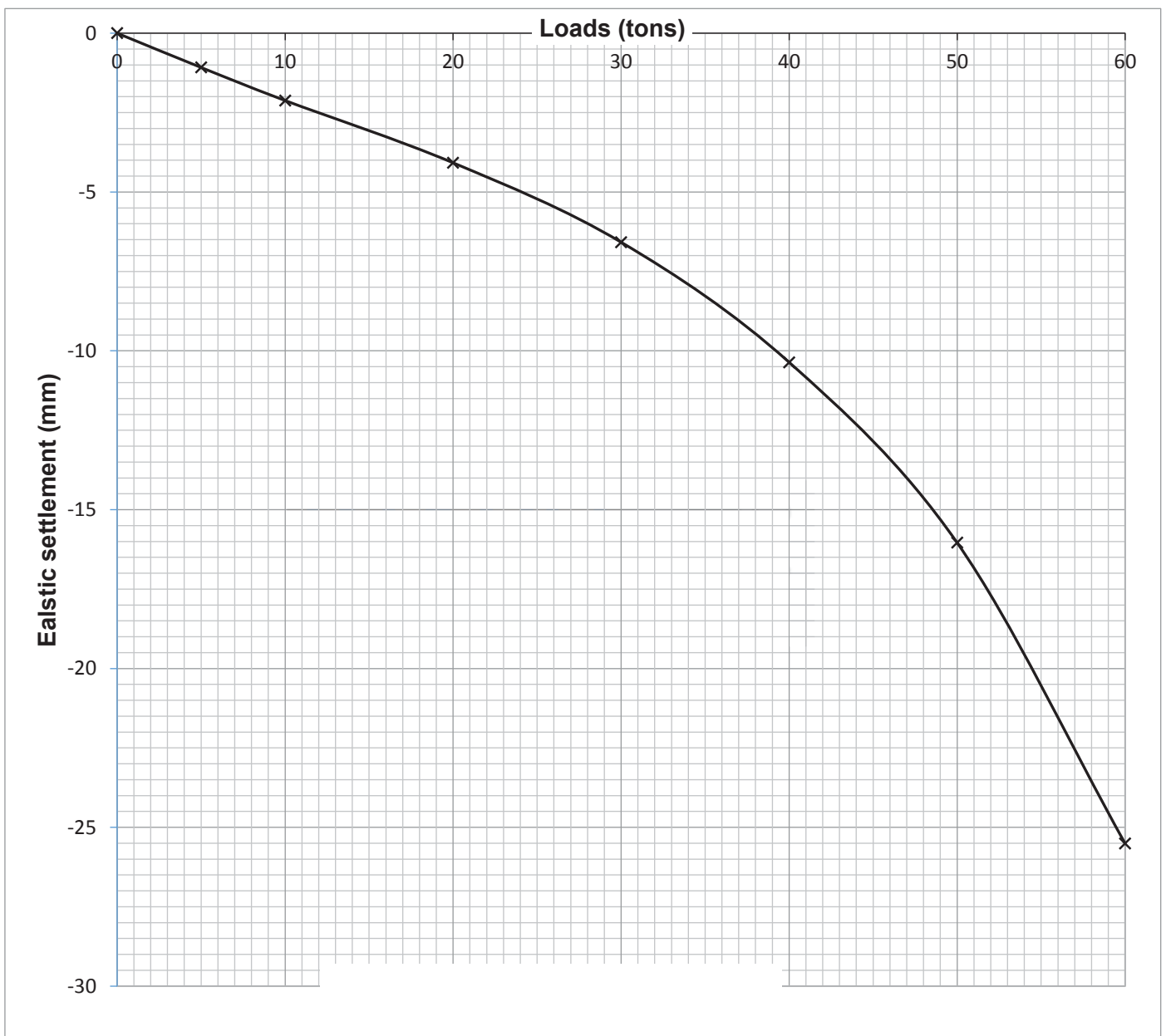
$$= \frac{297.5}{(1000)(2.41 \times 10^6)}$$

$$= 1.2344 \times 10^{-7} \text{ m}^3 \text{ s}^{-1}$$

$$= 4.44 \times 10^{-4} \text{ m}^3 \text{ hr}^{-1} \quad [A1]$$

7 a (i) 78, 78 [B1]

(ii) [B1] for plotting correctly within $\frac{1}{2}$ smallest division.
[B1] for sketching good fit curve



(iii) -20.5 ± 1.0 mm

(iv) $\frac{Q_s}{\text{Actual load}} = \frac{58+68}{2} = 63\%$ [B1]

Assumption: There is a linear relationship of Q_s to actual load between 50 tons and 60 tons of actual load. [B1]

(v) Elastic settlement meant the settlement of the pile/ distance or length that pile sinks into ground that follows elasticity theory. [B1]

(vi) By Newton's third law, when the force by hydraulic jack acted on the loading platform is equal to the force by the loading platform acted on the hydraulic jack but in different direction. In this way, the pile is being load tested accordingly.

[B1] – correctly relating the acted forces

[B1]- correctly relating N3L

(vii)
$$\begin{aligned} \text{Upthrust} &= V\rho g \\ &= \pi \frac{d^2}{4} l\rho g \\ &= \pi \frac{0.8^2}{4} \times 10.0 \times 1050 \times 9.81 \text{ [M1]} \\ &= 51.8 \text{ kN [A1]} \end{aligned}$$

(viii) A large factor of safety is needed as the soil condition underground can be erratic. [B1]

(b) (i)
$$\begin{aligned} \text{Energy input} &= \text{Force} \times \text{distance moved} \\ &= 600 \times 9.81 \times 0.3 \text{ [M1]} \\ &= 1770 \text{ J [A1]} \end{aligned}$$

(ii)
$$\text{time} = \frac{2L}{v} = \frac{2 \times 30.5}{4000} = 0.0153 \text{ s [A1]}$$

(iii) [B1] Possible reason:

There is a crack in the pile (such that the wave gets reflected before the tip of the pile).

$$(iv) \quad E = \frac{\rho c^2}{k} = \frac{23.5 \times 1000 \times 4000^2}{9.81} = 38.3 \times 10^9 \text{ Pa}$$

$$\begin{aligned} \frac{\Delta E}{E} &= \frac{\Delta \rho}{\rho} + 2 \frac{\Delta c}{c} \\ &= \frac{0.4}{23.5} + 2 \times \frac{400}{4000} \\ &= 0.217 \end{aligned} \quad [M1]$$

$$\begin{aligned} \Delta E &= 0.217 \times 38.3 \times 10^9 \\ &= 8 \times 10^9 \text{ Pa (1 s.f.)} \end{aligned} \quad [M1]$$

$$\begin{aligned} \text{Therefore, } E \pm \Delta E &= (38 \pm 8) \times 10^9 \text{ Pa} \\ &= (38 \pm 8) \times 10^6 \text{ kPa} \end{aligned} \quad [A1]$$

[A1] for correct units; kN m⁻² or N m⁻² or kPa or Pa (with correct values)

OR

$$E_{\max} = \frac{\rho c^2}{k} = \frac{23.9 \times 1000 \times 4400^2}{9.81} = 47.2 \times 10^9 \text{ Pa}$$

$$E_{\min} = \frac{\rho c^2}{k} = \frac{23.1 \times 1000 \times 3600^2}{9.81} = 30.5 \times 10^9 \text{ Pa} \quad [M1\text{--- for identifying max and min}]$$

$$E_{\text{average}} = \frac{E_{\max} + E_{\min}}{2} = 38.9 \times 10^9 \text{ Pa}$$

$$\Delta E = \frac{E_{\max} - E_{\min}}{2} = 8 \times 10^9 \text{ Pa [1 s.f.] [M1]}$$

Therefore,

$$\begin{aligned} E \pm \Delta E &= (39 \pm 8) \times 10^9 \text{ Pa} \\ &= (39 \pm 8) \times 10^6 \text{ kPa} \end{aligned} \quad [A1]$$

[A1] for correct units; kN m⁻² or N m⁻² or kPa or Pa (with correct values)

H2 Physics Paper 3 Answers:

1a Units of Q

$$\begin{aligned} &= \frac{m^3 (\text{kgm}^{-1}\text{s}^{-2})}{m} \sqrt{\frac{\text{kgmol}^{-1}}{(\text{JK}^{-1}\text{mol}^{-1})(\text{K})}} \\ &= \text{kgms}^{-2} \sqrt{\frac{\text{kg}}{\text{kgm}^2\text{s}^{-2}}} \\ &= \text{kg s}^{-1} \end{aligned}$$

1b (i) Vernier callipers, zero error.

(ii)

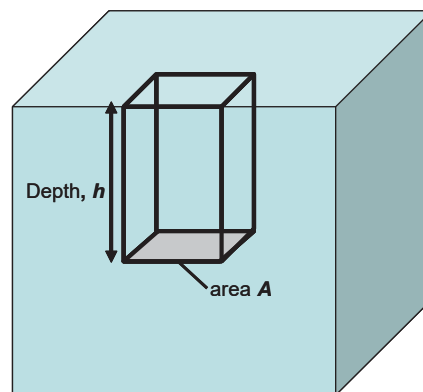
$$V = \frac{\pi D^2}{4} \times h = \frac{\pi (8.4)^2}{4} \times (21.5) = 1191.48 \text{ cm}^3$$
$$\frac{\Delta V}{V} = 2 \frac{\Delta D}{D} + \frac{\Delta h}{h} = 2 \frac{0.01}{8.4} + \frac{0.1}{21.5} = 0.0070321$$
$$\Delta V = 8 \text{ cm}^3$$
$$V = (1191 \pm 8) \text{ cm}^3$$

2 Pressure is defined as force acting per unit area, where the force F acts perpendicularly to the area A .

Density of a substance ρ is defined as the mass m per unit volume V .

[B1 – for correct definition of pressure and density]

Consider a point at a depth h below the surface of a liquid in a container.



The pressure can be determined by finding the weight of the column of liquid acting above a very small area at that depth. [B1- for stating of correct column of liquid]

The weight W of the column of liquid is:

$$W = m_{\text{liquid}} \cdot g = \rho_{\text{liquid}} V_{\text{liquid}} g = \rho_{\text{liquid}} h A g \quad [\text{B1}]$$

Therefore, the pressure p is: $P = \frac{\text{Force}}{\text{Area}} = \frac{W}{A} = \rho_{\text{liquid}} h g \quad [\text{B1}]$

[4]

3 (a) Mass [B1]

(b) Impulse of a force is defined as the product of force and time of impact, and is equal to the change in momentum. [B1]

(c) (i) By conservation of momentum,
total momentum just before firing = total momentum just after firing

$0 = \text{momentum of bullets} + \text{momentum of man}$
[C1- for stating zero initial momentum]

$$0 = 10 \times 1.0 \times 10^{-2} \times 750 - [90 - (10 \times 1.0 \times 10^{-2})] v \quad [\text{M1}]$$

$$v = 0.83426 \text{ m s}^{-1}$$
$$= 0.834 \text{ m s}^{-1} \quad [\text{A1}]$$

[Note: deduct one mark for i & ii if students did not consider reduction in mass due to bullets being shot out]

(ii) Let average force exerted on man be F

$$F\Delta t = \Delta p$$

$$F\Delta t = \text{mass of man} (\text{final velocity of man} - \text{initial velocity of man})$$

$$F(2.0) = [90 - (10 \times 1.0 \times 10^{-2})] (0.83426 - 0) \quad [\text{M1}]$$

$$F = 37.5 \text{ N} \quad [\text{A1}]$$

(iii) 1. Perfectly inelastic collision [B1]

2. Part of the loss in KE needs to account for the increase in gravitational potential energy of the block-bullet system besides the work done by frictional force. [M1]

Hence, the distance x would be shorter. [A1]

- 4 (a) (i) The light is unpolarized, so $I_1 = 1/2 I_0 = 16 \text{ W m}^{-2}$ [B1]
- (ii) When it emerges from the first polarizer the light is linearly polarized at 50° . The angle between this and the transmission axis of the second polarizer is 30° .

Therefore: using Malus Law,

$$\begin{aligned} I_2 &= 16 \cos^2 30^\circ. \text{ [M1]} \\ &= 16 * 0.75 \\ &= 12 \text{ W m}^{-2} \quad \text{[A1]} \end{aligned}$$

(b)

Two images of different perspectives from the same scene **are**
perpendicularly polarised and projected on the screen **simultaneously** B1

The viewer wears **glasses with left and right sides polarised**
perpendicularly to one another (aligned with the plane of polarization of B1
 image). **Each filter only allows light that are similarly polarised to pass**
through and block images in the perpendicular direction, so each eye sees a
 different image.

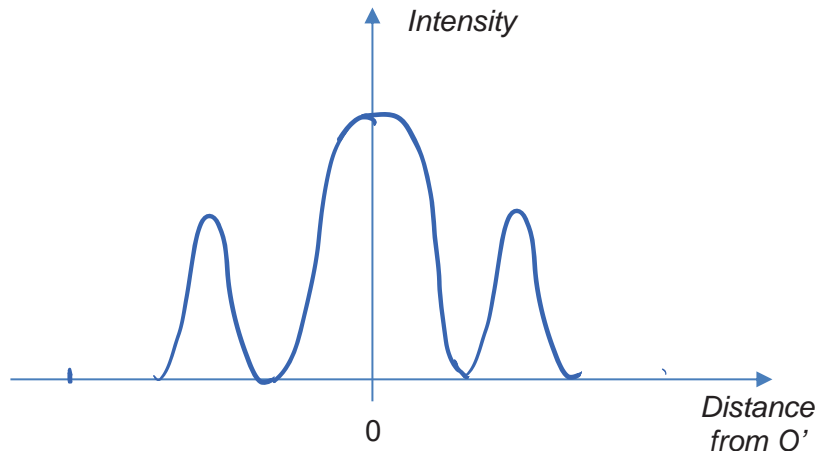
Hence, both eyes are able to see the same scene simultaneously but images are of slightly different perspectives, producing a 3D effect.

- 5 (a) The Principle of Superposition states that when two or more waves of the same kind overlap, the resultant displacement at any point at any instant is the vector sum of the displacements that the individual waves would have separately produced at that point and at that instant. (from notes) [B1]

(b) (i) **Coherent waves (from laser) emerging from the slits will meet at a point on the screen with a phase/path difference.** [B1]

When waves meet in phase with phase difference is $n(2\pi \text{ rad})$ / path difference is integer $\times \lambda$, constructive interference occurs. And at the points where the waves meet exactly out of phase (any equivalent explanation of minima e.g. $(n+1/2) \times 360^\circ$), destructive interference occurs. [B1]

(ii) 1. [1]



Student shows 3 maxims,
 Decreasing intensity
 Correct spacing
 Symmetrical about O'
 Any missing- minus 1 mark [B2]

2.

$$\sin \theta = \frac{\lambda}{b}$$

$$\sin \theta = (4.5 \times 10^{-7}) / (2.0 \times 10^{-6}) \text{ [M1]}$$

$$\theta = 13.0^\circ$$

$$\tan 13.0 = O'Y / 2.5 \quad \text{[M0]}$$

$$O'Y = 0.577 \text{ m} \quad \text{[A1]}$$

6 (a)

$$R = \rho \frac{l}{A}$$

$$= (9.0) \left(\frac{7.5}{23} \right) \quad \text{[M1]}$$

$$= 2.9 \Omega$$

$$I = \frac{V}{R}$$

$$= \frac{12}{2.9} \quad \text{[M1]}$$

$$= 4.1 \text{ A} \quad \text{[A1]}$$

(b) sodium ion = right; chloride ion = left [B1]

(c) Number density of charge carriers

$$= \left(\frac{1.7}{1000} \right) (6.02 \times 10^{23}) \quad \text{[M1]}$$

$$= 1.023 \times 10^{21} = 1.0 \times 10^{21} \text{ cm}^{-3} \quad \text{[A1]}$$

(d) $I = nAvq$

$$v = \frac{I}{nAq}$$

$$= \frac{(0.5)4.1}{(1.0 \times 10^{21})(23)(1.6 \times 10^{-19})} \quad [\text{M1}]$$

$$= 5.6 \times 10^{-4} \text{ cm s}^{-1} \quad [\text{A1}]$$

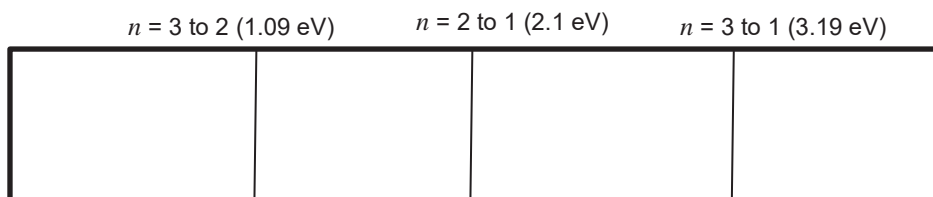
- (e) (i) As chloride ions form chlorine gas, the number density of charge carriers (or the number of charge carriers per unit volume) decreases. [M1]

Hence the current decreases. [A1]

- (ii) As the emf of the cell is constant, the net external electric field between the electrodes remains constant. [M1]

Hence the average drift velocity of the ions remains constant. [A1]

7 (a) (i)



[B1] - three spectral lines with labelled transitions

[B1] – correct relative positions

- (ii) Energy of incident electron = $3.19 + 0.24$ [M1]
 $= 3.43 \text{ eV}$ [A1]

(iii)

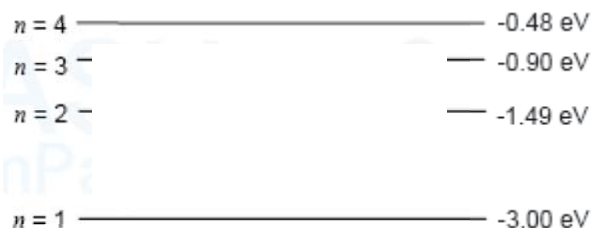


Fig. 7.4

The photons of energy 2.1 eV emitted from sodium/ emitted from de-excitation $n=2$ to $n=1$ of sodium, in discharged tube will be absorbed to cause excitation (from $n=1$ to $n=3$) in the cool gas. [B1]

As this gas de-excites (transition $n=3$ to 2 , $n=3$ to 1 and $n=2$ to 1), photons are emitted. While the **photons are re-emitted to produce three spectral lines, the intensity would be relatively weak**. Hence three faint lines are observed [B1]

The **other two photons of energy emitted by sodium gas** (from transitions $n=3$ to 1 and $n=3$ to 2) **will not be absorbed by the cool gas** and pass through resulting in two bright lines on the detector. [B1]

(b) (i) Electrons have a wave-like nature. [B1]

(ii)

Kinetic energy of electron at wall, $E_k = 600 \text{ eV} = 9.6 \times 10^{-17} \text{ J}$

Momentum of electron at wall, p

$$p^2 = 2mE_k$$

$$p = \sqrt{2(9.11 \times 10^{-31})(9.6 \times 10^{-17})} \text{ [M1]}$$

de Broglie wavelength λ of electron at wall

$$= \frac{h}{p}$$

$$= \frac{6.63 \times 10^{-34}}{1.32 \times 10^{-23}} \text{ [M1]}$$

$$= 5.01 \times 10^{-11} \text{ m}$$

$$d = \frac{\lambda D}{a}$$

$$= \frac{(5.01 \times 10^{-11})(0.240)}{272 \times 10^{-9}} \text{ [M1]}$$

$$= 4.42 \times 10^{-5} \text{ m} \text{ [A1]}$$

(ii) As accelerating potential increase, **velocity and momentum** of electron reaching the wall **increase**. Its **de Broglie wavelength decreases**, and hence the fringe separation of interference pattern decrease. [M1]

Distance d , the separation between the centres of adjacent bright spots, will **decrease**. [A1]

8 (a) The electric field strength at a point in an electric field is the electric force per unit positive charge on a small test charge placed at that point. [B1]

(b) $F_E = q \frac{V}{d} = ma$ [M1]

(i)
$$a = \frac{(1.6 \times 10^{-19}) \left(\frac{100}{0.50 \times 10^{-2}} \right)}{(9.11 \times 10^{-31})} = 3.5 \times 10^{15} \text{ m s}^{-2}$$
 [A1]

(ii) $v_y = u_y + a_y t$ [M1]

$2.3 \times 10^6 = 0 + (3.5 \times 10^{15})(t)$ [A1]

$t = 6.6 \times 10^{-10} \text{ m s}^{-1}$

(iii) Since electric force on electron is downwards, the magnetic force has to be directed upwards. [M1]

Using Fleming's LHR, the magnetic field is directed out of the page. [A1]

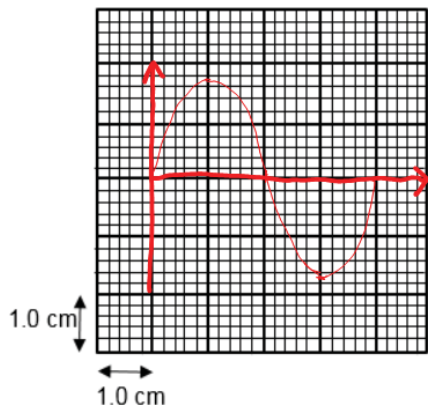
(v) 1. $100\pi = 2\pi f$

frequency = $100 / 2 = 50 \text{ Hz}$ [B1]

Period = $1/50 = 0.02 \text{ s}$

2. When $V_{\text{r.m.s.}} = 60 \text{ V}$,

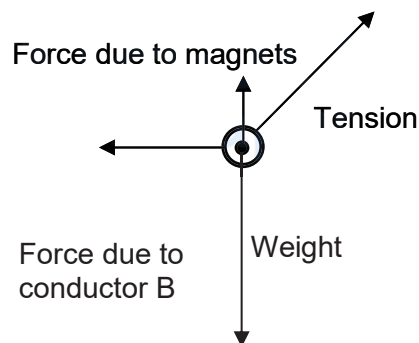
$V_0 = (\sqrt{2})(60) = 85 \text{ V}$



[B1] Calculation of V_0

[B1] Correct sketch

8 (c) (i)



For each force drawn, it must be labelled and of the correct length [B2]

(ii) $F = BIL = (3.2 \times 10^{-3})(5.0)(0.20) = 3.2 \times 10^{-3} \text{ N}$ [B1]

(iii) Magnitude of T_x = Magnitude of force due to conductor B [B1]

$$|T_x| = |BIL| = \frac{\mu_0 I}{2\pi d} (I)(L) = \frac{4\pi \times 10^{-7}}{2\pi(0.010)} (5.0)(5.0)(0.20)$$

$$= 1.0 \times 10^{-4} \text{ N}$$

$$T_y + F_{\text{magnets}} = mg$$

$$T_y = mg - F_{\text{magnets}} = \left(\frac{0.35}{1000} \times 9.81\right) - 3.2 \times 10^{-3} \quad [\text{B1}]$$

$$= 2.3 \times 10^{-4} \text{ N}$$

$$\text{Tension} = \sqrt{(1.0 \times 10^{-4})^2 + (2.3 \times 10^{-4})^2} = 2.54 \times 10^{-4} \quad [\text{B1}]$$

$$\tan\left(\frac{\theta}{2}\right) = \frac{T_x}{T_y} = \frac{1.0 \times 10^{-4}}{2.3 \times 10^{-4}}$$

$$\theta = 47^\circ \quad [\text{B1}]$$

(iv) The claim is false. The force due to the magnets acts downwards on the conductor **B**. Hence for the same tension, the mass of conductor **B** is less than **A**. [A1]
[M1]

At equilibrium, the sum of the weight and the force due to the magnets balances the vertical component of tension.

$$T \cos\left(\frac{\theta}{2}\right) = mg + F_{\text{magnets}}$$

$$mg = T \cos\left(\frac{\theta}{2}\right) - F_{\text{magnets}}$$

9 (a)

	alpha	beta	gamma
mass	$4u$	$1/1840u$	massless
nature	particle	particle	EM radiation
penetrating ability	Stopped by few cm of air	Stopped by few mm of aluminium	Stopped by few cm of lead

1 mark each for each property. Students must get both answer correct for each property to get that mark.

(b) (i) X: alpha

Y: gamma

Z: beta

Each mistake to deduct 1 mark.

- (ii) 1. Radiation **X** are emitted with the same KE/ energy. [A1]
2. Radiation **Z** are emitted with different speeds. [A1]
- (iii) If there are only two products produced during the decay process, the speed of radiation **Z** must be fixed. [B1]

Since radiation **Z** is emitted with varying speeds, by Principle of Conservation of Momentum and Energy, there must be a third particle produced in the decay process. [B1]

- (c) 1. The number of nuclear decays per unit time occurring in the source. [A1]
2. Time taken for half the original number of radioactive nuclei to decay. [A1]

- (d) (i) Activity, $A = 2 \text{ Bq}$

Since $A = \lambda N$ [M1]

$$\frac{\ln 2}{t_{1/2}} N = A$$

$$N = \frac{A t_{1/2}}{\ln 2} = \frac{(2)(1.42 \times 10^{19})}{\ln 2} = 4.1 \times 10^{19} \text{ particles} \quad [\text{M1}]$$

$$\text{Mass of } {}_{92}^{238}\text{U} = \frac{(4.1 \times 10^{19})(238)}{6.02 \times 10^{23}} \quad [\text{M1}]$$
$$= 1.6 \times 10^{-2} \text{ g} \quad [\text{A1}]$$

- (ii) By conservation of momentum, $m_{\alpha} v_{\alpha} = m_{\text{Th}} v_{\text{Th}}$ [M1]

$$\frac{1}{2} (m_{\alpha} v_{\alpha})^2 = \frac{1}{2} (m_{\text{Th}} v_{\text{Th}})^2$$

$$m_{\alpha} KE_{\alpha} = m_{\text{Th}} KE_{\text{Th}}$$

$$KE_{\text{Th}} = \frac{m_{\alpha}}{m_{\text{Th}}} KE_{\alpha} = \frac{4u}{234u} 4.18 = 0.0715 \text{ MeV} \quad [\text{M1}]$$

$$\text{Total energy released} = 0.0715 + 4.18 = 4.25 \text{ MeV} \quad [\text{A1}]$$

- (e) 1. The radioactive nuclide should have a short half-life. [B1]
2. The radioactive nuclide should produce gamma radiation during the decay process. [B1]



H2 Physics

9749/4

Paper 4 Practical

12 September 2017

2 hours 30 minutes

Candidate Name: _____

Class Reg Number

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READ THESE INSTRUCTIONS FIRST

Write your name, class and index number 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** the questions.

You are allowed 1 hour to answer Questions 1 and 2; and you are allowed another 1 hour to answer Question 3.

Question 4 is a question on the planning of an investigation and does not require apparatus.

Write your answers in the space provided in 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, Question 1&2, Question 3, Question 4 are to be submitted separately.

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

Shift	
Laboratory	

Examiner's Use	
1	
2	
3	
4	
Total	/55

1 In this experiment, you will investigate the equilibrium of a wooden rule.

(a) (i) Attach masses to the apparatus as shown in Fig. 1.1.

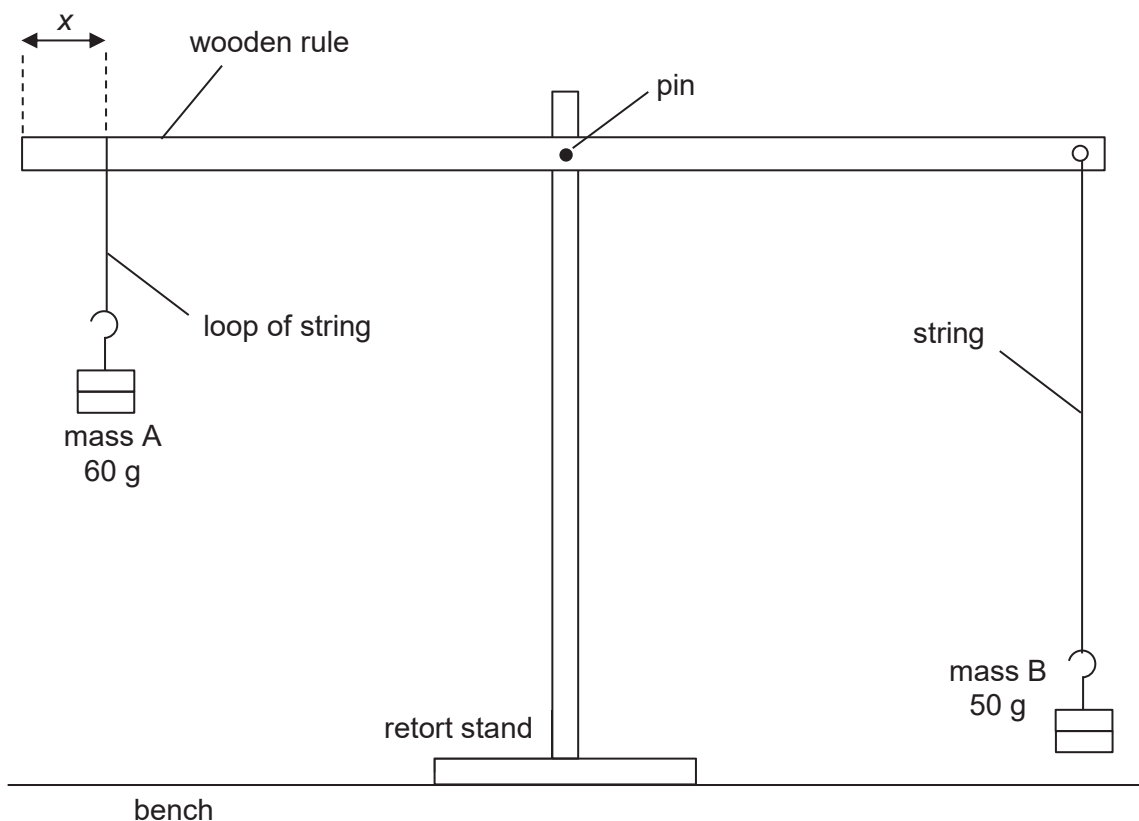


Fig. 1.1

Mass A is suspended from the wooden rule using a loop of string. The distance between the loop of string and the nearest end of the wooden rule is x .

(ii) Change x until the wooden rule is balanced and approximately parallel to the bench. Measure and record x .

$x = 9.3 \text{ cm}$ [1]
Accepted range: up to 15 cm

- (b) (i) Remove both masses. Clamp the pulley to the retort stand using two wooden blocks.

Thread the string for mass B over the pulley, and then attach the masses again, as shown in Fig. 1.2.

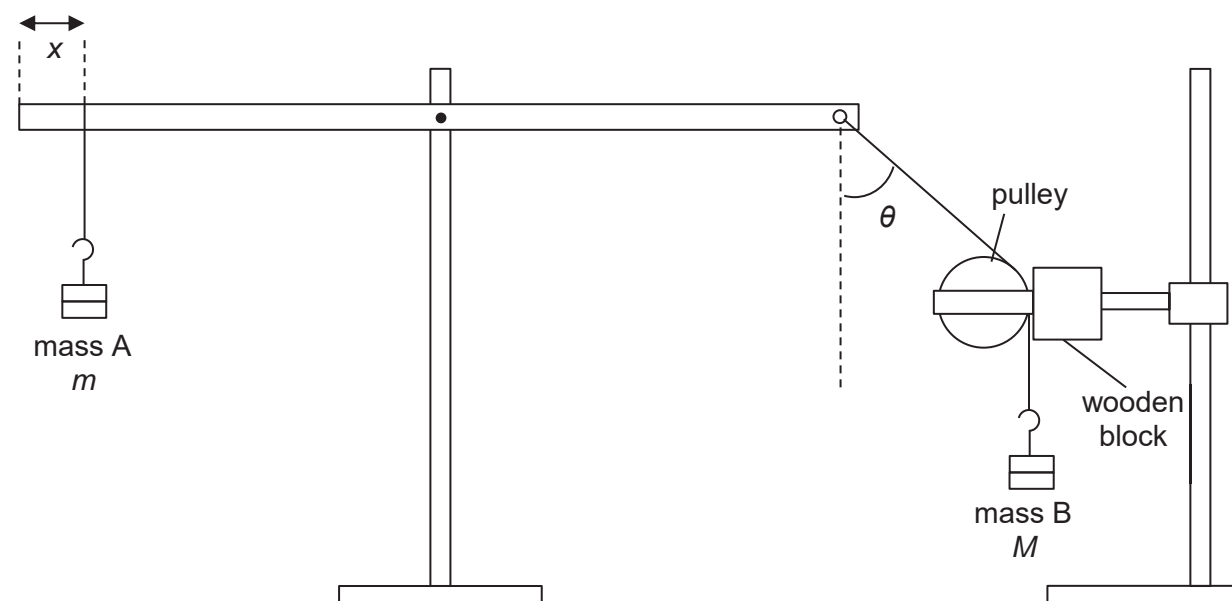


Fig. 1.2

- (ii) Transfer 10 g from mass A to mass B.
- (iii) With x at the same value as (a)(ii), adjust the position of the pulley until the wooden rule is approximately parallel to the bench.

Measure and record the angle θ that the string for mass B makes with the vertical, as shown in Fig. 1.2.

$$\begin{aligned}\theta_1 &= 47^\circ \\ \theta_2 &= 47^\circ \\ \langle \theta \rangle &= 47^\circ\end{aligned}$$

$$\theta = \underline{47^\circ} \quad [1]$$

*evidence of repeated readings
 θ presented to the nearest degree*

- (iv) Estimate the percentage uncertainty in your value of θ .

$$\begin{aligned}\text{Percentage Uncertainty} &= \frac{\Delta\theta}{\theta} \times 100\% \\ &= \frac{3}{47} \times 100\% = 6.4\% \quad (2 \text{ s.f.})\end{aligned}$$

$$\text{percentage uncertainty} = \underline{6.4\%} \quad [1]$$

*$\Delta\theta$ (2 to 5 degrees, to 1 s.f.)
Percentage uncertainty to 2 s.f.*

(v) Record the mass m of mass A and mass M of mass B.

$$m = 50 \text{ g}$$

$$M = 60 \text{ g} \quad [1]$$

(vi) Calculate the value of $\frac{m}{M}$.

$$\frac{m}{M} = \frac{50}{60} = 0.83$$

$$\frac{m}{M} = 0.83 \quad [1]$$

(c) It is suggested that the $\cos \theta$ is directly proportional to $\frac{m}{M}$.

Take further measurements to investigate this suggestion and explain whether your results support the suggested relationship.

Present your measurements and calculated results clearly.

Collection of data and calculation of k (with correct sf and units):

$$\frac{m}{M} \propto \cos \theta$$

$$\therefore \frac{m}{M} = k \cos \theta \text{ where } k \text{ is a constant of proportionality}$$

m / g	M / g	$\theta_1 / ^\circ$	$\theta_2 / ^\circ$	$\langle \theta \rangle / ^\circ$	$\frac{m}{M}$	$\cos \theta$	K
50	60	47	47	47	0.83	0.68	1.22
50	70	56	55	56	0.71	0.56	1.27

Criterion: Results support the suggested relationship if percentage difference of k is smaller than percentage uncertainty of θ of 6.4% (or student's stated criterion)

Calculation of % difference:

$$\begin{aligned} \text{Percentage difference of } k &= \frac{1.27 - 1.22}{1.22} \times 100\% \\ &= 4.1\% \end{aligned}$$

Conclusion:

Since the percentage difference of k is smaller than percentage uncertainty of θ of 6.4, hence the result supports the suggested relationship.

.....

[4]
[Total: 9 marks]

- 2 The resistance of a light-dependent resistor (LDR) changes when it is illuminated with light of different intensities.

In this question, you will investigate how the light detected by a LDR depends on the thickness of an absorber.

- (a) (i) Connect the circuit shown in Fig. 2.1. The light-emitting diode (LED) should be connected the right way round so that light is emitted.

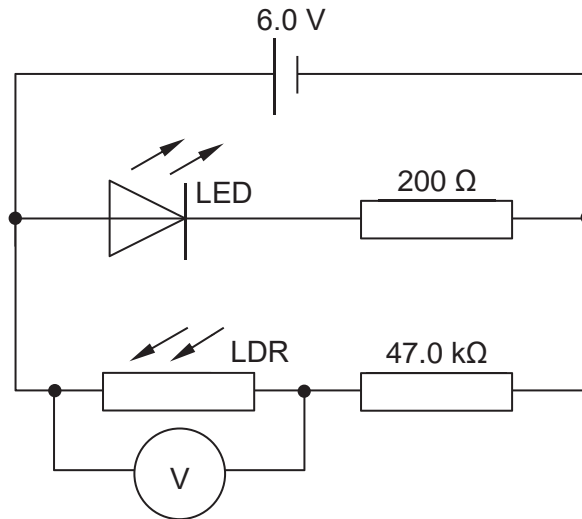


Fig. 2.1

- (ii) You are provided with a black straw of approximate length of 4 cm.
 (iii) Use the straw and clear adhesive tape to make a cylinder that fits neatly over the LDR and LED.

Cut the cylinder into two halves of approximately 2 cm each and fit the 2 cylinders over the LDR and LED, as shown in Fig. 2.2.

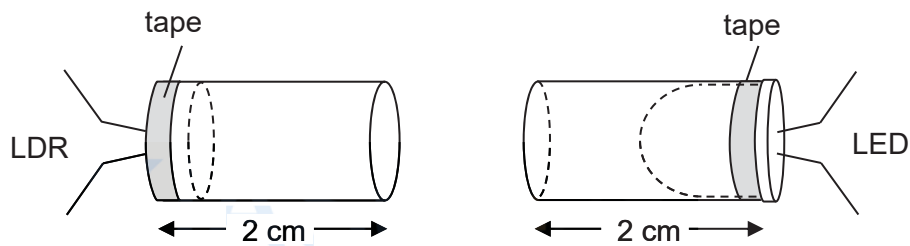


Fig. 2.2

- (b) Place the cylinders together, as shown in Fig. 2.3.

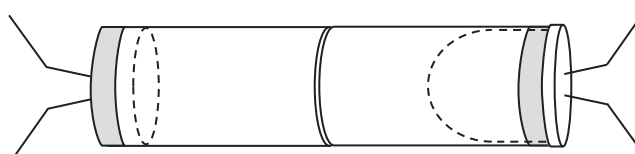


Fig. 2.3

Record the voltmeter reading V_0 .

$$V_0 = \underline{0.28 \text{ V}} \quad [2]$$

Accept up to 3.0 V (cannot be negative)

Correct d.p and units

(c) Fold the sheet of tracing paper in half four times so that you have 16 layers.

(i) Measure and record the thickness of these 16 layers.

$$d_1 = 1.00 \text{ mm}$$

$$d_2 = 0.97 \text{ mm}$$

$$\langle d \rangle = 0.99 \text{ mm}$$

$$\text{thickness of 16 layers} = \underline{0.99 \text{ mm}} \quad [1]$$

Repeated readings

Correct d.p and units

Accepted range: 0.5 mm to 5 mm

(ii) Determine the thickness t of one layer of tracing paper.

$$\begin{aligned} t &= \frac{\langle d \rangle}{16} \\ &= \frac{0.99}{16} \\ &= 0.062 \text{ mm} \end{aligned}$$

$$t = \underline{0.062 \text{ mm}} \quad [1]$$

Correct calculation with correct sf and units

(iii) Estimate the percentage uncertainty in your value of t .

$$\text{Since } t = \frac{\langle d \rangle}{16} \quad \therefore \frac{\Delta t}{t} = \frac{\Delta d}{d}$$

$$\begin{aligned} \text{Percentage Uncertainty} &= \frac{\Delta d}{\langle d \rangle} \times 100\% \\ &= \frac{0.02}{0.99} \times 100\% \\ &= 2.0\% \text{ (2 s.f.)} \end{aligned}$$

$$\text{percentage uncertainty} = \underline{2.0\%} \quad [1]$$

$\Delta d \geq 0.02 \text{ mm}$ (accept up to 0.05 mm) for 16 layers (to 1 s.f.)

Percentage uncertainty to 2 sf

- (d) (i) Place four layers of tracing paper between the LED and the LDR as shown in Fig. 2.4.

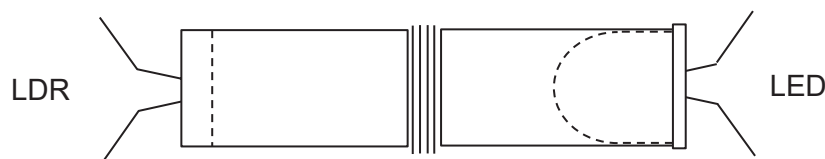


Fig. 2.4

Record the voltmeter reading V .

$$V = 1.29 \text{ V} \quad [1]$$

Correct dp and units

- (ii) Repeat (d)(i) using eight layers of tracing paper.

$$V = 2.15 \text{ V} \quad [1]$$

Correct dp and units
 $V_0 < V(\text{di}) < V(\text{dii})$

- (e) (i) State and explain two significant sources of error or limitations of the procedures for this experiment.

Any two of the following

- 2 readings not enough (to draw a conclusion)
- Alignment of LDR and LED (not just alignment of cylinder)
- Stray light coming in because the cylinders are not sealed / external light hits LDR
- Difficult to hold all together therefore voltage reading fluctuates
- Separation between LED and LDR changes as paper is added.

[2]

- (ii) Suggest two improvements that could be made to the experiment and explain how this addresses the errors identified in (e)(i). You may suggest the use of other apparatus or a different procedure.

Corresponding improvements

- Take many readings and plot a graph / find many values of k
- Guide used / line on desk / adjust LED/LDR to get max voltage / method of fixing LED/LDR in cylinder
- Dark room / black cloth over / lights off and curtains drawn / black box / black tape
- Method of fixing. Eg, clamp/plasticine / tape
- Pre-slots in tube

[2]

Do not allow:

- 'varying thickness of paper, scratches on tracing paper, zero error on micrometer'
- 'repeated readings, parallax error'
- 'use a computer to improve the experiment'

Ignore separation of layers affects light getting through and squashing of paper for micrometer reading.

- (f) Suggest changes that could be made to the experiment to investigate how the light detected by a LDR depends on the angle between the polarising axes of a pair of polarizing filters.

You may assume that a pair of *unmarked* polarizing filters is available.

You may draw a diagram to show how the apparatus would be arranged.

- Replace the tracing paper with 2 polarising filters
- Mark the axis where the polarizing filters give the minimum V reading. Polarising axes of the 2 polarisers are parallel at this angle.
- Vary angle between polarizing axes and measure the angle with a protractor.

.....

.....

.....

..... [3]

[Total: 14 marks]

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Turn over for Question 3

Candidate Name: _____ () Class: _____

- 3 In this experiment you will investigate the relationship between the current in a copper wire and the orientation of a magnet suspended near to the copper wire. The magnet (with a pointer attached) has been suspended as shown in Fig. 3.1.

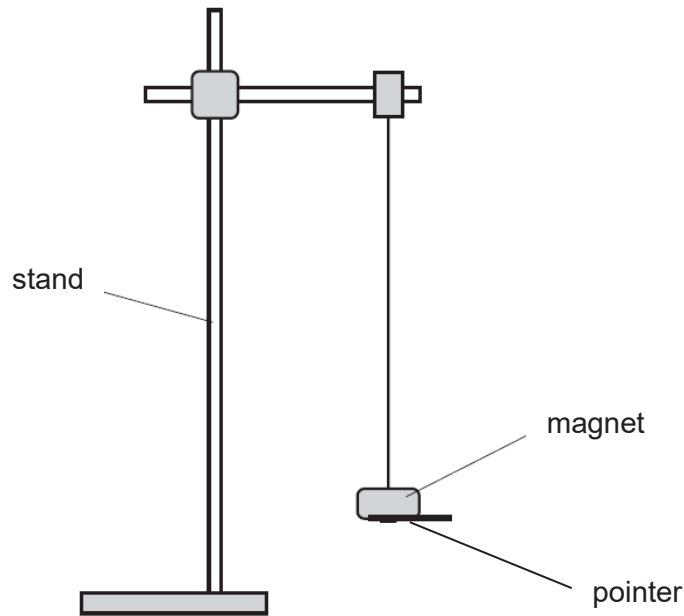


Fig. 3.1

A piece of straight copper wire has been taped to one edge of a 50 cm rule and a protractor attached to the centre of the rule. You should not disturb the copper wire or the protractor from their positions on the rule during the course of the experiment.

- (a) (i) Set up the circuit shown in Fig. 3.2.

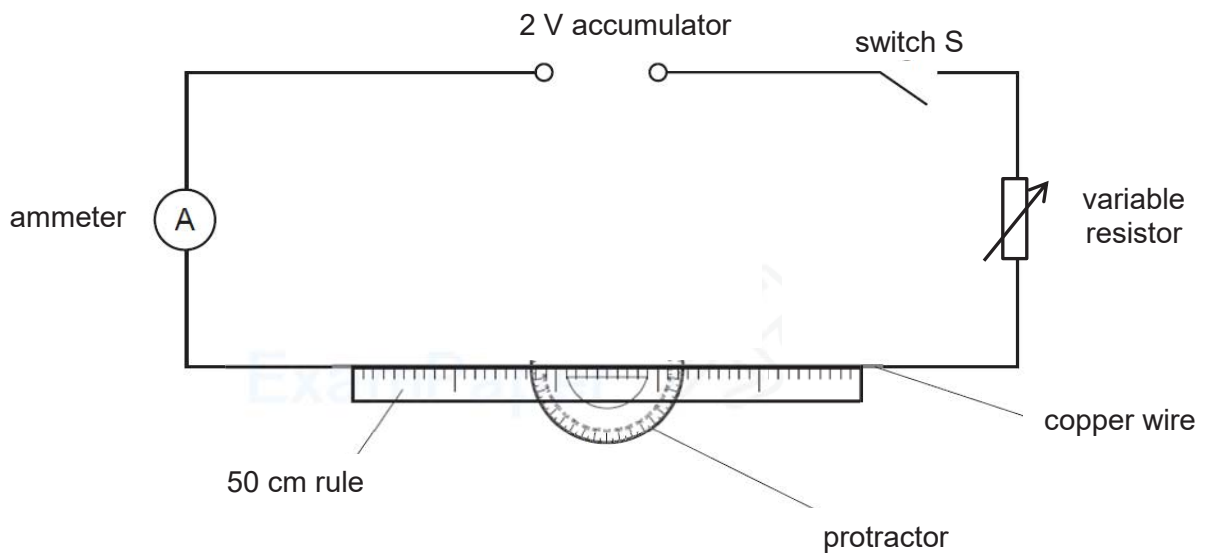


Fig. 3.2

- (ii) Place the rule just below the magnet such that the pointer is at most 5 mm above the top of protractor. The pointer should be perpendicular to the wire and the centre of the protractor directly below the point of suspension. The arrangement is shown in Fig. 3.3.

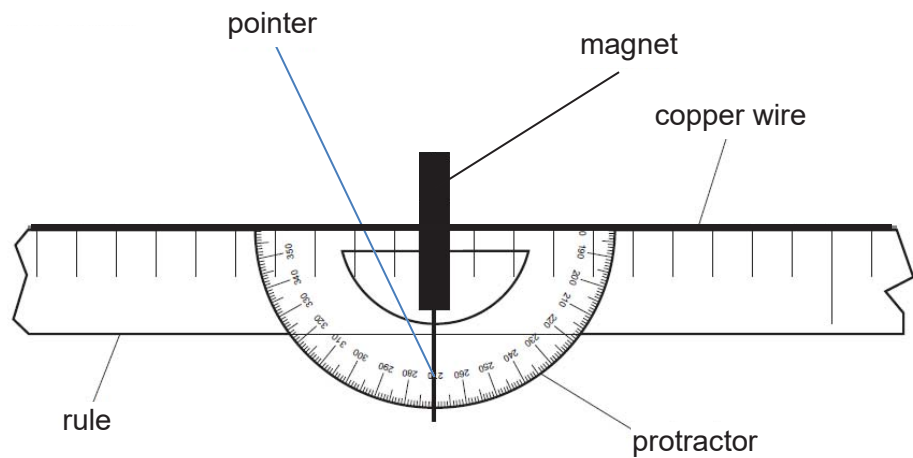


Fig. 3.3 (top view)

- (iii) Close switch S.
- (iv) Adjust the current until the pointer shows a measurable deflection. Slow down the motion of the magnet by touching it. When the pointer is steady, measure and record the angle of deflection θ and the current I .

$$\theta = \frac{8 + 8}{2} = 8^\circ$$

$$\theta = \underline{8^\circ}$$

$$I = \underline{1.34 \text{ A}} \quad [1]$$

[1] – correct dp with units

- (v) Estimate the percentage uncertainty of θ .

$$\frac{\Delta\theta}{\theta} = \frac{2}{8} \times 100\% = 25\%$$

[1] – correct sf, $2^\circ \leq \Delta\theta \leq 4^\circ$ due to oscillation of magnet

$$\text{percentage uncertainty of } \theta = \underline{25\%} \quad [1]$$

- (vi) Vary the resistance of the variable resistor and repeat (iv) to obtain further sets of readings for θ and I . The current should not exceed about 4 A.

$\theta_1 / ^\circ$	$\theta_2 / ^\circ$	$\theta_{ave} / ^\circ$	I / A	$\tan \theta$
8	8	8	1.34	0.14
11	10	11	2.05	0.194
17	17	17	2.70	0.306
20	19	20	3.35	0.364
21	22	22	3.98	0.404
28	28	28	4.80	0.532

- [2]- 6 sets of readings without assistance
 [1]- repeated reading
 [1]- heading and units
 [1]- d.p. of raw data
 [1]- correct sf
 [1]- correct calculations

[7]

- (vii) Open switch S.

- (b) The formula which relates θ and I is

$$\tan \theta = A I + B$$

where A and B are constants.

Plot a graph to determine the values of A and B.

Plot a graph of $\tan \theta$ against I . If the equation is valid, a straight line graph with gradient A and vertical intercept B will be obtained.

$$\text{Gradient} = \frac{y_2 - y_1}{x_2 - x_1} = 0.11$$

$$A = 0.11 \text{ A}^{-1}$$

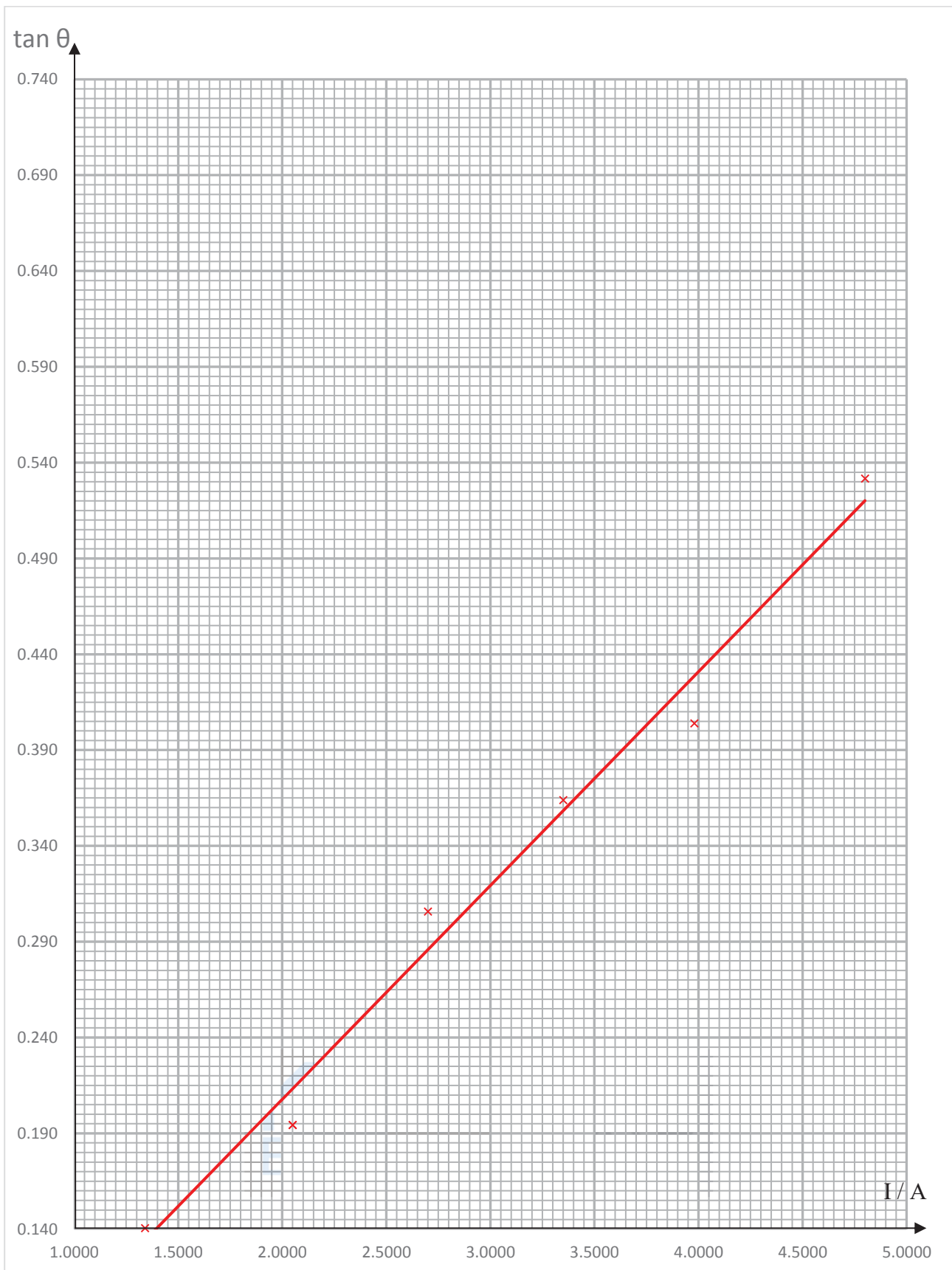
$$\text{Intercept} = -0.015$$

$$B = -0.015$$

- [1]- Statement
 [1]- gradient
 [1]- A with correct units and sf
 [1]- B (no units) with correct sf

$$A = \dots\dots\dots$$

$$B = \dots\dots\dots [4]$$



[1]- Axis labelled with units, good scale
 [1]- correctly plotted points
 [1]- Best fit line

[3]

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

[1]- Correct identification and explanation of any anomalous point [1]

- (d) (i) Use the results from your experiment to calculate a value for θ when the current in the copper wire is 15 A.

$$\tan \theta = 0.11 (15) + (- 0.015)$$

$$\theta = 59^\circ$$

[1]- value calculated correctly

$$\theta = \underline{59^\circ} \quad [1]$$

- (ii) Give one reason why it may be difficult to verify this experimentally.

Any one of the following:

- Heating problem with wire
- Fuse may blow if max current is exceeded
- Do not allow vague answers such as it is dangerous

[1] Possible reason stated

..... [1]

- (e) It is known that constant A is affected by the magnetic flux density due to the wire. On the graph grid on page 12, sketch a second graph to represent the results if distance between the magnet and the wire is increased. Label this graph Z. [1]

$$\tan \theta = A I + B$$

Increasing distance will reduce magnetic flux density. Though it is not stated how A will be affected by reduction in flux density, however it should be deduced that when flux density is very small, $\tan \theta$ will be a constant. Hence A should approach zero.

[1]- smaller gradient but same intercept.

[Total: 20 marks]

Candidate Name: _____ () Class: _____

- 4 Each of the propellers on a drone consists of two or more blades connected to a motor shaft. As the motor rotates air is drawn through the blades. This results in a thrust on the propeller, hence lifting the drone. Fig. 4.1 shows a propeller used in a drone. The speed of rotation of the motor is determined by the power supply it is connected to.

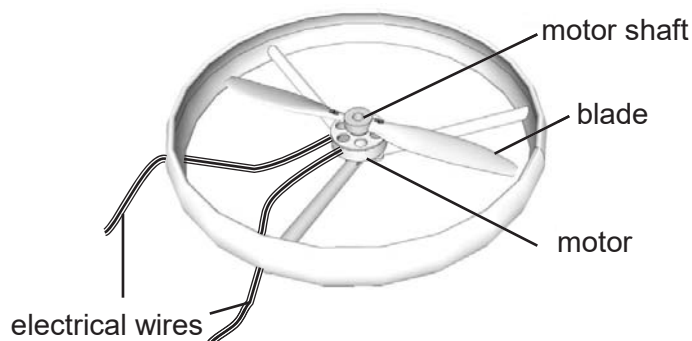


Fig. 4.1

A student suggests that the average thrust T on the propeller depends on the rotational speed ω of the blade, the blade angle θ , and the density of air.

The relation between the average thrust T , ω , and θ may be written in the form

$$T = k\omega^a \sin^b \theta$$

where k , a , b are constants.

You are provided with the following apparatus.

- a number of propellers with different blade angles indicated,
- tachometer (an instrument that measures the rotational speed of a shaft)
- electronic balance

You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine the values of k , a , b .

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

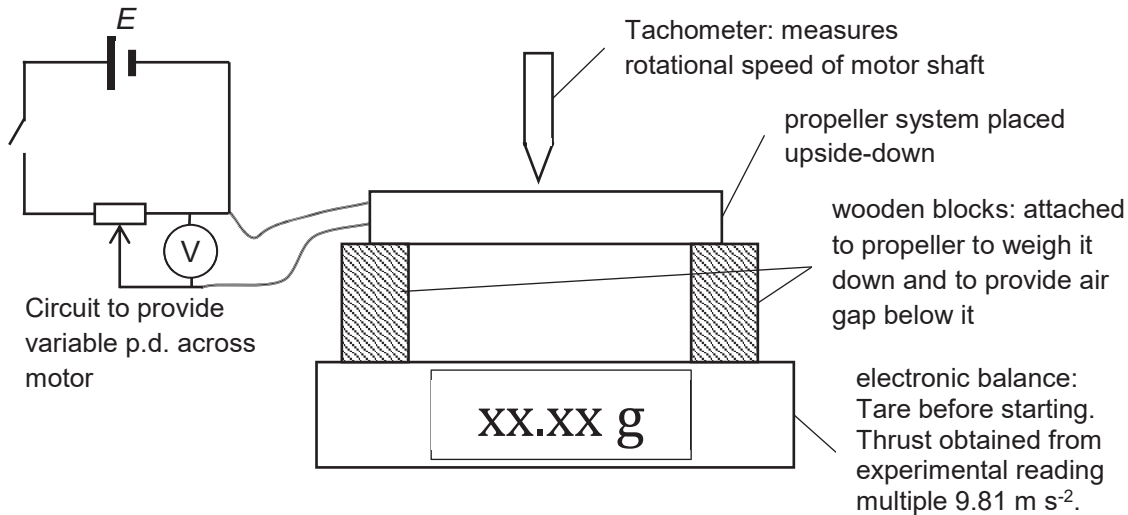
- (a) the identification and control of variables,
- (b) the equipment you would use,
- (c) the procedures to be followed,
- (d) how the values of k , a and b are determined from your readings,
- (e) any precautions that would be taken to improve the accuracy and safety of the experiment.

[Total: 12 marks]

Q4 Proposed Mark Scheme

Annotation	Rubrics	Max	Actual
Diagram (D)	(D1) Labelled diagram showing connection of propeller to a workable circuit. Propeller is placed on an electronic balance.	1	
Basic Procedure (BP)	(BP1) By varying rotational speed ω and blade angle θ <u>independently</u> , obtain and <u>measure</u> different values of thrust T to obtain at least <u>6 sets of readings each</u> .	1	
Control (C)	(CV1) Maintain <u>density</u> of air by <u>keeping temperature of room constant</u> . Achieve by conducting experiment in <u>temperature-controlled room</u> (e.g. air-conditioned room). (CV2) Keep rotational speed ω constant (for M2) by measuring ω and varying the voltage to achieve required ω .	1	
Methods of Measurement (M)	(M1) Keeping <u>blade angle θ constant</u> , vary rotational speed ω by <u>changing voltage</u> (e.g. varying power supply or rheostat) across motor. <u>Measure ω using a tachometer</u> . Record the rotational speed. (M2) Keeping <u>rotational speed ω constant (by keeping voltage constant)</u> , vary blade angle θ by <u>using propeller of different blade angles</u> . Record the angle. (M3) Place propeller on electronic balance and tare before turning on power. Turn on power and take balance reading m . Thrust is given by magnitude of mg .	3	
Analysis (A)	(A1) Plot a suitable graph of $\lg T$ vs $\lg \omega$ (<u>keeping θ constant</u>). gradient = a ; vertical-intercept = $b \lg(\sin \theta) + \lg k$ (A2) Plot a suitable graph of $\lg T$ vs $\lg(\sin \theta)$ (<u>keeping ω constant</u>). gradient = b ; vertical-intercept = $a \lg \omega + \lg k$ (A3) Obtain k by taking average of k values from (A1) and (A2).	3	
Reliability of Experiment (R) Method and reason	(R1) <u>Elevate</u> the propeller so as <u>not to obstruct air flow</u> during operation. (R2) <u>Using different θ and ω</u> to obtain several <u>a, b, and/or k</u> . Find <u>average</u> of the constants. (R3) When varying ω first <u>find the maximum ω</u> that will cause propeller to lift off / spin out of control. Maximise datasets of ω within this range. (R4) Place propeller upside-down so that the air will be push out from the top when turned on. To prevent air from exerting force on balance.	2	
Safety (S)	(S1) <u>Do not touch the propeller</u> when it is rotating to <u>avoid getting cut by blade</u> . (S2) <u>Weigh down propeller</u> (e.g. using heavy wood blocks) so that it <u>does not spin out of control</u> when turned on causing damage to equipment.	1	
Total		12	

Diagram: [D1]



Independent variable: Blade angle θ and rotational speed ω

Dependent variable: Thrust T

Control variables: Density of air

Procedure:

1. Conduct the experiment in a temperature-controlled room (e.g. air-conditioned room) so as to keep the temperature constant in order to maintain the density of air. [CV1]
2. Set up the apparatus as shown in the diagram above.
3. To prevent air drawn by propeller from exerting force on balance, the propeller should be placed upside-down so that the air will be push out from the top when turned on. [R4]

Vary ω , keeping θ constant

4. Record down the angle $\theta_{constant}$ of the blade.
5. Close the switch and increase voltage across the motor by adjusting the rheostat until just before the whole propeller spins out of control. Using the tachometer find this maximum rotational speed ω_{max} . [R3]
6. Open the switch. Tare the electronic balance.
7. Close the switch. By varying the voltage across the motor using the rheostat, obtain a lower value of rotational speed ω . Measure this with a tachometer and record it down. [M1]
8. Take the magnitude of reading m shown on the electronic balance. The thrust T can be obtained by $T = mg$, where g is the acceleration of freefall. [M3]
9. Repeat steps 6 to 8 for total of six sets of data by varying ω through adjusting voltage and using the same blade angle $\theta_{constant}$. Maximise the range between 0 and ω_{max} .

Vary θ , keeping ω constant

10. Select a rotational speed $\omega_{constant}$ from previous part.
11. Change the propeller to be of blade angle θ . Record it down. [M2]
12. Tare the electronic balance.

13. Close the switch. Using the tachometer to measure the rotational speed, adjust the voltage until the rotation speed is at $\omega_{constant}$. **[CV2]**
14. Take the magnitude of reading m shown on the electronic balance. The thrust T can be obtained by $T = mg$, where g is the acceleration of freefall. **[M3]**
15. Repeat steps 11 to 14 for total of six sets of data by changing the propeller for different blade angle θ and using the same rotational speed $\omega_{constant}$.

Analysis

16. Using data from varying ω (θ constant), plot a straight line graph of $\lg T$ vs $\lg \omega$. The gradient will give a and the vertical intercept will give $b \lg(\sin \theta) + \lg k$ **[A1]**
17. Using data from varying θ (ω constant), plot a straight line graph of $\lg T$ vs $\lg (\sin \theta)$. The gradient will give b and the vertical intercept will give $a \lg \omega + \lg k$ **[A2]**
18. k can be obtained from the vertical intercept of steps 16 and 17. **[A3]**
19. Using different θ and ω to obtain several a , b , and k . Find average of the constants. **[R2]**

Safety Precaution

- Do not touch the propeller when it is rotating as it might cut. **[S1]**
- Weigh down the propeller so that it does not spin out of control causing damage to equipment. **[S2]**

