Anglo-Chinese Junior College

JC2 Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

PHYSICS **9749**

Paper 1 Multiple Choice

29 August 2017
1 hours

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your Name and Index number in the answer sheet provided.

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 separate Answer Sheet.

Read the instructions on the Answer sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this Question Paper.

For Examiner's Use

DATA AND FORMULAE

Data

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

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Formulae

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

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For Examiner's Use

1 Which of the following gives the best estimate of the typical cruising speed of a 300-seater commercial passenger aircraft?

A 1,000 km h^{-1}

B 1,500 km h^{-1}

C 2,000 km h^{-1}

D 2,500 km h^{-1}

2 A student measured the diameter of a coin using a vernier calipers and found it to be
(5.06 ± 0.04) mm.

Which if the following procedures will most significantly reduce the fractional uncertainty when determining the diameter of a coin?

A Use a micrometer screw guage and take one reading

B Account for the zero error of the vernier calipers and take one reading

C Taking six readings using the vernier calipers and take the average of the readings

D Measure the diameter of the three identical coins placed side by side and divide the reading by three

3 A car accelerates uniformly from rest and reaches a speed of 30 m s^{-1} in 50 m.

If the car continues to accelerate at the same rate, what is the time taken for it to travel another 250 m?

A 4.8 s **B** 7.5 s **C** 11.5 s **D** 14.6 s

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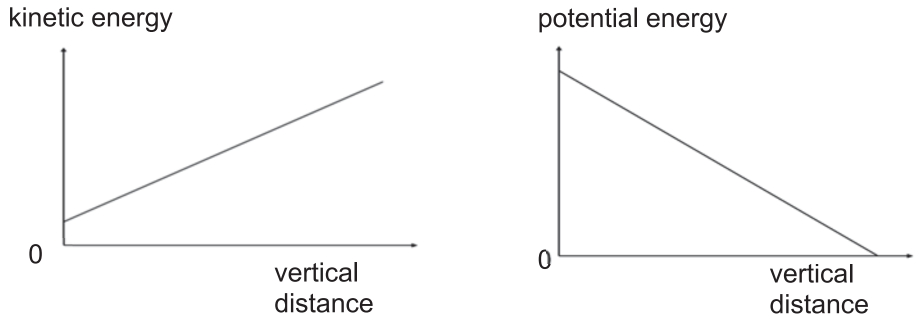
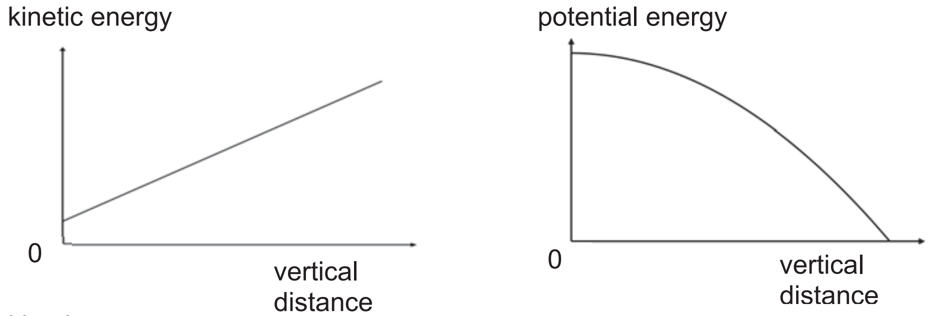
4 A stone was projected horizontally off a cliff as shown.

Ignoring air resistance, which graphs show the variation of kinetic energy and gravitational potential energy with the vertical distance?

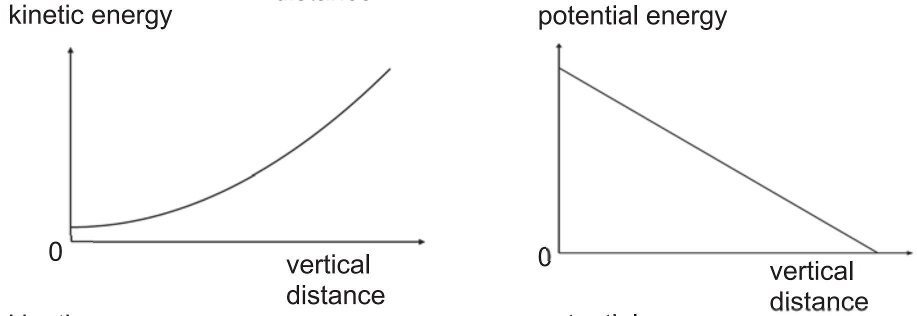
A



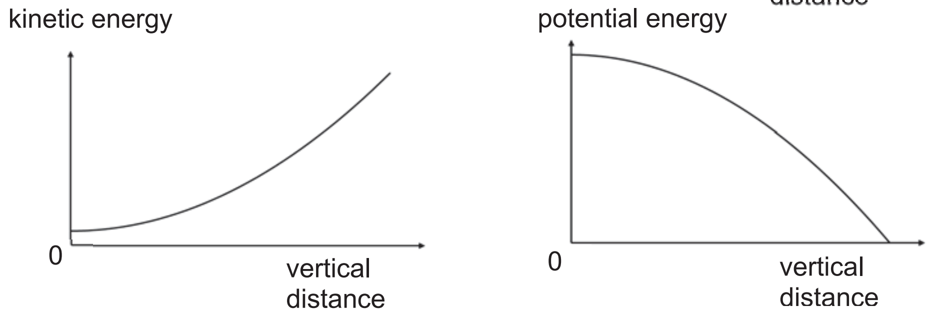
B



C



D



5 Box R of mass 5.00 kg rests on the smooth horizontal top of a trolley. Two strings

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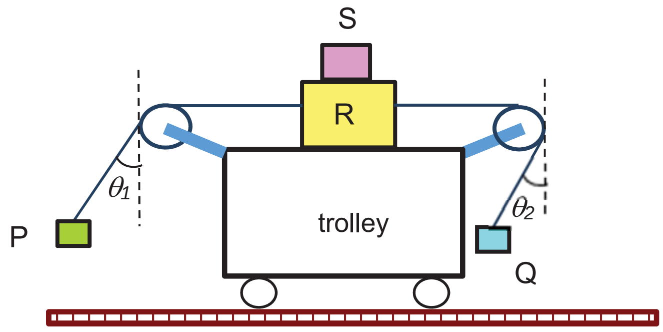
are attached to boxes P and Q of masses 2.00 kg and 3.00 kg respectively and the strings passes over two smooth pulleys. Box S of 0.50 kg mass rests on top of the box R. Frictional force F exist between the contact surfaces of R and S.



(Not drawn to scale)

There is no relative motion between the 4 boxes and the trolley, and the acceleration a of the system is 2.0 m s^{-2}.

Which of the following is correct?

	relationship between θ_1 and θ_2	direction of F on R
A	$\theta_1 > \theta_2$	left
B	$\theta_1 < \theta_2$	right
C	$\theta_1 > \theta_2$	right
D	$\theta_1 = \theta_2$	left

For Examiner's Use

6 Two identical smooth spheres X and Y have masses *m* and *3m* with charges *+q* and *+2q* respectively. They are projected on a smooth horizontal plane with speeds *2v* and *v* respectively towards each other and collided elastically. Fig. 6(a) shows a head-on collision. Fig. 6(b) shows an oblique collision.

Effects due to air resistance can be neglected.

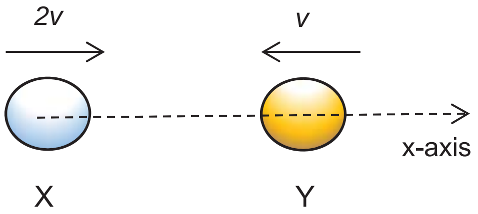


Fig. 6(a)

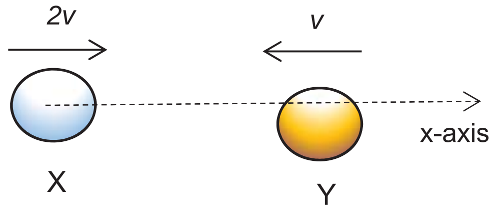


Fig. 6(b)

Which of the following is definitely correct?

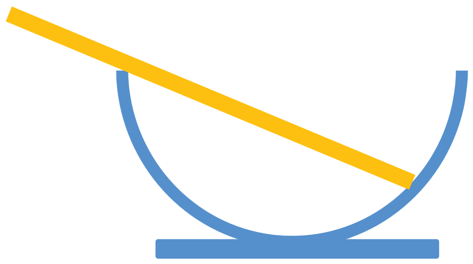
A As the spheres are both positively charged, due to repulsive force on each, they will not collide.

B In the oblique collision, the total momenta after impact is not along the x-axis, and the total kinetic energies after impact is less than 3.5 mv^2.

C In the head-on collision, at the distance of closest approach, both the spheres are at rest.

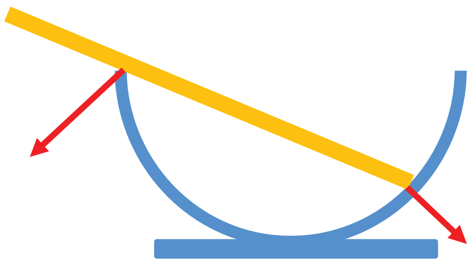
D If the spheres are incompressible, the total momenta after impact is *mv* to the left, and the total kinetic energies is equal to 3.5 mv^2.

7 A uniform smooth rod is resting on a smooth empty hemispheric bowl as shown below.

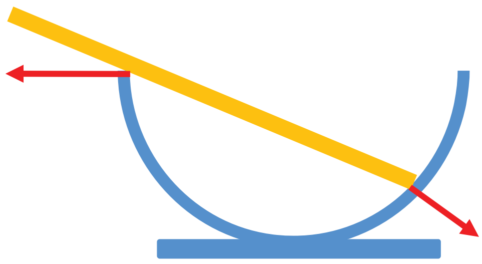


Which of the diagrams best shows the direction of the forces exerted by the rod on the bowl?

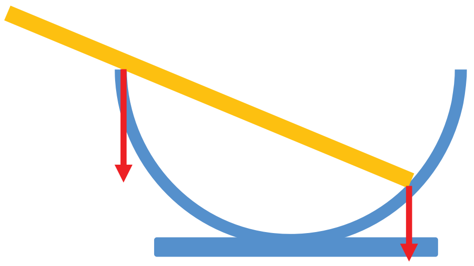
A



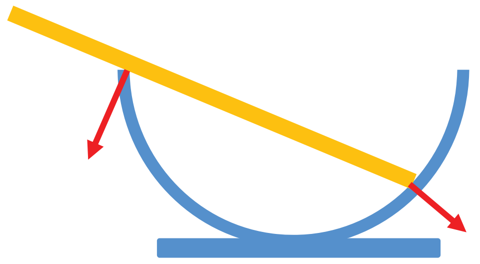
B



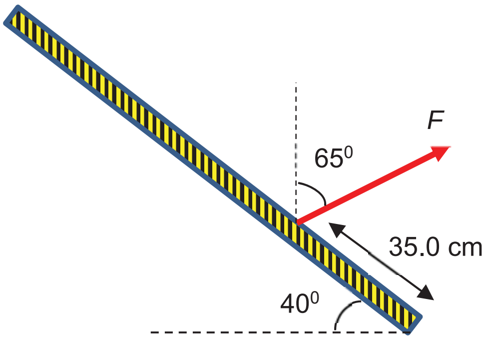
C



D



8 As shown in the figure below, a 2.0 m long uniform fishing rod has a mass of 126 g. With his right hand, the man grips the handle at a distance 35.0 cm from one end of the rod and exerts a force *F* at an angle 65° from the vertical. The fish is 500 g and hangs motionless at the other end or the rod.



Source: www.123RF.com

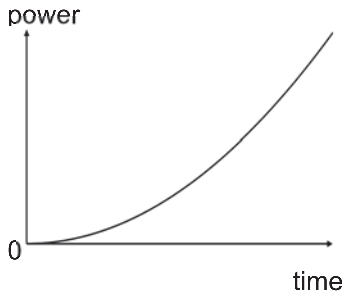
Which of the following is the value of *F*?

A 2.7 N **B** 3.0 N **C** 14.5 N **D** 26.7 N

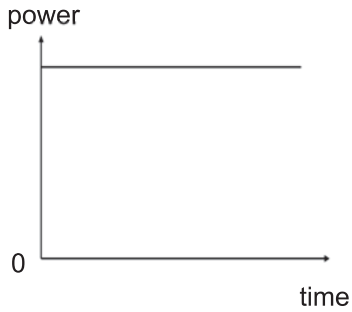
9 A constant force is applied on a box resting on a frictionless surface.

Which of the following graphs best represent the variation of power supplied with time?

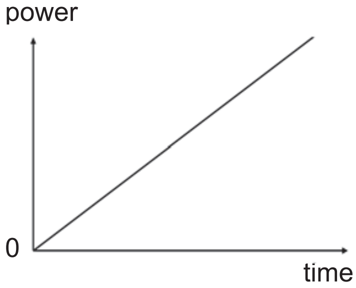
A



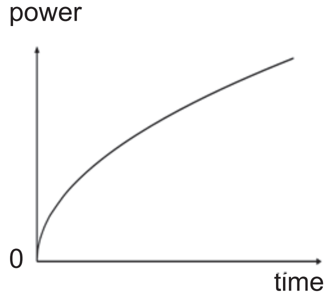
B



C



D



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10 The table lists four situations and the corresponding resultant forces acting on a man which provide him with a centripetal force during circular motion.

Which is incorrect?

	situation	resultant force on man
A	Man at the three o'clock position of a ferris wheel	Horizontal component of contact force of chair on man
B	Man onboard the international space station	Weight of man
C	Man on a motorbike during a turn	Frictional force of road on wheel
D	Man is upside down in a jet plane which is making a loop	Sum of normal contact force of chair on man and weight of man

11 In a system of Earth and Moon, which of the following is true?

A The common centre of mass of the system has net gravitational field strength of zero.

B The total gravitational potential is zero at the common centre of mass of the system.

C The change in potential energy in bringing a unit mass from infinity to a point between Earth and Moon is positive.

D The Moon orbits around a point near the centre of the Earth.

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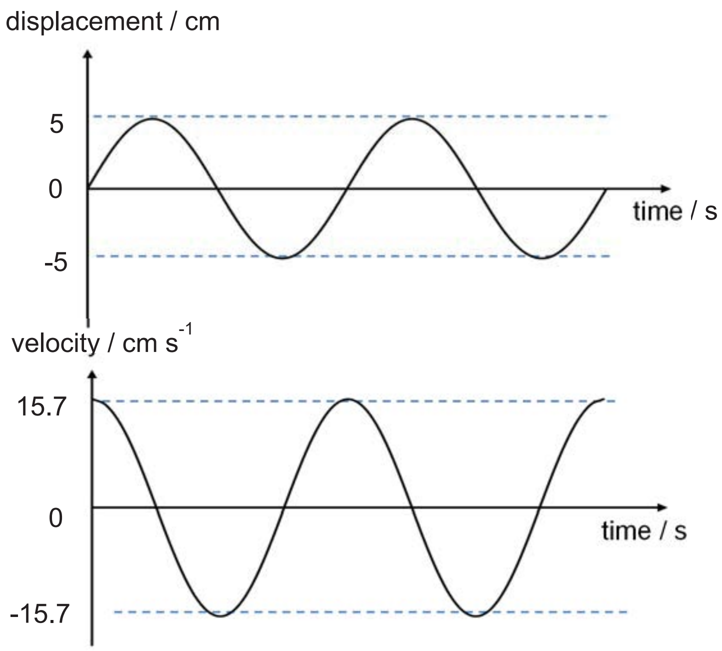
12 The graphs below show the variation of displacement and velocity with time of a body oscillating in simple harmonic motion.



Given that T is the period of the oscillation, what is the magnitude of the acceleration of the body at $\frac{T}{8}$ s?

A 0.7 cm s^{-2} **B** 34.8 cm s^{-2} **C** 49.3 cm s^{-2} **D** 55.5 cm s^{-2}

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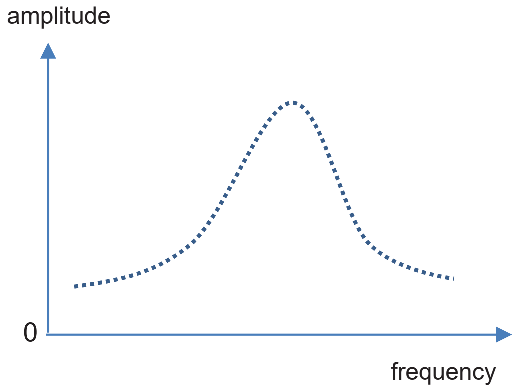
For Examiner's Use

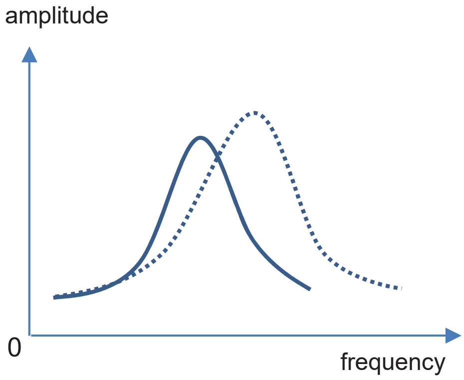
13 The graph below shows how the amplitude of a horizontal spring mass system varies with the driving frequency of an oscillator.



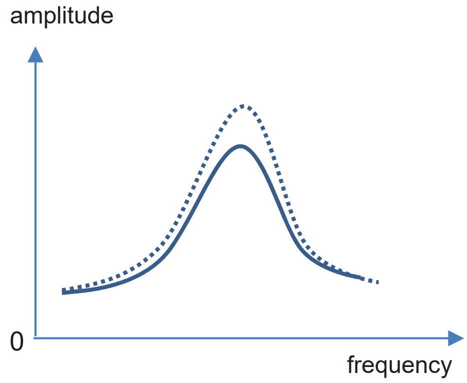
The spring is now replaced with a spring of higher spring constant.

Which graph best represents the new amplitude against frequency?

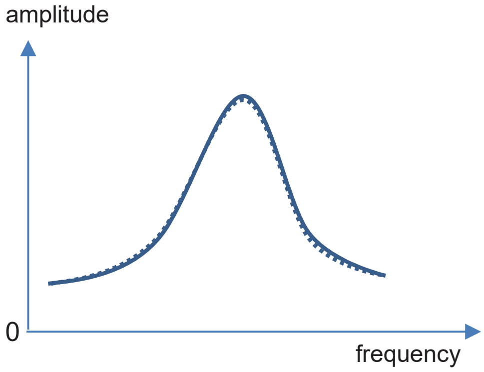
A



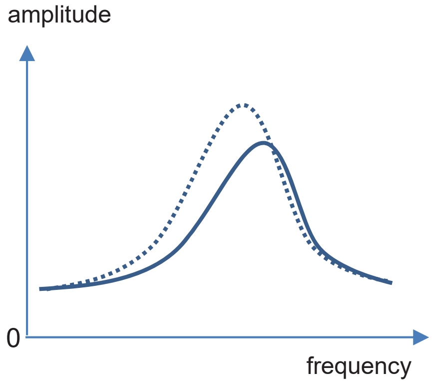
B



C



D



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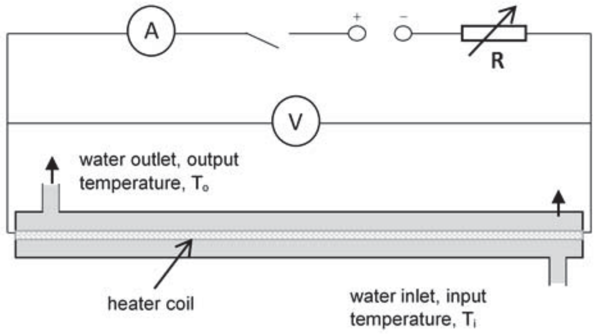
14 Water is passed through a heater coil in the setup as shown in order to determine its specific heat capacity.



The water flows over the heater coil at a constant rate. The output and input temperatures of the water at the water outlet and inlet are T_o and T_i respectively. A variable resistor R is connected to the circuit. The student conducted the experiment twice, each having a duration of 400 s.

Which of the following parameters must be kept constant for the two sets of experiment in order to account for the heat loss to the surrounding?

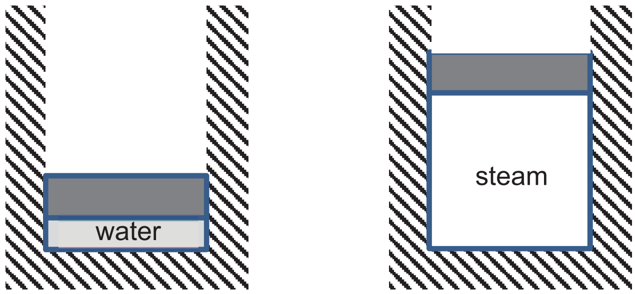
A T_o and T_i only

B R , T_o and T_i

C Flow rate of water between the outlets and R

D Flow rate of water between the outlets, T_o and T_i

15 Water at boiling point is converted into steam by a heating element placed within a well-insulated vessel with a moveable piston as shown.



Which of the following is correct?

	internal energy of the system	heat supplied to water	work done on steam
A	increase	is more than work done by steam	positive
B	increase	is more than work done by steam	negative
C	constant	is less than work done by steam	positive
D	constant	is less than work done by steam	negative

[Turn over

16 Plane-polarised radio waves are transmitted by a vertical aerial. The amplitude of the waves is A when they reach a receiving aerial which is tilted from the vertical at an angle θ in the plane perpendicular to the direction of arrival.

The power delivered by the vertical aerial to the receiving aerial is proportional to

A $A\cos^2\theta$

B $A\cos\theta$

C $A^2\cos\theta$

D $A^2\cos^2\theta$

17 A string is set to vibrate between two fixed ends and a single antinode is observed between the fixed ends at a frequency of 225 Hz.

Which of the following is true when the same string is vibrating at 900 Hz?

A It has 3 more nodes than the original wave.

B No stationary wave is observed.

C Its wavelength is 4 times the original wavelength.

D Its wave speed has increased by 4 times.

18 To be able to resolve a grain of red sand of radius 50 μm, the maximum distance your eye can be positioned is 19 cm away from the grain.

What is the maximum distance for your eye to resolve a blue grain of sand?

A The distance remains the same

B The new distance is smaller than 19 cm

C The new distance is larger than 19 cm

D The blue grain of sand cannot be resolved

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19 A basic capacitor consists of two parallel conductive plates with opposite charges on each plate. A dielectric is a good insulator placed between them to prevent the charges from moving across to the other plate.

Fig. 19(a) shows a basic capacitor with a dielectric between the plates. Region M is within the dielectric.

Fig. 19(b) shows the same capacitor but the dielectric is replaced by a conductor placed closer to the negative terminal. The charges are unable to move across the plates. The mediums of P, Q and R are air, conductor and air respectively.

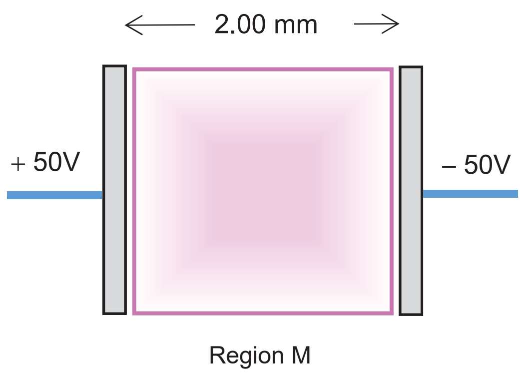

Fig. 19(a)

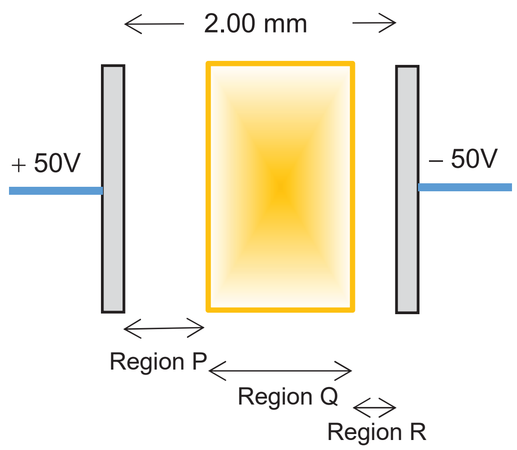

Fig. 19(b)

Which of the following is correct?

A Region P and Region R have the same electric field strength.

B The electric potential and electric field strength in Region Q are zero.

C Regions M, P and R have the same electric field strength, and the electric field strength at Region Q is zero.

D The electric field strength in Region Q is more than 5.00×10^5 N C^{-1}, but that in Region P and Region R are less than 5.00×10^5 NC^{-1}.

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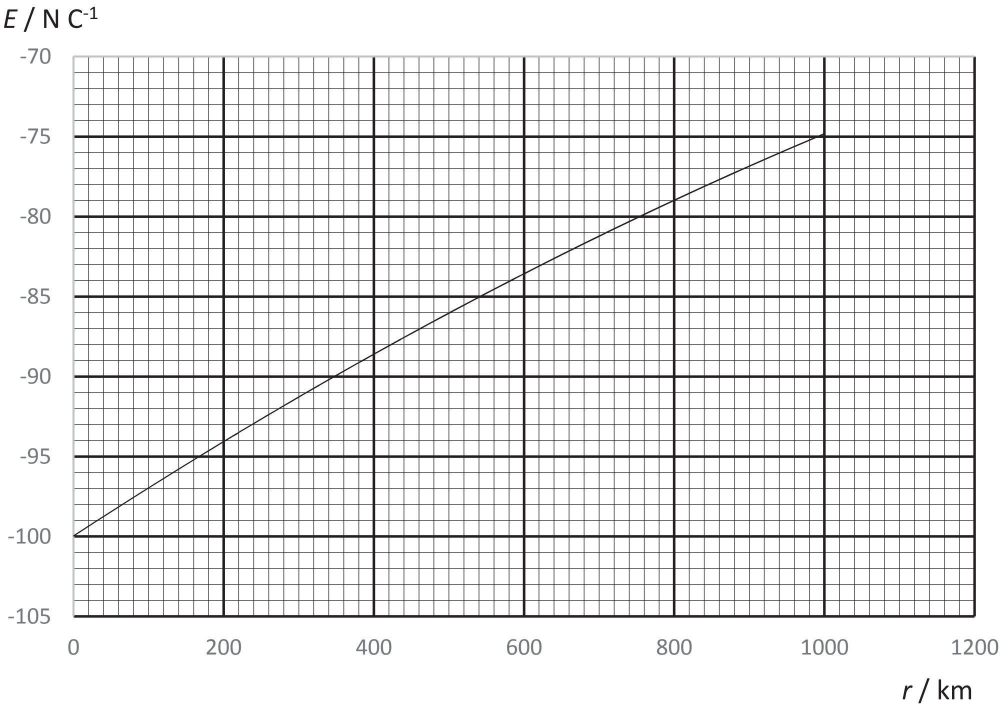
For Examiner's Use

20 The Earth can be assumed to be a sphere of radius 6400 km where charges are uniformly distributed on the surface. The figure below shows the variation of the electric field strength E with the distance r from the surface of the Earth.

The electric field strength E on the surface of the Earth is - 100 N C^{-1}.



At 800 km above the Earth's surface, the electric potential is

A -2.25×10^{-5} V

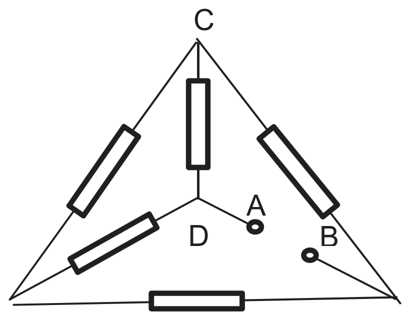
B -7.50×10^{-5} V

C the gradient of the tangent of graph at r = 800 km

D the area between the graph and r axis from infinity to r = 800 km

For Examiner's Use

21 Five equal resistors, each of resistance R, are connected as shown.

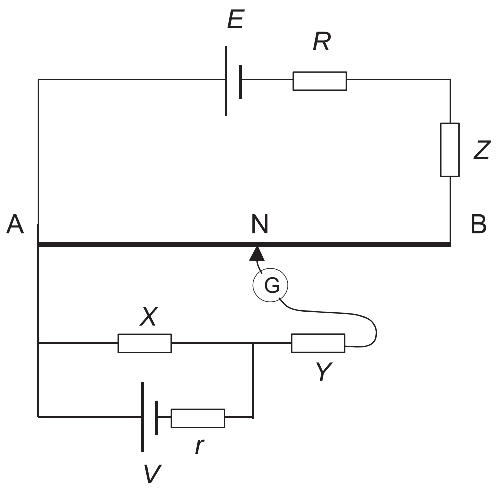


A battery of negligible internal resistance and emf V is connected between A and B.

What is the current flowing in CD?

A $\frac{V}{R}$ **B** $\frac{V}{2R}$ **C** $\frac{2V}{R}$ **D** $\frac{2V}{3R}$

22 A potentiometer containing a driver cell *E* of internal resistance *R* and resistor *Z* is connected to a circuit containing an unknown emf *V* of internal resistance *r* and resistors *X* and *Y* as shown.



In the experiment to determine *V*, a jockey is used to determine the null point on wire AB in order to obtain the length AN.

Which of the following will reduce the fractional uncertainty in the length AN?

A Decrease the resistance of *Y*

B Decrease the resistance of *X*

C Increase the resistance of AB

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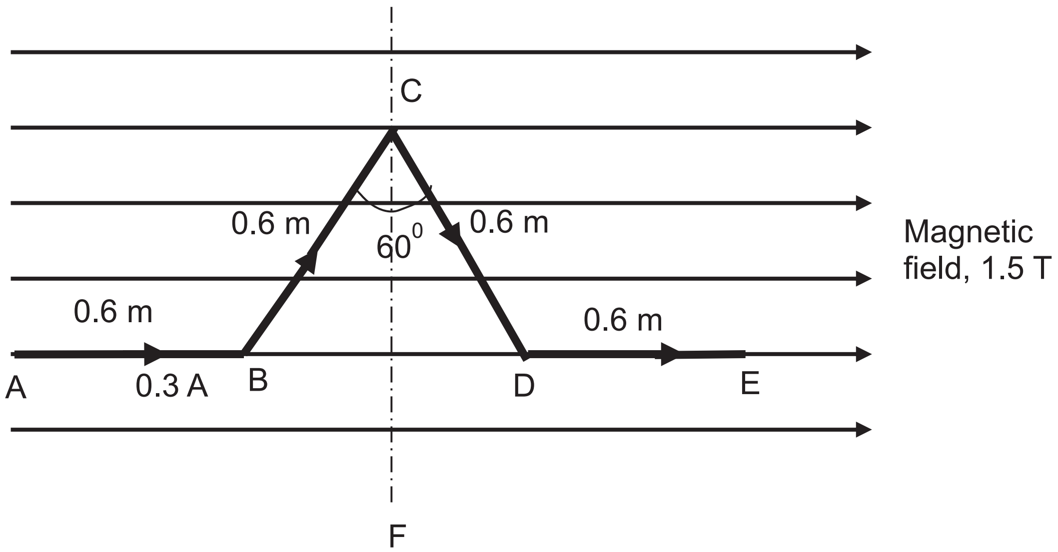
D Increase the resistance of *Z*

23 A current of 0.3 A flows in a conductor ABCDE that lies on the plane of the paper as shown in the figure below.



The conductor is inside a region of a uniform magnetic field having a magnetic field strength of 1.5 T. AB and DE are parallel to the magnetic field. Angle BCD is 60^o. The lengths of segments AB, BC, CD and DE are 0.6 m each.

Which of the following describe the resultant force and resultant torque on the conductor?

	magnitude of resultant force	torque (view from the top)
A	0 N	Clockwise about CF
B	0 N	No resultant torque
C	0.47 N	Anti-clockwise about CF
D	0.47 N	No resultant torque

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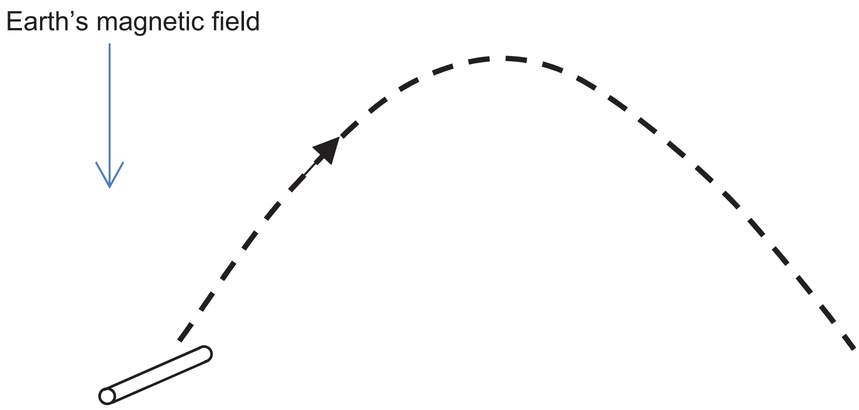
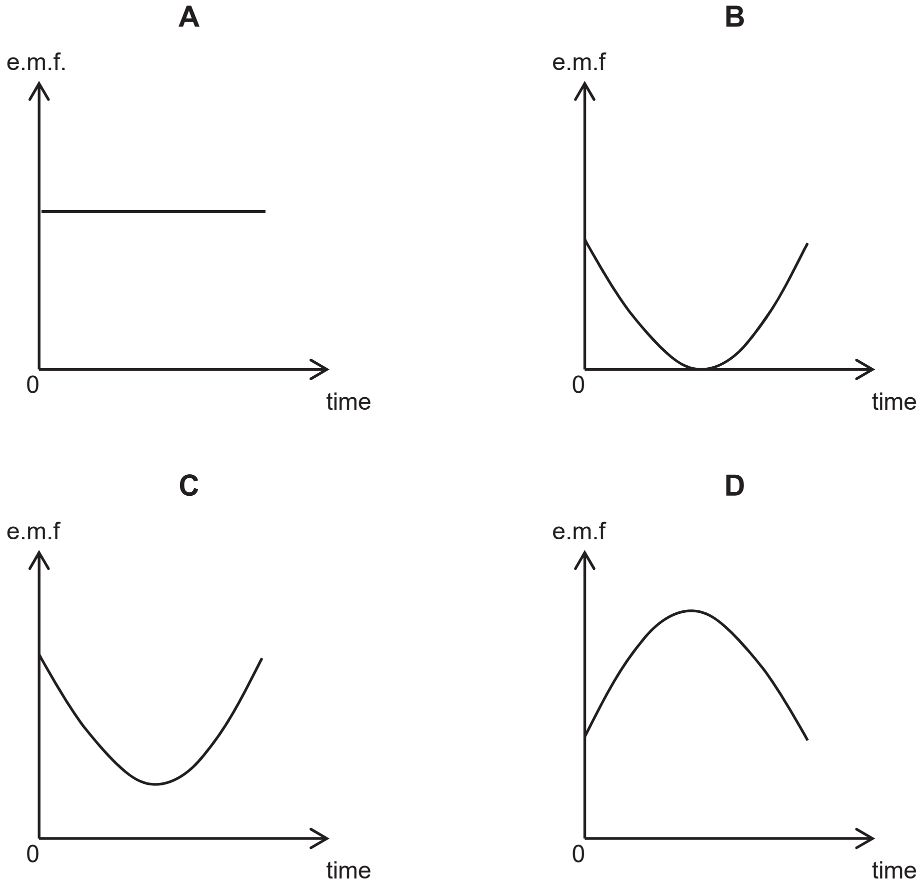
24 A metal rod moves in a parabolic path. Along its trajectory, the metal rod's long axis remains perpendicular to the earth's magnetic field. Air resistance is negligible.



Assuming that the earth's magnetic field is pointing downwards and is uniform throughout the rod's trajectory.

Which of the following graphs show the variation of the e.m.f. induced between both ends of the rod with time?



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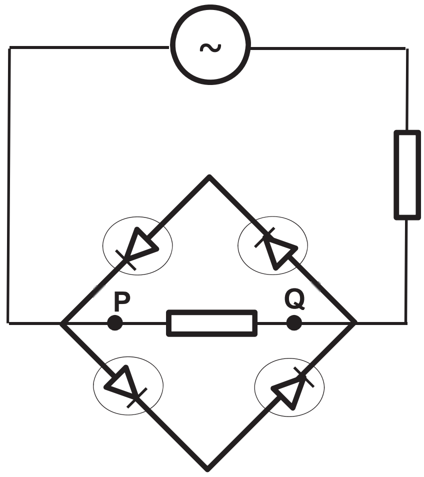
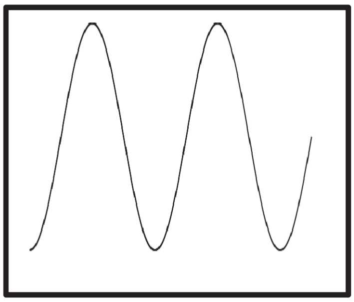
25 A sinusoidal alternating voltage source is applied to the circuit of diodes and resistors. The terminals P and Q are connected to a cathode-ray oscilloscope (C.R.O).

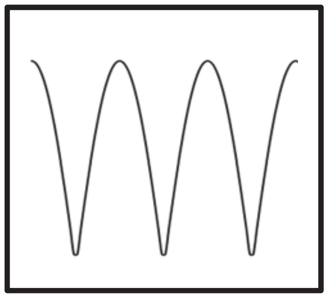


Which of the following traces would be seen on the C.R.O.?

A

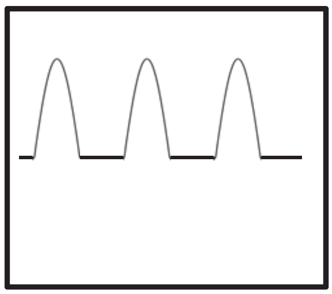


B



C

D



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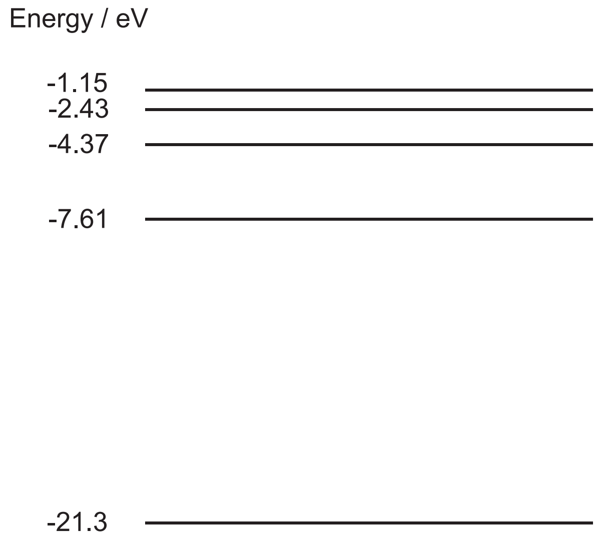
26 The lowest five levels of an atom are shown below.



A beam of electrons with energy 19.2 eV is incident on a cold gas of the atom.

Which of the following spectra will be produced?

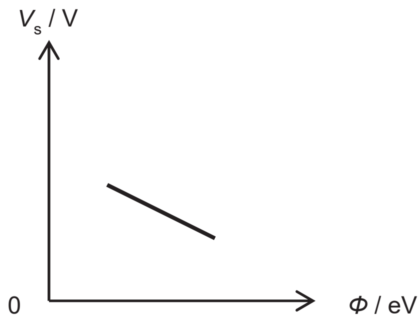
A


B

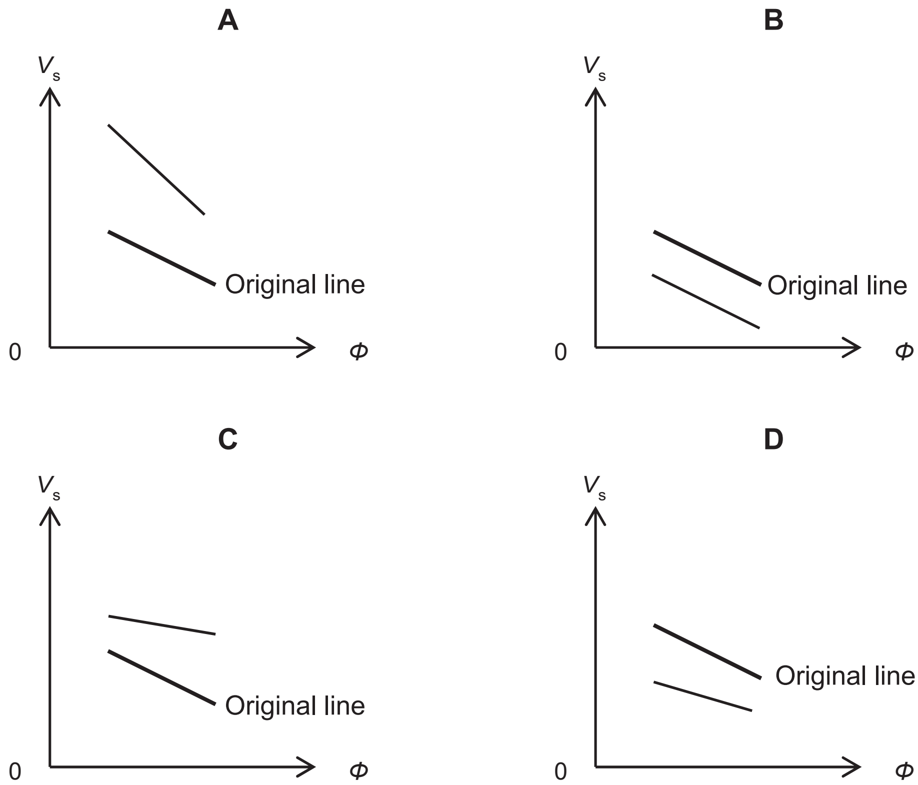

C


D


27 Electromagnetic radiation of a fixed wavelength is shone on different metals. The stopping potential for each metal is plotted against the work function of each metal to obtain the following graph.



If both the wavelength and the intensity of the electromagnetic radiation is doubled, which of the following graphs reflect this change?



28 A beam of electrons and a beam of protons are accelerated across the same potential difference. They each then undergo diffraction through a crystal lattice to determine their de Broglie wavelength. The de Broglie wavelength of the electron is found to be 3.9×10^{-9} m.

What is the theoretical de Broglie wavelength of the proton?

A 2.1×10^{-12} m **B** 9.1×10^{-11} m **C** 3.9×10^{-9} m **D** 1.7×10^{-7} m

For Examiner's Use

29 A fluorine-18 ($^{18}_{9}F$) nucleus can capture a proton (p), producing a neon-19 ($^{19}_{10}Ne$) nucleus as the product.

$$^{18}_{9}F + p \rightarrow ^{19}_{10}Ne$$

The mass defect of $^{18}_{9}F$ and $^{19}_{10}Ne$ are 0.147 12u and 0.153 98u respectively.

What is the energy change associated with this reaction?

A 930 MeV released

B 930 MeV absorbed

C 6.5 MeV released

D 6.5 MeV absorbed

30 The ratio of ^{14}C:^{12}C in living things is fixed when they are alive but decreases after death because of the radioactive decay of ^{14}C. A 10.0 g sample of wood cut from a live tree is measured to have an activity of 120.00 min^{-1}.

If a 1.0 g sample of a 3300 year old wooden relic is found to have an activity of 8.05 min^{-1}, what is the half-life of ^{14}C?

A 847 years **B** 1320 years **C** 5730 years **D** 8920 years

[Turn over

Anglo-Chinese Junior College

JC2 Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		Form CLASS	
TUTORIAL CLASS		INDEX NUMBER	

PHYSICS **9749**

Paper 2 Structured Questions

11 August 2017
2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

For Examiners' use only	
1	/ 7
2	/ 10
3	/ 9
4	/ 12
5	/ 11
6	/ 12
7	/ 19
Total	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

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

For Examiner's Use

Formulae

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

[Turn over

Answer all questions

1 **(a)** Box A rest on a smooth slope and is connected to Box B using a light inextensible string as shown in Fig 1.1. Box A and Box B have masses of 10 kg and 3 kg respectively. The setup is initially at rest.

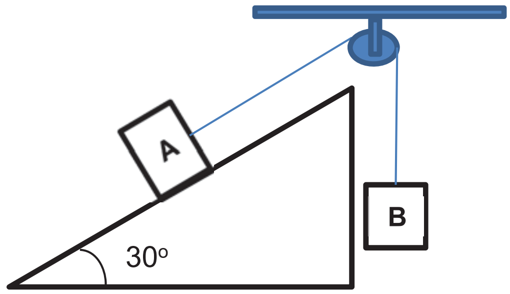


Fig 1.1

(i) Determine the initial acceleration of Box A.

Acceleration = ………………… m s^{-2} [3]

(ii) The string subsequently snapped. Box B is now 2.0 m above the ground and has an upward velocity of 0.5 m s^{-1} as shown in Fig 1.2.

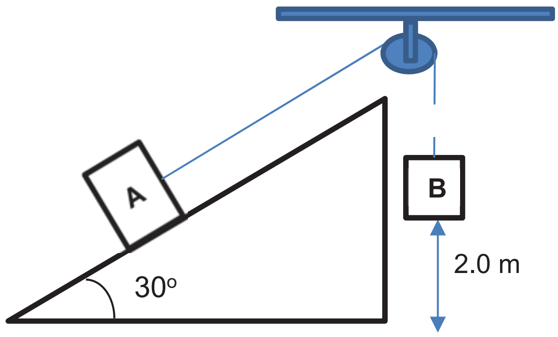


Fig 1.2

Determine the velocity of Box B when it hits the ground.

Velocity = ………………… m s^{-1} [2]

For Examiner's Use

(b) By considering the work done by the force(s) acting on a ball, derive the equation, $E_G = mgh$, where E_G is the change in the gravitational potential energy of a mass m moved through a vertical distance h near the earth's surface.

[2]

For Examiner's Use

2 The kinetic theory of gases deals with how molecular movement causes pressure to be exerted by a gas. The pressure of a gas is due to the elastic collision of the gas molecules with the walls of a container.

A single molecule of mass *m* is travelling with speed *u* directly towards a wall of a cubical box of sides *L* is as shown in Fig. 2.1.

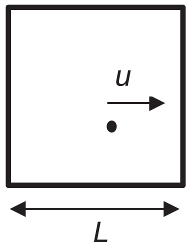


Fig. 2.1

(a) Express the following in terms of *L*, *m* and *u*.

Momentum to the right before collision with wall = *mu*

Momentum immediately after an elastic collision = …………

Time between collisions with the same wall = …………

Number of collisions with this wall per unit time = …………

Rate of change of momentum of the molecule = …………

Average force on the wall = ………… [2]

(b) The pressure *p* of an ideal gas which contains *N* molecules with different speeds in a container of volume *V* is given by

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

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

(i) State the assumption regarding the type of collision between gas molecules.

……………………………………………………………………………………. [1]

(ii) The deduction of the relationship stated in **(a)** does not involved collisions between the gas molecules. In practice, gas molecules will collide with one another.

Using your answer in **(b)(i)**, explain why the collision among the molecules do not have an impact on the pressure.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………. [2]

For Examiner's Use

(c) Using the expression in **(b)** and the ideal gas equation, show that the average kinetic energy of an ideal gas molecule is proportional to the thermodynamic temperature T.

[1]

(d) The first law of thermodynamics when applied to an ideal gas can be expressed as

$$\Delta U = Q + W$$

where ΔU is the increase in internal energy, Q is the heat supplied to the gas and W is work done on the gas.

(i) The gas undergoes a process from state A to state B in such a way that ΔU is 0 as shown in Fig. 2.2.

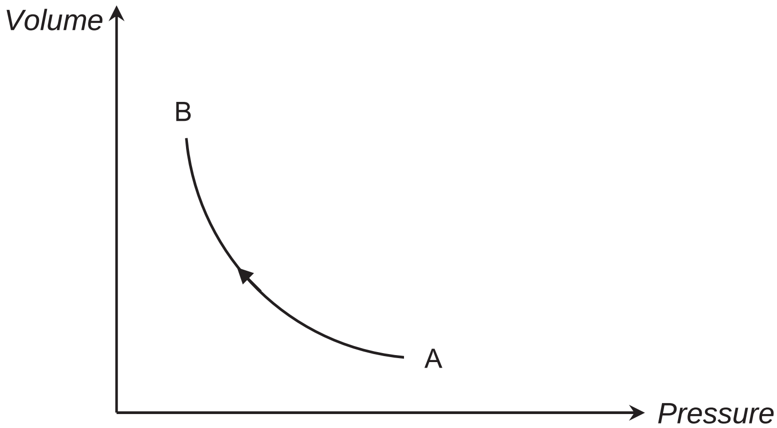


Fig. 2.2

1. Shade in Fig. 2.2 the area that numerically represents the heat exchange between the gas and its surroundings. [1]

2. Deduce the difference in the product of pressure and volume of the gas at both state A and state B.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) The change in volume in **(d)(i)** takes place slowly. State and explain the changes to the mean square speed of the gas molecules if the change in volume takes place very quickly instead.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

[Turn over

For Examiner's Use

3. **(a)** An electron passes through a region of uniform magnetic field of flux density, B as shown in Fig 3.1.

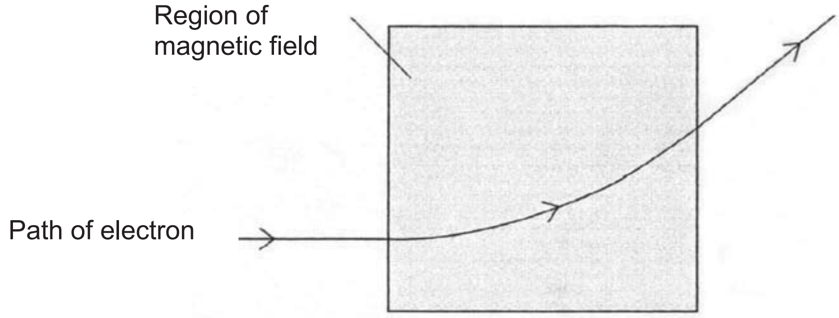


Fig 3.1

(i) Deduce the direction of the uniform magnetic field

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

(ii) Suggest how an electric field of strength E may be applied to allow the electron to pass through the region undeflected.

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(iii) Hence or otherwise, show that the velocity v, for the electron to pass through the fields undeflected is given by $v = \dfrac{E}{B}$

[1]

For Examiner's Use

(b) The electron of mass m_e and charge q subsequently enters into another uniform magnetic field. The magnetic field is directed along the positive x-axis and has a field strength of B. The electron, traveling with a speed v and kinetic energy of 10 eV, enters the field along a direction that makes an angle of θ = 60° with the x-axis and is perpendicular to the z-axis as shown in Fig. 3.2.

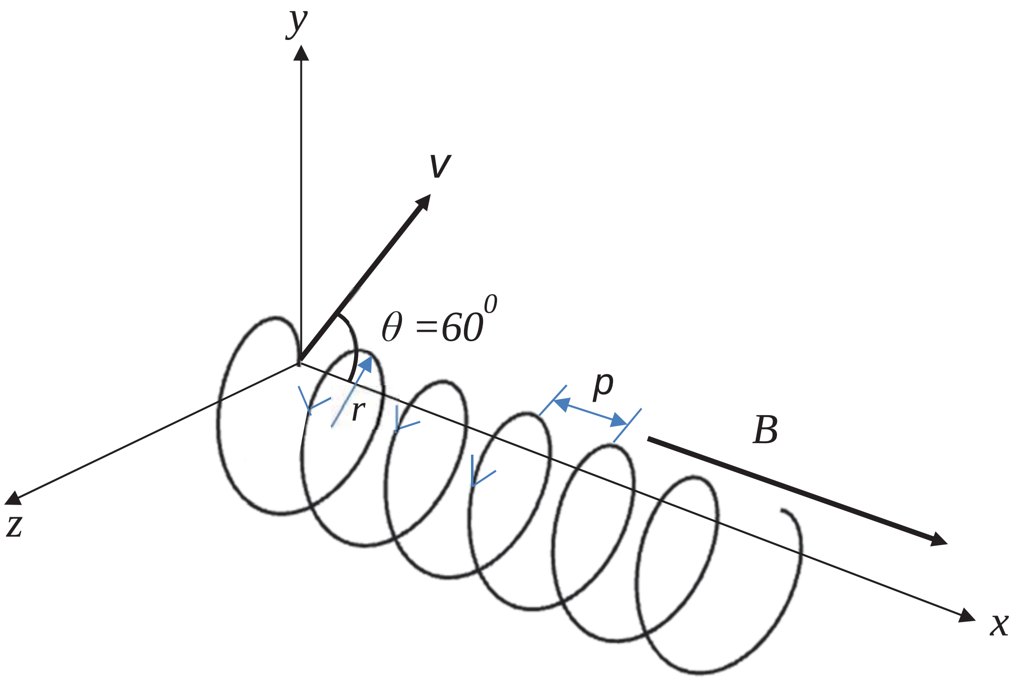


Fig. 3.2

(i) Show that v is 1.87×10^6 m s^{-1}.

[1]

[Turn over

For Examiner's Use

(ii) The pitch p is defined as the distance along the x-axis between 2 successive helical paths.

Show that p is given by the following expression:

$$p = \frac{2\pi m_e v \cos\theta}{qB}$$

[3]

(iii) The magnitude of B is given to be 5.0 x 10^{-4} T. Hence or otherwise, determine distance that the electron will travel in the x-direction after it has completed 3 successive helical paths.

Distance = …………………….. m [2]

For Examiner's Use

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

....

....

....

.... [2]

(b) A hypothetical model of a planet of radius of 6400 km is illustrated in Fig. 4.1, consists of negative charges $-Q$ uniformly distributed on the surface, and a positive point charge $+Q$ at the centre. The planet is neutral.

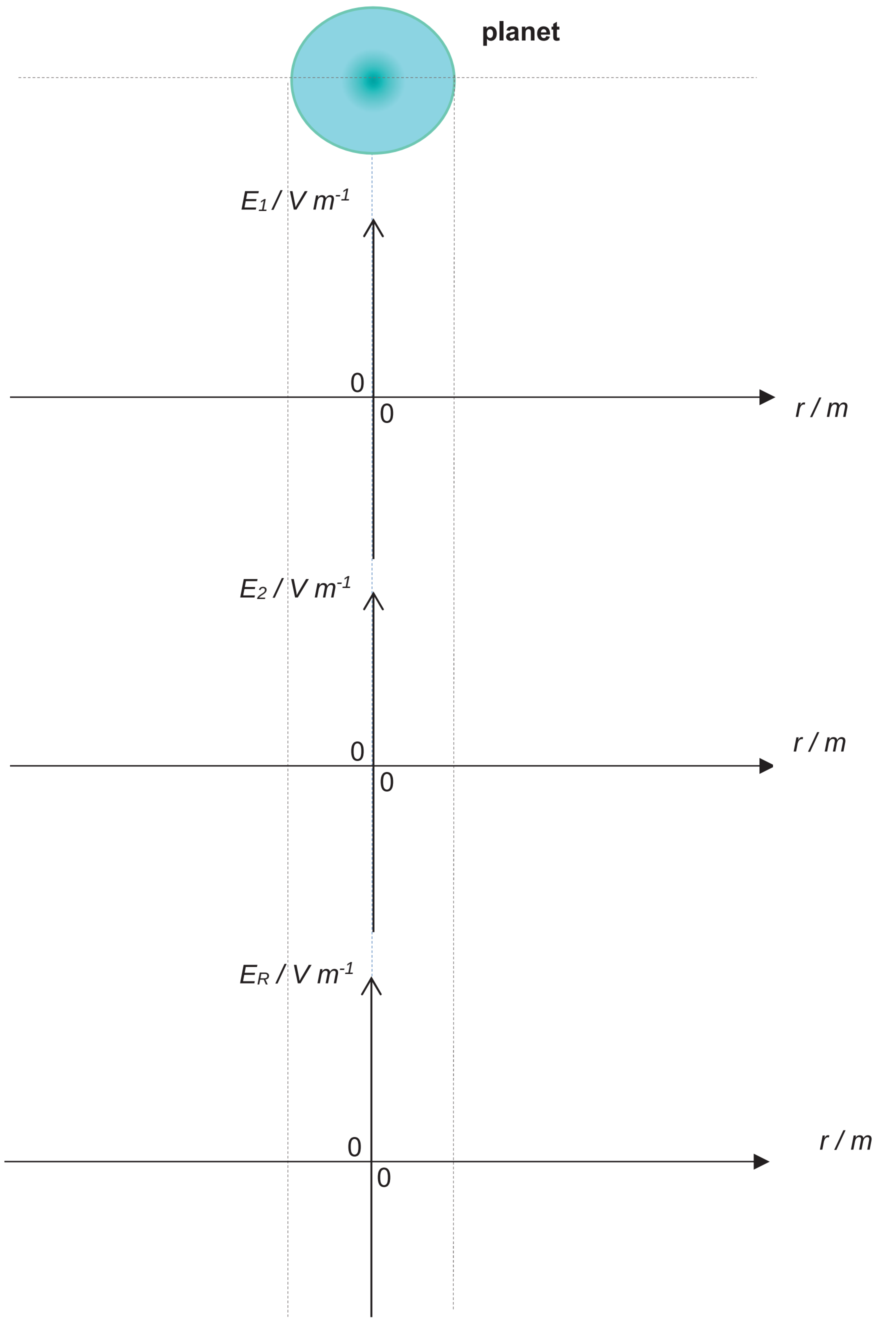


Fig. 4.1(a)

Fig. 4.1(b)

Fig. 4.1(c)

[Turn over

For Examiner's Use

Sketch graphs of the electric field strength E against distance r, due to the

(i) negative charges $-Q$ on the surface only on Fig. 4.1(a)

(ii) positive point charge $+Q$ at the centre only on Fig. 4.1(b)

(iii) both negative and positive charges on Fig. 4.1(c)

[3]

(c) A second hypothetical model suggests that both a planet and its moon are negatively charged and the charges reside on their surfaces only. The diameter of the planet, D, diameter of the moon, d, and distance between the planet and moon, L, are given by the equations below

$$L = 10^5 D, \quad \text{and} \quad D = 10^5 d,$$

and the planet and its moon have the same density.

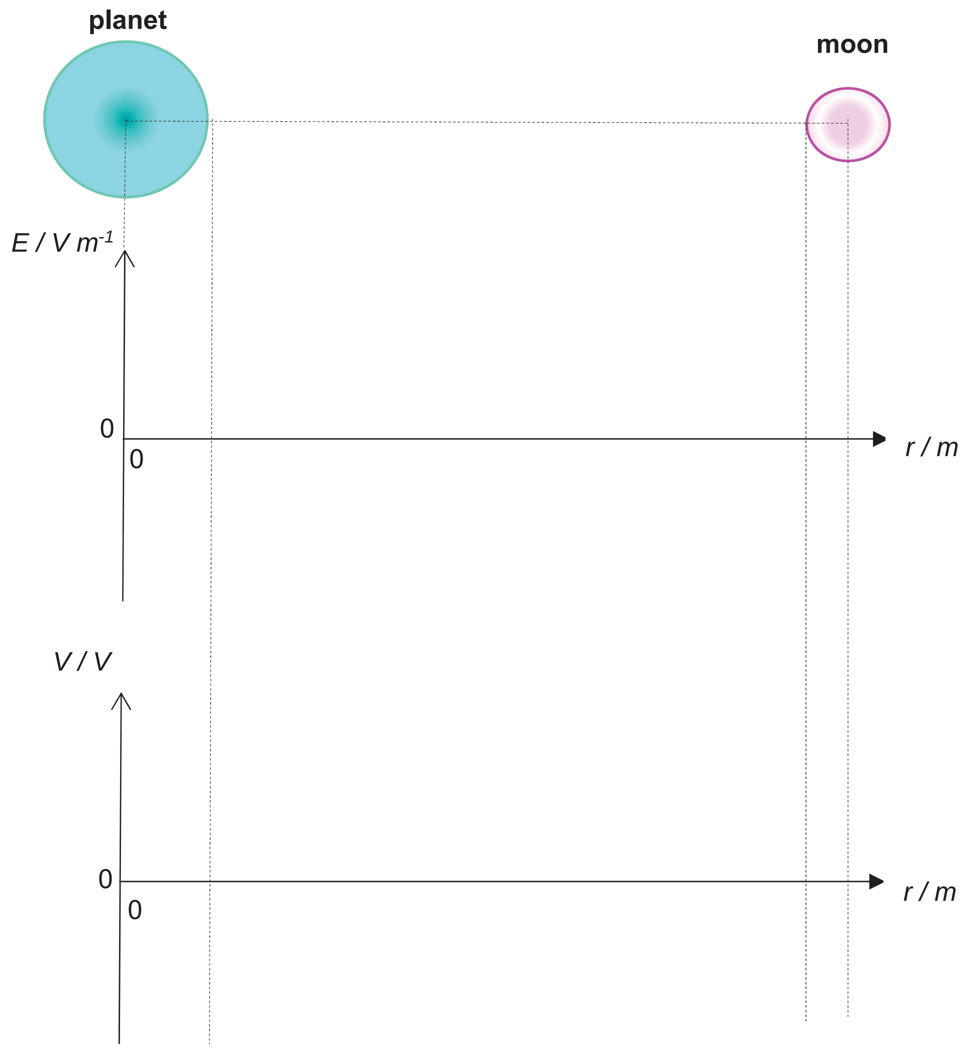


Fig. 4.2(a)

Fig. 4.2(b)

For the planet and its moon, sketch graphs of the

(i) resultant electric field strength E in Fig 4.2(a), and

(ii) resultant electric potential V in Fig 4.2(b)

against distance r from the centre of the planet. Graphs do NOT need to be drawn exactly to scale. [3]

For Examiner's Use

(d) A beam of electrons with velocity *v* enter the centre of a uniform electric field established between 2 charged plates as shown in Fig. 4.3. The plates are 5.0 cm long and 4.0 mm apart and has a potential difference of 80 V.

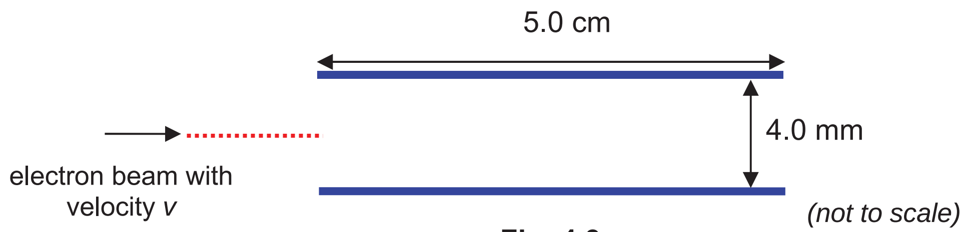


Fig. 4.3

Determine the minimum speed of the electrons such that they can emerge from the charged plates.

Minimum speed = …………………….. m s^{-1} [4]

[Turn over

For Examiner's Use

5 **(a)** The graph in Fig. 5.1 shows the spectrum of the visible light coming from a bright star. These lines correspond to the Balmer series for hydrogen gas which are transitions from higher energy levels to level n = 2.

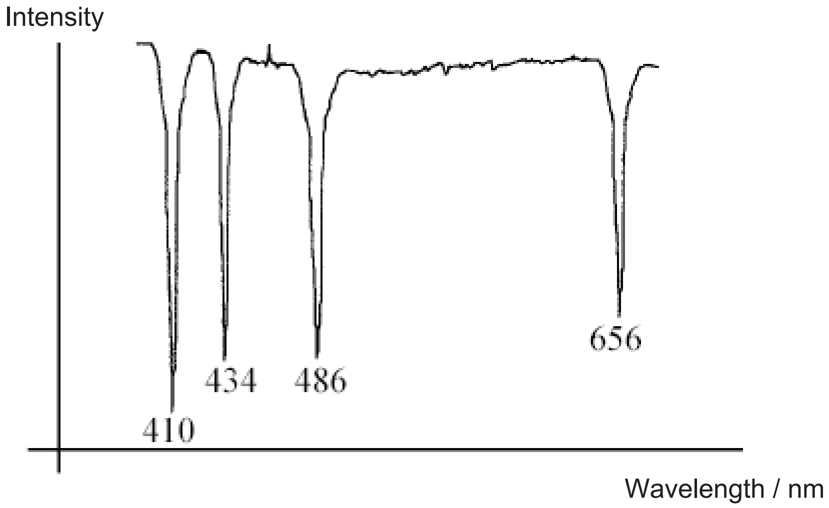


Fig. 5.1

(i) State and explain the type of spectrum shown in Fig. 5.1.

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

……………………………………………………………………………..………...

……………………………………………………………………………………. [2]

(ii) Given that the energy of level n = 2 is -5.44 x 10^{-19} J, calculate the energy of level n = 3, E_3.

E_3 = ………………………… eV [3]

For Examiner's Use

(b) Ultra-violet radiation of wavelength 184 nm is shone on a cathode within a vacuum tube as shown in Fig. 5.2 and photoelectrons are observed to be emitted.

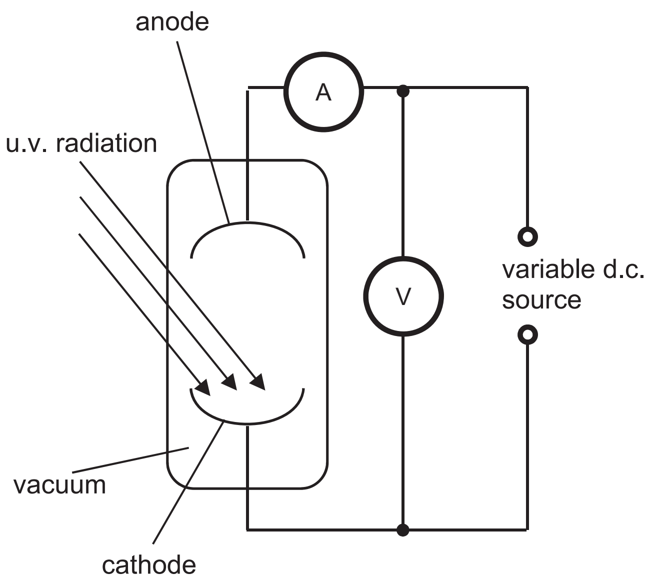


Fig. 5.2

The potential difference across the cathode and anode is varied and the corresponding value of the current is measured with the ammeter. Fig. 5.3 shows the relationship between these two quantities.

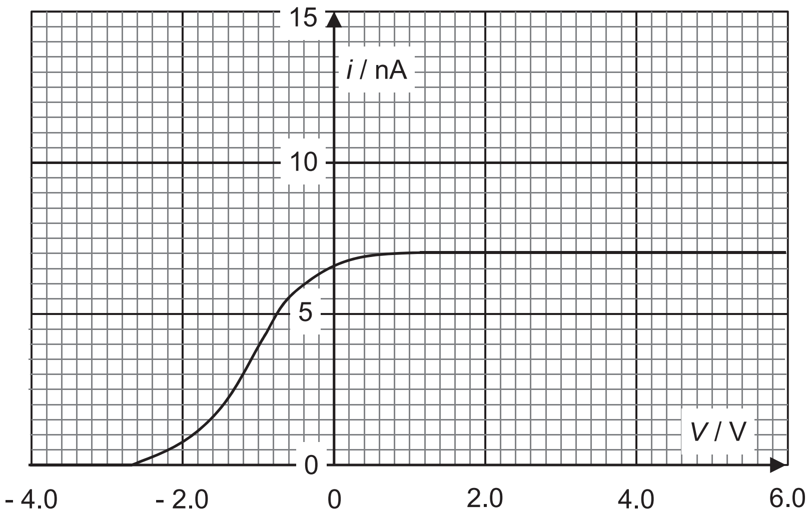


Fig. 5.3

[Turn over

For Examiner's Use

(i) The presence of a threshold frequency is an evidence for the particulate nature of electromagnetic radiation.

Explain why the wave nature of electromagnetic radiation does not support this observation.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

…………………………………………………………………………………… [2]

(ii) Determine the work function of the cathode.

Work function = ………………………….. J [3]

(iii) The cathode is replaced with a metal with **lower** work function.

Sketch, on Fig. 5.3, the new *i*-*V* graph.

[1]

For Examiner's Use

6 **(a)** When a star has fused all its hydrogen to helium, it will start to fuse helium into carbon through the following reaction.

$$^{4}_{2}He + ^{4}_{2}He + ^{4}_{2}He \rightarrow ^{12}_{6}C$$

(i) The binding energy per nucleon of helium and carbon are given in the table below.

	Binding Energy per nucleon / MeV
$^{12}_{6}C$	7.680
$^{4}_{2}He$	7.074

Calculate the energy produced from this fusion reaction.

Energy produced = …………………… MeV [2]

(ii) A star in the milky way gives off energy at a rate of 2.75 x 10^{26} W solely due to the fusion of helium in its core.

Calculate the number of helium nuclei *N*, that reacted in one second.

N = ……………………… s^{-1} [3]

[Turn over

For Examiner's Use

(b) Beta decay provides evidence for the existence of neutrinos. One such example is the spontaneous decay of carbon-14 into nitrogen-14. Neutrinos, ν, which have negligible mass and no charge, are emitted in the process.

$$^{14}_{6}C \rightarrow {}^{14}_{7}N + e + \nu$$

In beta decays, the electrons emitted has a range of possible velocity. Explain how this can be used to predict the existence of neutrinos.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(c) Radon ($^{220}_{86}Rn$) decays spontaneously with a half-life of 56 s to form polonium ($^{216}_{84}Po$). During this decay, an alpha particle and a gamma ray photon are emitted.

$$^{220}_{86}Rn \rightarrow {}^{216}_{84}Po + {}^{4}_{2}\alpha + \gamma$$

A 2.0 g sample of radon is left to decay. The mass of one mole of radon and polonium are 220.0 g and 216.0 g respectively.

Determine the mass of the sample after 5.0 minutes.

Mass = …………………………… g [4]

For Examiner's Use

7 Renewable energy is energy that is generated from natural processes that are continuously replenished. This includes sunlight, geothermal heat, wind, tides, water, and various forms of biomass. This energy cannot be exhausted and is constantly renewed.

While raw forms of energy are both free and practically infinite, the equipment and materials needed to collect, process, and transport the energy to the users can be costly. Table 7.1 compares the average electricity cost in dollars per kilowatt-hour for both non-renewable and alternative fuels in new power plants.

Power Plant Type	Cost $/kW-hr
Coal	$0.095-0.15
Natural Gas	$0.07-0.14
Nuclear	$0.095
Wind	$0.07-0.20
Solar PV	$0.125
Solar Thermal	$0.24
Geothermal	$0.05
Biomass	$0.10
Hydro	$0.08

Source: Adapted from US Energy Information Administration

Fig 7.1

(a) With reference to Fig 7.1, suggest

(i) why geothermal energy is not widely adopted even though it is the cheapest.

……………………………………………………………………………………………

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

(ii) a possible factor that may cause the cost of some renewable energy, such as wind energy, to vary across a range.

……………………………………………………………………………………………

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

(iii) one advantage that conventional energy sources has over renewable energy.

……………………………………………………………………………………………

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

[Turn over

For Examiner's Use

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity.

(b) (i) Using momentum consideration, explain how the wind is able to turn the blades of the wind turbine.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[3]

(ii) The average size of a wind turbines being manufactured today can be more than a hundred metres tall with blades of about 50 metres length. If the average speed of the wind before it enters the wind turbine is 13.5 m s^{-1} and is 12.8 m s^{-1} after it exits the wind turbine, determine the maximum power that the wind turbine can generate.

You may assume that the density of air before it enters the wind turbine is 1.23 kg m^{-3}.

Maximum power = ………………… W [3]

For Examiner's Use

(iii) A mayor wanted to build a wind farm to supply the energy needs of his town of 2,000 households. The average monthly (30 days) household consumption of each household is 4,100 kWh and the wind turbine can be assume to be running at an average of 22% of its maximum output power for the entire year.

Determine the minimum number of wind turbines that are needed to be built.

Minimum number of wind turbine needed = ………………… [3]

[Turn over

For Examiner's Use

Many innovations had evolved in the area and wind lens is one of them. Wind lens, as shown in Fig 7.2, is a type of wind power system consisting of a simple brimmed ring structure that surrounds the rotor causing greater wind to pass through the turbine. As a consequence, the turbine's efficiency of capturing energy from the wind increases and a wind lens turbine can generate 2 to 5 times the power of an existing wind turbine, as shown in Fig 7.3, given at the same rotor diameter and incoming wind speed.

Fig 7.2

Fig 7.3

Source: Research Institute for Applied Mechanics, Kyushu University

Fig 7.4 shows a simple schematic of a wind lens attached to a turbine while Fig 7.5 show the power generated against wind speed of a normal wind turbine and one that has an attached wind lens.

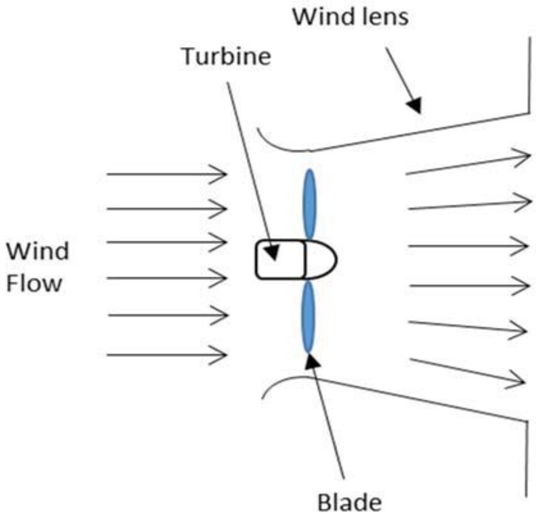
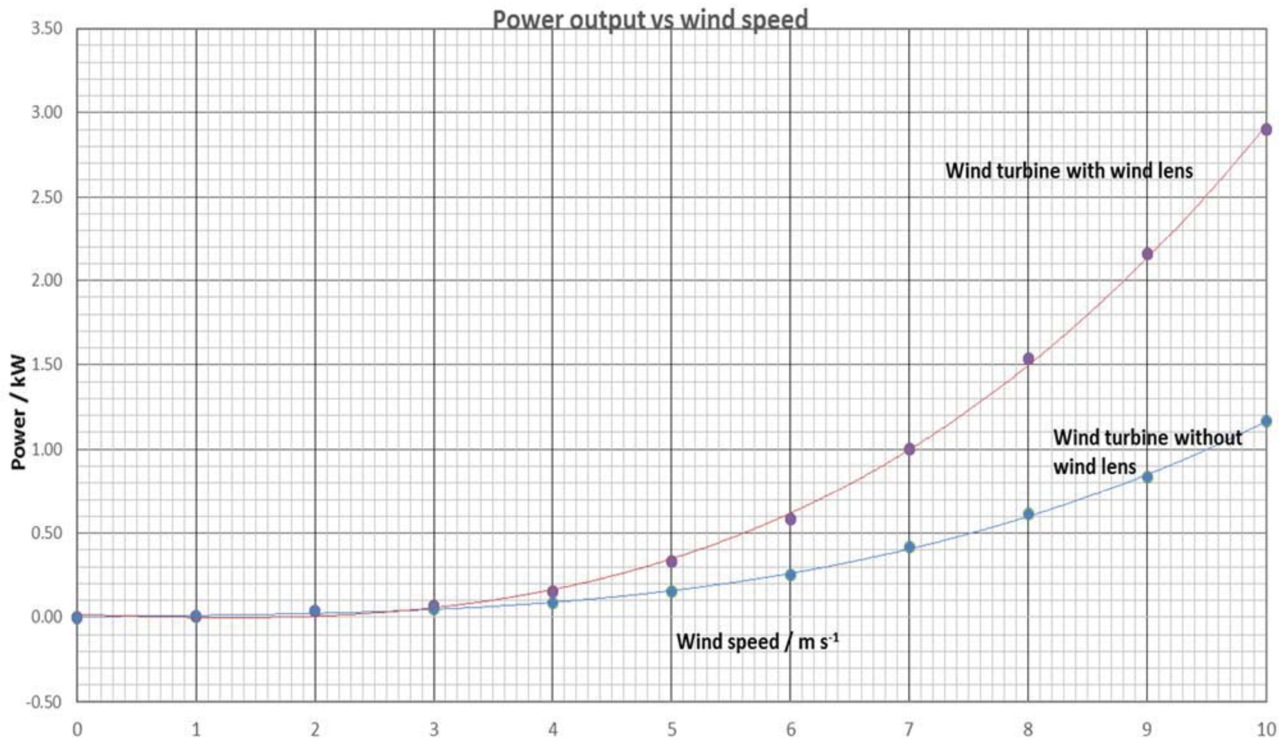


Fig 7.4

For Examiner's Use



Source: Adapted from Research Institute for Applied Mechanics, Kyushu University

Fig 7.5

(c) **(i)** Suggest a possible reason why the use of a wind lens allow the wind turbine to generate a higher power output.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) Using Fig 7.5, determine the additional power that can be can be generated by a wind turbine with wind lens compared to a wind turbine without a wind lens when the wind speed is 9.5 m s^{-1}.

Additional Power = ………………… W [2]

[Turn over

For Examiner's Use

(iii) Using Fig 7.5, determine the relationship between the power generated by a wind turbine without a wind lens and the wind speed.

[3]

Anglo-Chinese Junior College

Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		CLASS	

CENTRE NUMBER	S	3	0	0	4	INDEX NUMBER					

PHYSICS **9749/03**

Paper 3 Longer Structured Questions

17 August 2017
2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your Name and Index number in the spaces on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer **one** questions only

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

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

For Examiners' use only	
Section A	
1	/ 10
2	/ 11
3	/ 10
4	/ 8
5	/ 10
6	/ 11
Total	/ 60
Section B	
7	/ 20
8	/ 20
Grand Total	/ 80

For Examiner's Use

DATA AND FORMULAE

Data

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

For Examiner's Use

Formulae

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

[Turn over

For Examiner's Use

Section A

Answer **all** questions in the spaces provided

1 **(a)** It is suggested that the mass flow rate Q of grains through a hopper can be given by

$$Q = C\rho\sqrt{g}(D - kd)^{3/2}$$

where C and k are constants, ρ is the density of the grains, D is the diameter of the aperture of the hopper, d is the diameter of the circular grain and g is the acceleration due to free fall.

Determine the units of C and k in terms of the SI base units

units of k = …………………………..

units of C = ………………………….. [3]

(b) A student wants to determine the density of a solid circular disc by measuring its dimensions with a ruler and its weight using a mass balance. He recorded his readings as follows.

Diameter of the circular disc = (3.6 ± 0.2) cm
Height of the circular disc = (2.4 ± 0.2) cm
Mass of the circular disc = (212.5 ± 0.1) g

For Examiner's Use

(i) Determine a value for the density of the disc with its associated uncertainty.

density = ……..……… ± ……...…… kg m^{-3} [4]

(ii) Explain which variable has the largest impact on the uncertainty of the density.

……………………………………………………………………………….….

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

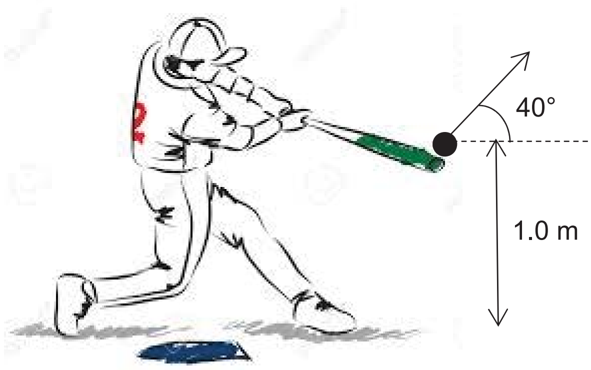
(c) A glider is at the location as indicated in Fig. 1.1 and is flying with a speed of 3 m s^{-1} in the direction 30° East of North. A wind of speed of 5 m s^{-1} is blowing towards the direction of 35° West of North.

By drawing a scale diagram, indicate on Fig 1.1, the location of the glider after 2 seconds. State your scale for your diagram clearly.

Fig. 1.1

[2]

2 A baseball player strikes a baseball with his bat. At the point where the baseball loses contact with the bat, it is 1.0 m above the ground and is travelling with a speed of 38.0 m s^{-1} and makes an angle of 40° with the horizontal as shown in Fig. 2.1. Air resistance can be neglected.



Source: www.123rf.com

Fig. 2.1

(a) Determine

For Examiner's Use

(i) the maximum height above the ground that the baseball can reach.

Height = ………………………….. m [3]

(ii) the speed of the baseball when it hits the ground.

Speed = ………………………….. m s^{-1} [2]

(iii) If air resistance is not negligible, sketch on Fig. 2.2, a well-labelled graph of the variation of its height above the ground with horizontal distance for the baseball from the start till it hits the ground.

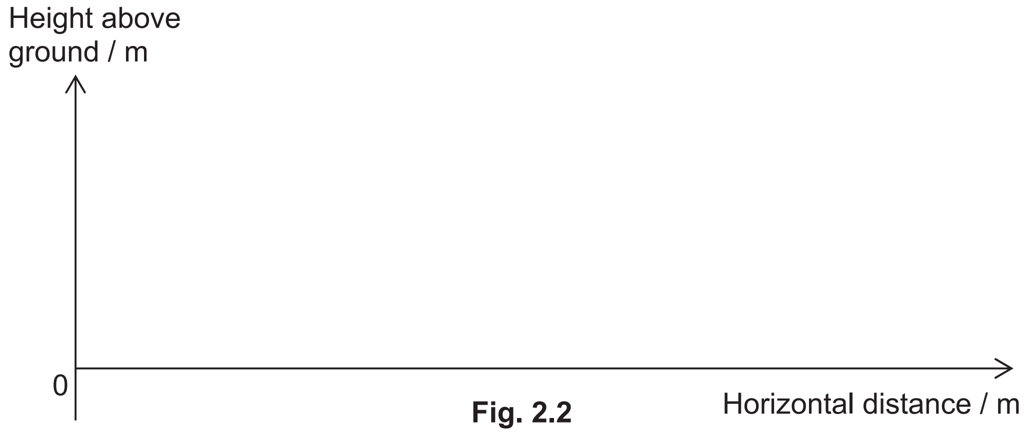


Fig. 2.2

[2]

[Turn over

For Examiner's Use

(b) An outfielder is a player in the opposing team who will try to catch the baseball using his gloves before it hits the ground. When the baseball first loses contact with the bat, the outfielder is 25.0 m away and the baseball is moving in his direction as shown in Fig. 2.3. His outstretch arm is 1.0 m above the ground.

(i) Determine the average speed that he has to start running from this instant in order to catch the baseball if he remains in this outstretch posture.

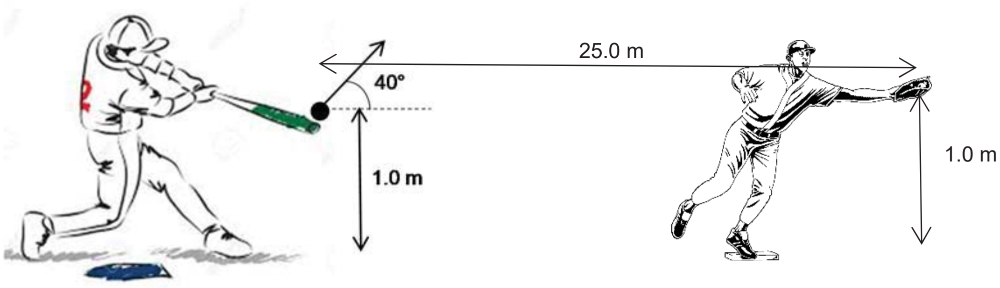


Fig. 2.3

(Not drawn to scale)
Source: clipart panda

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

(ii) Hence or otherwise, comment if it is likely that the outfielder is able to catch the baseball.

……………………………………………………………………………………..…

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

3 A 220 kg satellite is travelling in a circular orbit at a distance of 640 km above the surface of Earth.

The Earth has a radius of 6.37×10^6 m and mass 5.98×10^{24} kg.

(a) Determine the speed of the satellite.

speed = ………………………….. m s^{-1} [3]

(b) The satellite loses mechanical energy at the average rate of 1.4×10^5 J per orbital revolution. The satellite's orbit can be approximated to be a circle of diminishing radius.

(i) Show that the total energy of a satellite is given by $-\dfrac{GMm}{2r}$, where M is the mass of Earth, m is the mass of the satellite and r is the radius of its orbit.

[2]

For Examiner's Use

(ii) Hence or otherwise, show that the initial total energy of the satellite is -6.26×10^9 J.

[1]

(iii) Determine the satellite's new orbiting radius at the end of its 1500th revolution.

radius = ………………………….. m [2]

(iv) Hence or otherwise, determine the magnitude of the average retarding force on the satellite.

force = ………………………….. N [2]

For Examiner's Use

4 (a) (i) Define the *coulomb*.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Explain why a body cannot have a charge of 2.5×10^{-19} C.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) A battery is connected to a uniform Wire A as shown in Fig. 4.1. The battery is assumed to have negligible internal resistance.

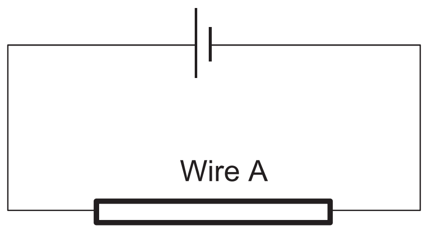


Fig. 4.1

(i) The battery sets up an electric field in the wire, exerting a force on the conducting electrons, causing them to flow across the wire.

Explain why the average kinetic energy of the electron remains unchanged even though its electric potential energy decreases as it flows through the wire.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Wire B, which has the same material and length as Wire A but twice the cross-sectional area, is connected in series to Wire A.

State and explain if there is any difference between the drift velocity of the electrons in Wire A and Wire B.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[2]

[Turn over

(iii) Draw the potential graph for the circuit in **(b)(ii)** in Fig. 4.2.

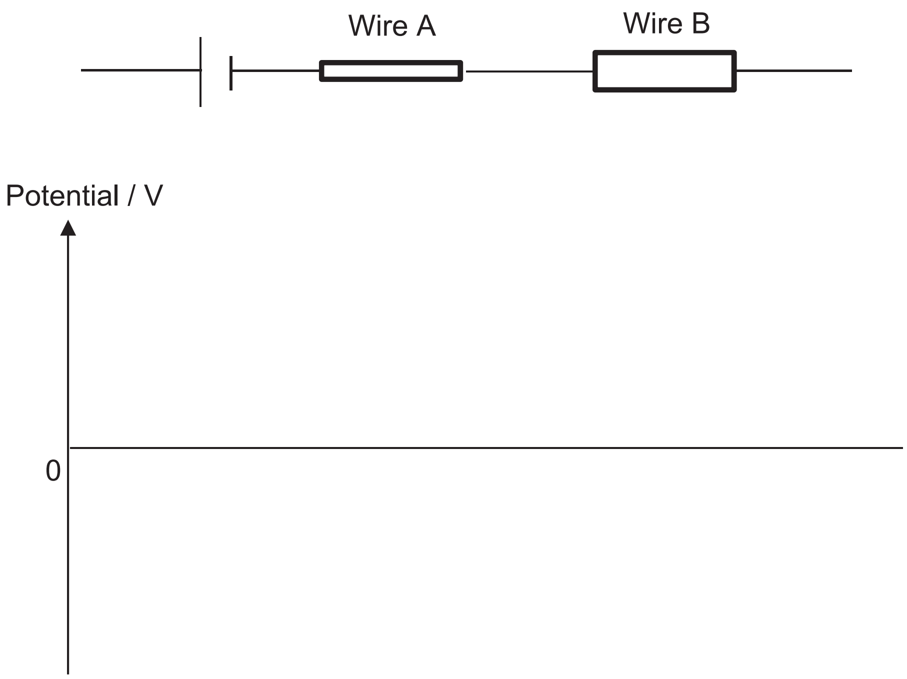


Fig. 4.2

[2]

For Examiner's Use

5 **(a)** Contactless smart cards, such as EZ-link cards, use electromagnetic induction to power its circuitry without any physical contact with the card reader. Fig. 5.1 below shows a common implementation of such a contactless smart card.

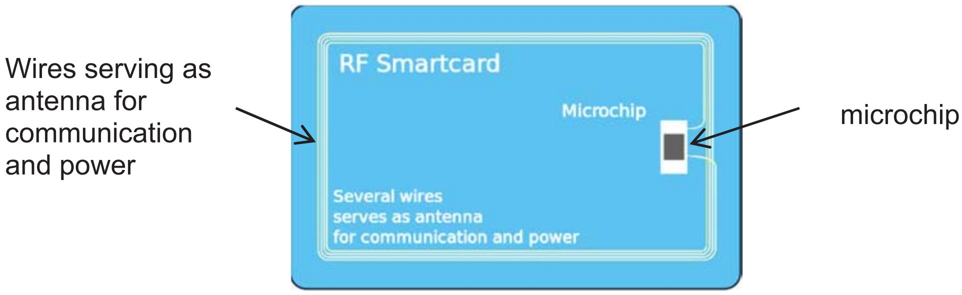


Fig. 5.1

(i) Using Faraday's law of electromagnetic induction, suggest how a smart card reader is able to power the microchip of a contactless smart card without being connected to it by wires.

....

....

....

....

....

....

.... [3]

(ii) A contactless smart card is left on the reader as shown in Fig. 5.2.

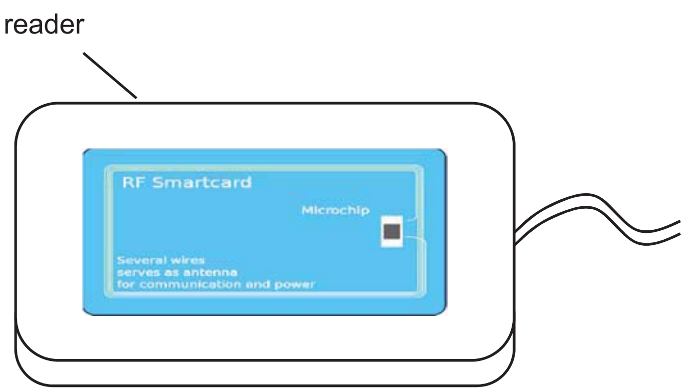


Fig. 5.2

At one instance, the magnetic field generated by the reader is directed out of the surface of the reader, but decreasing in magnitude.

[Turn over

For Examiner's Use

State and explain, using Lenz's law, the direction of current flowing in the smartcard's antenna.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(b) A transformer steps down the mains voltage of 240 V to 5 V to power a lamp that is rated at 2.0 W, 5 V.

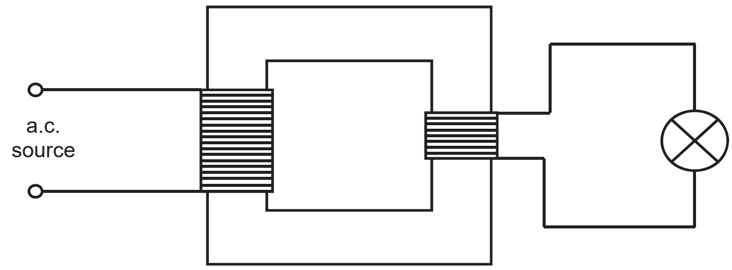


Fig. 5.3

(i) Given that the efficiency of the transformer is 95%, determine the peak current of the ac source.

peak current = ………………………….. mA [3]

(ii) In order to improve the efficiency of power transfer, a student replaces the solid iron core with a laminated iron core.

Explain why this is an effective way to increase the efficiency.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

For Examiner's Use

6 A ball of mass m is suspended from the end of a light spring with spring constant k as shown in Fig. 6.1. At equilibrium, the extension of the spring is x. Air resistance can be neglected.

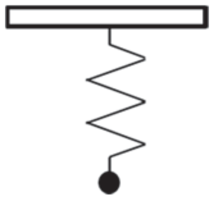


Fig. 6.1

(a) Draw a free body diagram of the forces acting on the ball.

[2]

(b) The ball is given a further downward displacement e and released.

(i) Using Newton's Second Law, show that the relationship between the acceleration of the ball a, and e can be given by $a = -\frac{k}{m}e$.

[2]

(ii) Explain why the motion of the ball is simple harmonic.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

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

[Turn over

For Examiner's Use

(iii) Given that m = 0.2 kg, k = 2.0 N m^{-1} and the maximum amplitude is 0.095 m, determine the maximum kinetic energy of the ball.

maximum kinetic energy = ………………………….. mJ [2]

(iv) Sketch on Fig. 6.2, graphs of the variations with time of the kinetic energy (label **K**) and the gravitational potential energy (label **U**) for the ball over 2 periods.

Fig. 6.2

[2]

(v) A cardboard is attached to the bottom of the ball.

Sketch on Fig. 6.2, the kinetic energy vs time graph for this scenario and label it as **X**.

[1]

For Examiner's Use

Section **B**
Answer **one** question from this section

7 **(a)** State the *principle of conservation of momentum*.

....

....

.... [2]

(b) Fig. 7.1(a) shows a sphere **A** of mass m_1 and speed u_1, and a sphere **B** of mass m_2 and speed u_2.

Fig. 7.1(b) shows the spheres moving at speeds v_1 and v_2 after a head-on elastic collision.

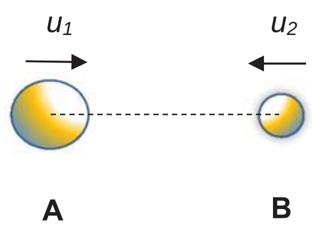


Fig. 7.1(a)

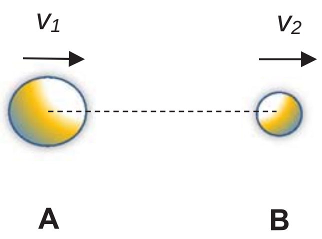


Fig. 7.1(b)

Given that $m_1 = 3$ kg, $m_2 = 1$ kg, and $u_1 = u_2 = 2$ m s^{-1}.

Complete Table 7.1.

	BEFORE collision		***DURING*** collision and at <u>maximum</u> compression		***AFTER*** collision	
	A	**B**	**A**	**B**	**A**	**B**
momentum / Ns	6	– 2				

Table 7.1

All workings must be shown.

For Examiner's Use

[5]

(c) Fig. 7.2 shows identical spheres **P**, **Q** and **R**, each of mass *M*, and sphere **S** of mass *m*. Spheres **P**, **Q** and **R** are stationary while sphere **S** is moving at speed *u*. Collisions are taken to be elastic.

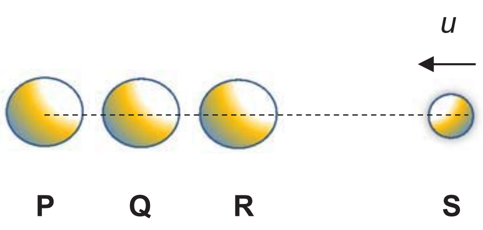


Fig. 7.2

In a head-on elastic collision between 2 spheres, the fraction of the kinetic energy transferred from one sphere to the other is given by

$$\frac{4m_x m_y}{(m_x + m_y)^2}$$

where m_x and m_y are the masses of the 2 spheres.

For Examiner's Use

Given that $M = 3$ kg, $m = 1$ kg, and $u = 2$ m s^{-1}.

Complete Table 7.2.

	BEFORE any collision has taken place				***AFTER*** *all* collisions are completed			
	P	**Q**	**R**	**S**	**P**	**Q**	**R**	**S**
kinetic energy / J	0	0	0	2				
momentum / Ns	0	0	0	– 2				

Table 7.2

All workings must be shown.

[3]

For Examiner's Use

(d) **(i)** **1.** State the *Principle of Floatation*.

....

....

.... [1]

2. State the *Archimedes Principle*.

....

....

....[1]

(ii) A motorboat powered by an engine which rotates an underwater propeller is shown in Fig. 7.3.

To ensure the propeller blades produce the same constant thrust along each blade, the blades are twisted. The rotating blades have an effective radius r which pushes the water backward with a velocity v relative to the boat. The water can be considered to move as a long column of density ρ, radius r and velocity v.

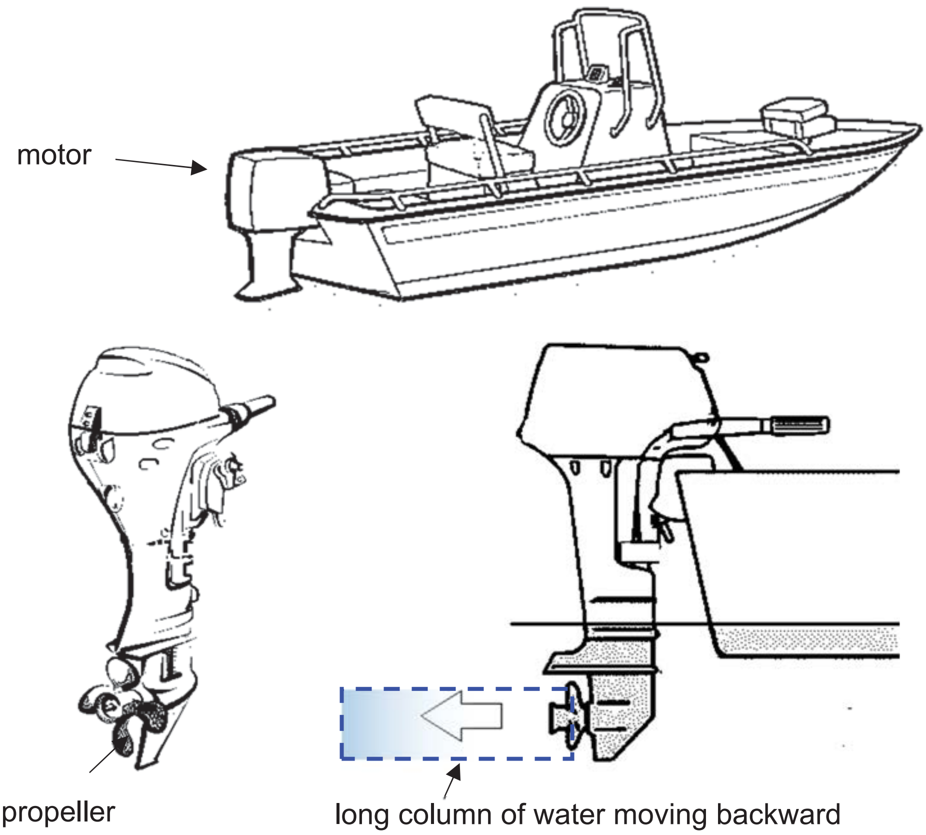


Fig. 7.3

For Examiner's Use

1. Show that the expression of the force exerted on the water by the propeller blades is

$$F = \pi \rho r^2 v^2$$

[2]

2. Given the following data:

effective radius of propeller blades *r*	=	25 cm
density of water ρ	=	1000 kg m^{-3}
mass of motorboat and helmsman	=	1400 kg
cruising speed of motorboat	=	12 m s^{-1}
top speed of motorboat	=	18 m s^{-1}
maximum power of motorboat	=	112 kW

Determine the maximum velocity *v* of the column of water.

v = ………………………….. m s^{-1} [3]

[Turn over

For Examiner's Use

(iii) Fig. 7.4(a) shows a schematic diagram of a motorboat in **(ii)** shaped like a cuboid of base dimensions 6.0 m x 2.0 m.

Fig. 7.4(b) shows the actual shape of the motorboat.

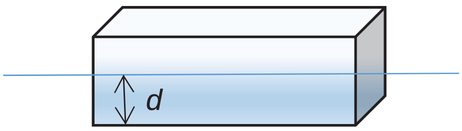


Fig. 7.4(a)

Fig. 7. 4(b)

1. Determine the depth of the waterline *d* when the motorboat is stationary.

d = ………………………….. m [2]

2. When the motorboat is moving at high speed, part of the hull is lifted out of the water as shown in Fig. 7.5.

Fig. 7.5

Explain the reason for the design.

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

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

....…………………………………………………………………………… [1]

For Examiner's Use

8 **(a)** **(i)** State the conditions for the formation of observable stationary waves.

……………………………………………………………………………………….

………………………………………………………………………………………

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

(ii) A contractor tries to measure the depth of a new well shaft to build a ladder to reach the bottom of the shaft. He uses an audio oscillator with adjustable frequency and applies it across the top of the well. Two successive resonances are heard at 70.6 Hz and 90.8 Hz. The speed of sound is 343 ms^{-1}. Determine the depth of the well.

depth of well = ………………………….. m [3]

(b) **(i)** State the *Principle of Superposition*.

………………………………………………………………………………………

……………………………………………………………………………………..

……………………………………………………………………………………..

………………………………………………………………………………………[2]

[Turn over

(ii) An engineering student designed an Automated Guided Vehicle (AGV) using interference of radio waves from two coherent emitters 2 m apart emitting radio waves of frequency f that are in phase as shown in Fig. 8.1. The computer on the AGV detects and searches for lines of constructive interference and adjusts the AGV so that it is always align along the middle line of the emitters where one such line of constructive interference is located.

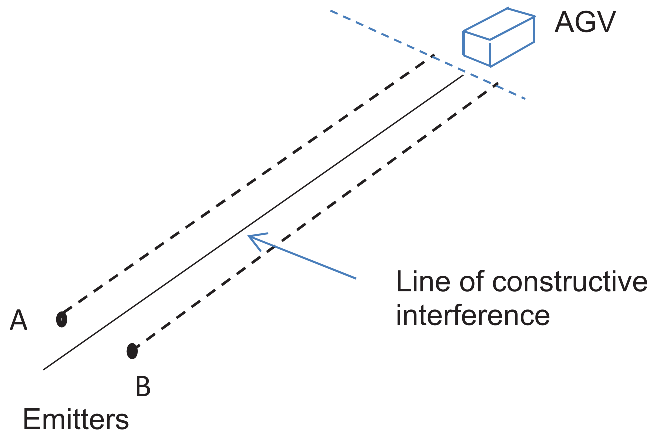


Fig. 8.1

During one such operation, the AGV strays off the centre-line as shown in Fig. 8.2. Fig. 8.3 shows the radio signals X and Y detected by the receiver on the AGV.

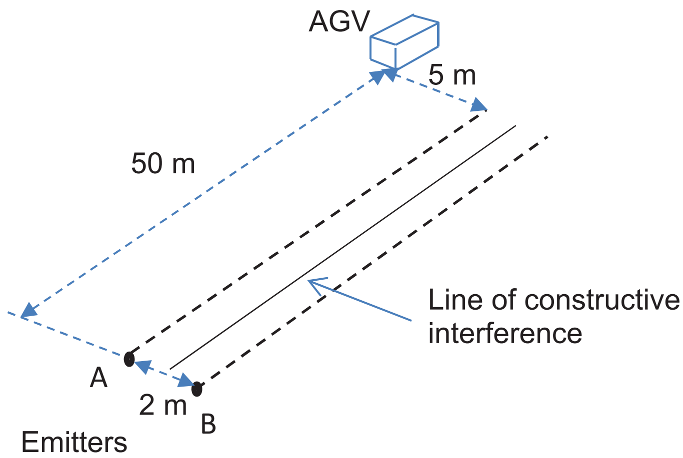


Fig. 8.2

For Examiner's Use

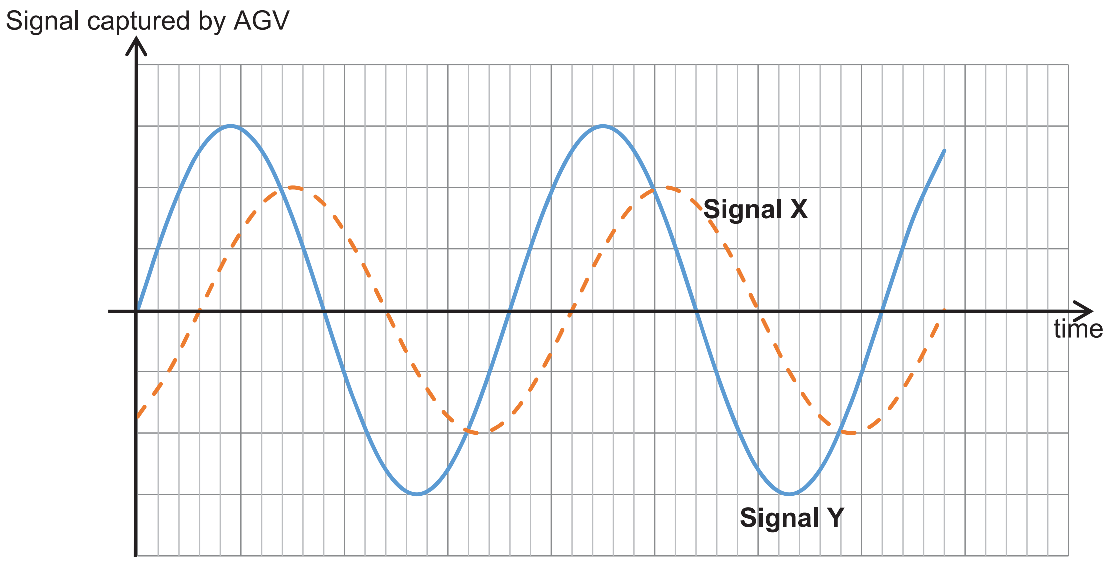


Fig. 8.3

1. State and explain whether the source of signal X is from emitter A or B.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………[2]

2. State the phase difference between signals X and Y.

phase difference = ………………………….. rad [1]

3. Hence determine the frequency *f* of the radio wave used.

frequency = ………………………….. Hz [4]

[Turn over

For Examiner's Use

4. Suggest how the AGV can align itself to the centre of the 2 emitters.

....

....

....

....

....

....[2]

(c) Blue light of wavelength 486.5 nm is incident on a diffraction grating. The light is diffracted into a number of beams as shown in Fig. 8.4. The second order bright spots are observed at 0.845 m from the central spot on a screen which is placed at 2.00 m from the grating.

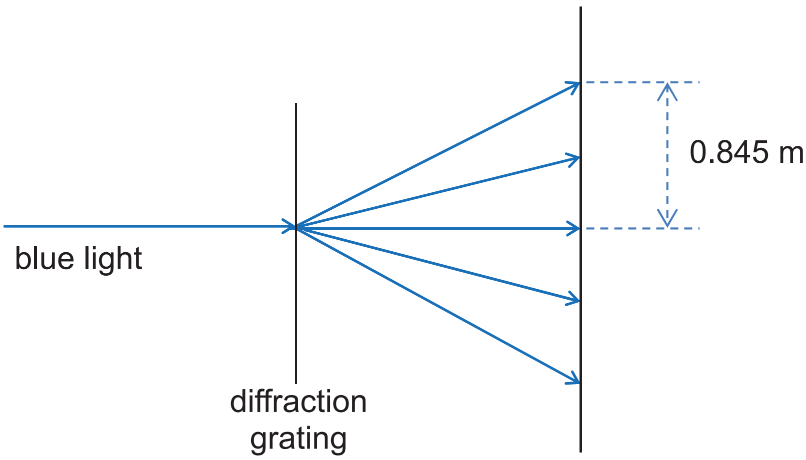


Fig. 8.4

(i) Calculate the number of lines per millimeter on the grating.

number of lines per mm = ... mm^{-1} [2]

For Examiner's Use

(ii) State and explain an advantage and a disadvantage of obtaining the lines per millimeter of the grating by using the second-order diffracted light rather than the first-order diffracted light.

....

....

....

....

....

.... [2]

H

Anglo-Chinese Junior College

JC2 Physics Preliminary Examination
Higher 2

A Methodist Institution
(Founded 1886)

CANDIDATE NAME		Form CLASS	
CENTRE NUMBER		INDEX NUMBER	

Paper 4 Practical Test **9749**

4 August 2017
2 hour 30 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Write your answers in the spaces provided on the question paper.
The use of 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, fasten all your work securely together.

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

Shift
Laboratory

For Examiners' use only	
Section A	**Marks**
1	/ 20
2	/ 16
3	/ 7
4	/ 12
Total	/ 55

For Examiner's Use

1. In this experiment, you will time the oscillations of a small mass suspended on V-shaped string at varying angles.

(a) **(i)** Set up the apparatus as shown in Fig. 1.1.

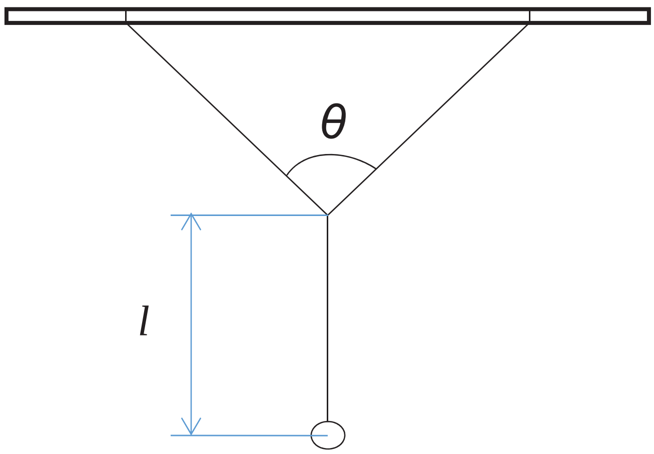


Fig. 1.1

(ii) Measure and record the distance l.

l = ………………..........

(iii) Measure and record the angle θ.

θ = ………………..........

(b) Displace the bob through a short distance and release it so that it performs oscillations in a vertical plane at right angles to the rule as shown in Fig. 1.2.

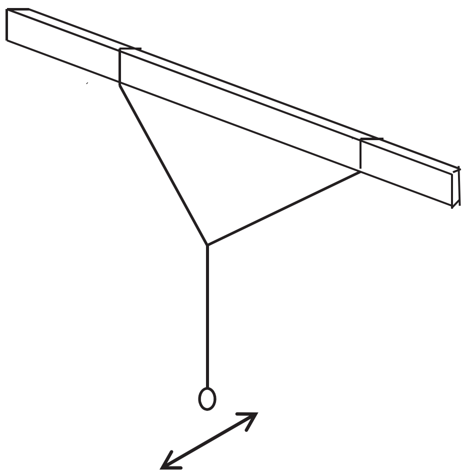


Fig. 1.2

For Examiner's Use

Make and record measurements to determine the period T of the oscillation.

T = ……………….......... [1]

(c) Vary θ in the range $50^0 \leq \theta \leq 150^0$. Repeat to obtain further sets of readings for T.

[6]

(d) Justify if the angle θ has an effect on the period T of the oscillation. Explain your conclusion clearly.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

[Turn over

For Examiner's Use

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

$$T^2 = \frac{4\pi^2 l}{g} cos\frac{\theta}{2} + c$$

where c is a constant and g is the gravitational field strength.

Plot a suitable graph and determine the gradient and the y-intercept of the line.

gradient = …………….............

y-intercept = ……………............. [3]

(f) Use your values in **(e)** to determine a value for g.

g = ……………............. [1]

For Examiner's Use

[3]

[Turn over

For Examiner's Use

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

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

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

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

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

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………..[1]

(i) In the expression in **(e)**, *c* is inversely proportional to *g*. On the same graph grid, sketch a second graph to represent the results if the same experiment is conducted in another location with a higher gravitational field strength.

[1]

For Examiner's Use

2. In this question, you will investigate if the mass flow rate of salt passing through the hole in a funnel depends on the mass of salt in the funnel.

You are supplied with 2 small containers, Container **A** and **B**, of identical dimensions and holding a total of 90 g of salt. You are also provided with a larger empty container. The mass of salt in Container **A** is m_A and the mass of salt in Container **B** is m_B.

(a) **(i)** Measure and record the depth x of salt in Container **A** using the vernier caliper.

x = ……………........... [1]

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

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

(iii) Make further measurements with the vernier caliper to determine the mass m of salt in Container **A** and Container **B**.

m_A = ……………...........

m_B = ……………........... [3]

[Turn over

For Examiner's Use

(iv) Suggest a modification that can be made to the experiment to improve the reliability of the measurement of x made using the vernier caliper.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(b) Mount the funnel using a retort stand and place the empty container beneath the funnel as shown in Fig. 2.1.

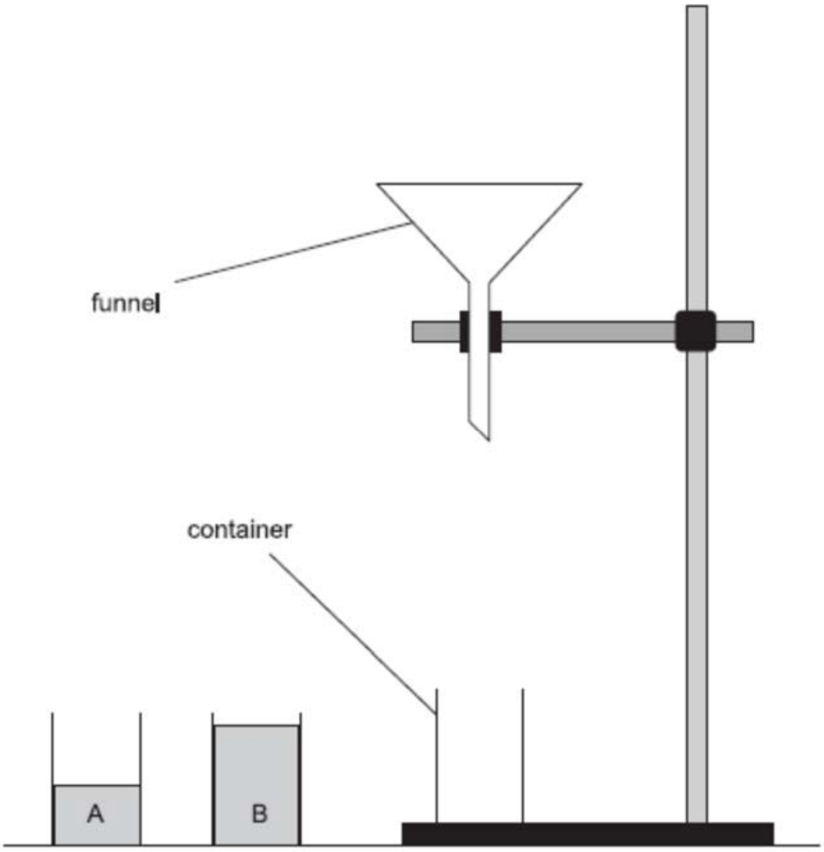


Fig. 2.1

(i) Place your finger over the hole at the bottom of the funnel and pour the salt from Container **A** into the funnel.

Move your finger away and record t_A, the time taken for all the salt to leave the funnel.

t_A = ……………............ [1]

For Examiner's Use

(ii) Estimate the percentage uncertainty in t_A.

Percentage uncertainty in t_A = …………….......... [1]

(c) The mass flow rate of a material can be defined by the rate of flow of the mass per unit time.

Determine the mass flow rate of the salt from Container **A** through the funnel.

Mass flow rate of salt in Container **A** = …………….......... [1]

(d) State and explain which of the 2 measurements, t_A or m_A, has a more significant effect on the uncertainty of mass flow rate.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

[Turn over

For Examiner's Use

(e) It is suggested that an increase in mass of salt in the funnel will increase the mass flow rate of the salt through the funnel.

With the apparatus given, take further measurements to investigate the relationship between the mass of the salt in the funnel and its mass flow rate. Use your results to comment whether you agree with this suggestion.

Present your measurements and calculated results clearly.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………[4]

(f) In practice, hoppers used in food processing industry are used to store and dispense loose material such as grains. The design of the hopper bears resemblance to a funnel.

As the size of grains may vary, suggest one method that can be used to maintain the flow rate during the dispensing of the grains.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

For Examiner's Use

3. In this experiment you will investigate the contents of Box **A** and Box **B** which contain resistors.

The contents of the boxes are shown below in Fig. 3.1.

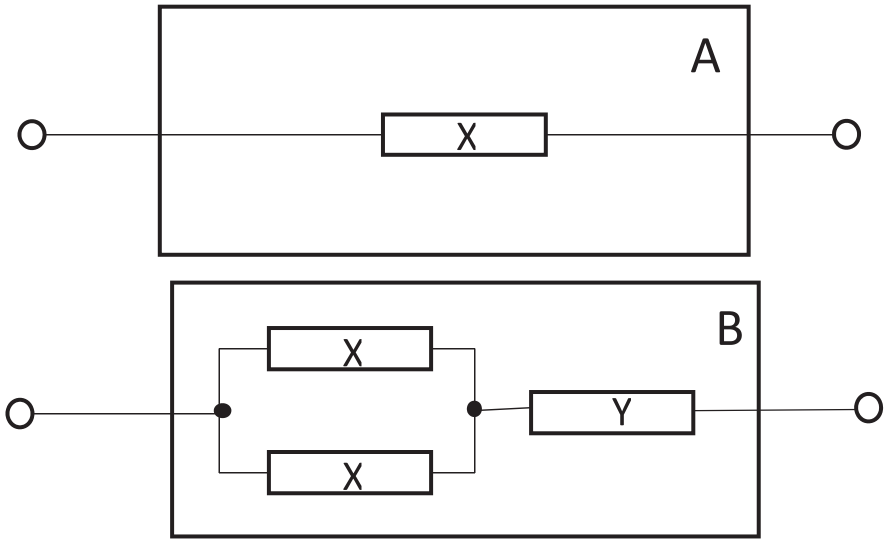


Fig. 3.1

(a) Set up the digital multi-meter as an ammeter to measure current with a range of 200 mA.

Use the 1.5 V dry cell and the digital multi-meter to set up a circuit to estimate the resistance of Resistor **X** and Resistor **Y**.

Draw a circuit diagram of your setup and show your readings and working clearly.

Resistance of Resistor **X** = ……………………........

Resistance of Resistor **Y** = ……………………........ [4]

[Turn over

For Examiner's Use

(b) Set up the digital multi-meter as an ohmmeter by selecting the appropriate range for resistance measurement. Make direct measurement and obtain readings for boxes **A** and **B**. Determine the resistance of Resistor **X** and Resistor **Y**.

Resistance of Resistor **X** = ……………………..……

Resistance of Resistor **Y** = ……………………………[2]

(c) Justify the differences in the values obtained in **(a)** and **(b).**

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

4. Static friction can be defined as the frictional force which exist between a stationary object and the surface it is in contact with. The magnitude of static friction that an object experiences can vary over a range of values. It can be affected by factors such as the mass of the object, the magnitude of the external force that is exerted on the object and the texture of the surface that it is in contact with. The maximum static friction can be defined as the magnitude of the force the surface exerts on the stationary object just before the object starts to move.

When an object is placed on a circular disc and the disc starts to spin about its centre, the static friction provides the centripetal force to keep the mass on the same location on the disc. The mass can be observed to start slipping when the angular velocity of the disc exceed a certain value.

A student suggested that the relationship between the angular velocity of the disc, ω, the mass of the object, m, and its distance from the centre of the disc, r, may be written in the form

$$\omega = k\, r^x\, m^y$$

where k, x and y are constants.

You are provided with a motor which has an axle that is attached to the centre of a circular disc. You may also use any of the other equipment usually found in a physics laboratory.

Design an experiment to determine the values of k, x and y.

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

[Turn over

For Examiner's Use

Diagram

For Examiner's Use

[12]

[Turn over

JC2 H2 Physics
Preliminary Examinations Paper 1 MS

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

Qn	MS
1a) (i)	$T - m_B g = m_B a$ $T - 3g = 3a$
	$10g\sin 30° - T = 10a$ $5g - T = 10a$
	$13a = 2g$ $a = 1.51 ms^{-2}$
(ii)	$\frac{1}{2}mv_i^2 + mgh = \frac{1}{2}mv_f^2$ $\frac{1}{2}(3)(0.5)^2 + 3g(2) = \frac{1}{2}(3)v_f^2$
	$v_f = 6.28 ms^{-1}$
1 b)	Gain in gpe = -Work done by conservative force
	= - $F_g D$ =- (mg(-h))
	= mgh

2(a)(i)	momentum after elastic collision = - mu time between collisions = 2L/u number of collisions per unit time = u/2L
	rate of change of momentum = - mu^2/L average force = mu^2/L
(b)(i)	Gas molecules collide with one another elastically
(ii)	Since KE is conserved, the average speed of the gas molecule incident on the wall remains the same.
	Frequency of collision between each wall and the molecule remains unchanged.
(c)	$pV = 1/3\ Nm\langle c^2\rangle$
	$NkT = 1/3\ Nm\langle c^2\rangle$
	(3/2)kT = Ave KE *T α Ave KE*

(d)(i)1.	Area under graph bounded by y-axis
2.	Hence $P_AV_A = P_BV_B$ Difference is 0
(iii)	If expansion takes place very quickly, Q = 0
	There is an decrease in KE of the gas hence mean square speed decreases

3a) (i)	Out of the page
(ii)	Apply an Electric Field with E. Field strength in the upwards direction
(iii)	$qE = Bqv$
	$v = \frac{E}{B}$
(b) (i)	$\frac{1}{2}mv^2 = 10eV$ $\frac{1}{2}(9.11\times10^{-31})v^2 = 10(1.6\times10^{-19})$
	$v = 1.87\times10^6 ms^{-1}$
(ii)	The magnetic force provides the centripetal force
	$Bqv_{vert} = \frac{m_e v_{vert}{}^2}{r}$ $Bq = \frac{m_e v_{vert}}{r} = m_e w$ $\frac{2\pi}{T} = \frac{Bq}{m_e}$ $T = \frac{2\pi m_e}{Bq}$
	Pitch, p = V_{hor}T = (v cos θ)(T)
	$p = \frac{v\cos\theta(2\pi m_e)}{Bq}$
(iii)	$3p = \frac{v\cos\theta(2\pi m_e)}{Bq}\times3$ $= \frac{1.87\times10^6(\cos60°)(2\pi)(9.11\times10^{-31})}{(5\times10^{-4})(1.6\times10^{-19})}\times3$
	$= 0.201m$

4a)	Electric field strength at a point in the field is defined as the electric force experienced per unit charge
	by a small stationary positive point test charge placed at that point and is in direction of the electric force on a positive test charge at that point

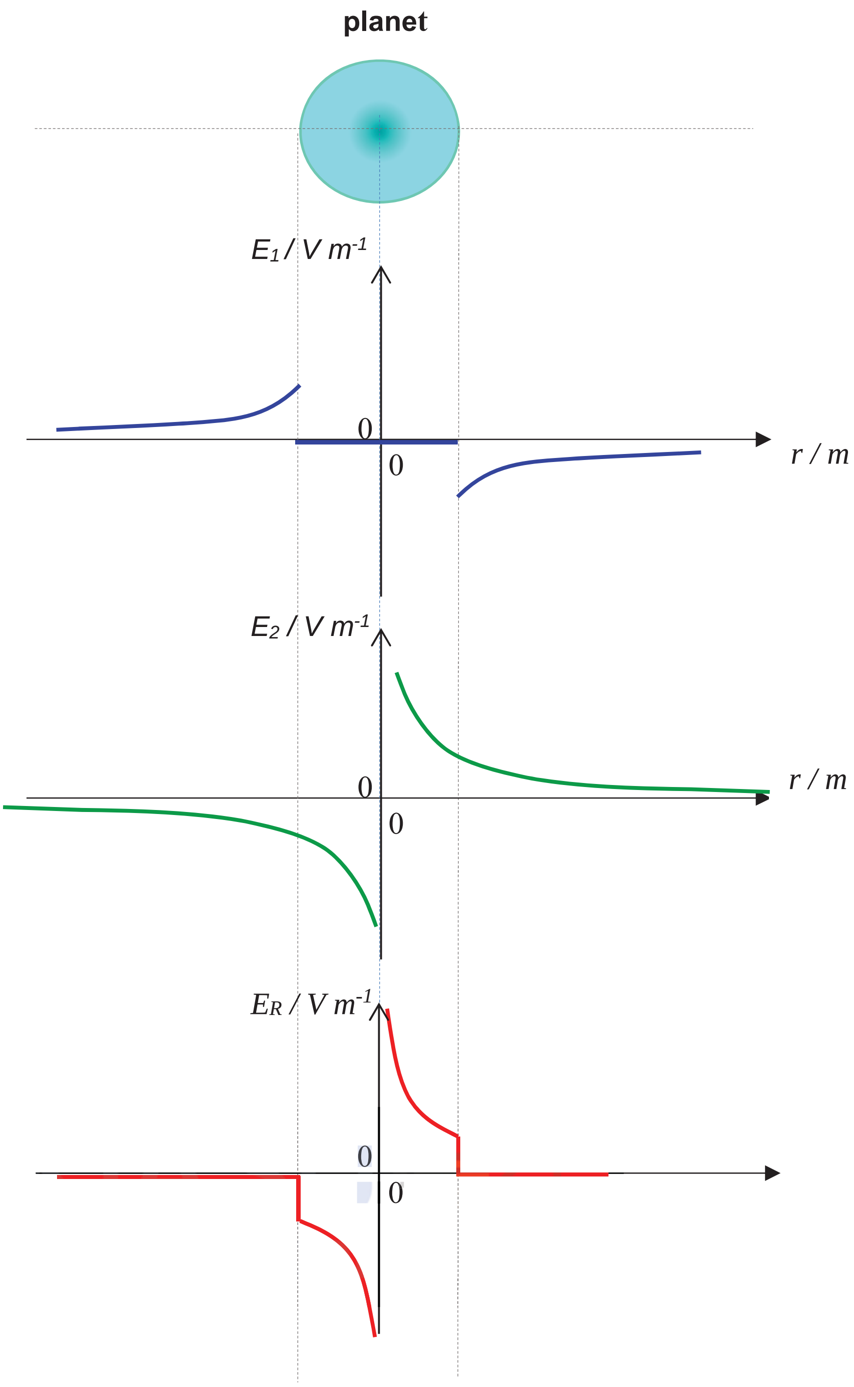
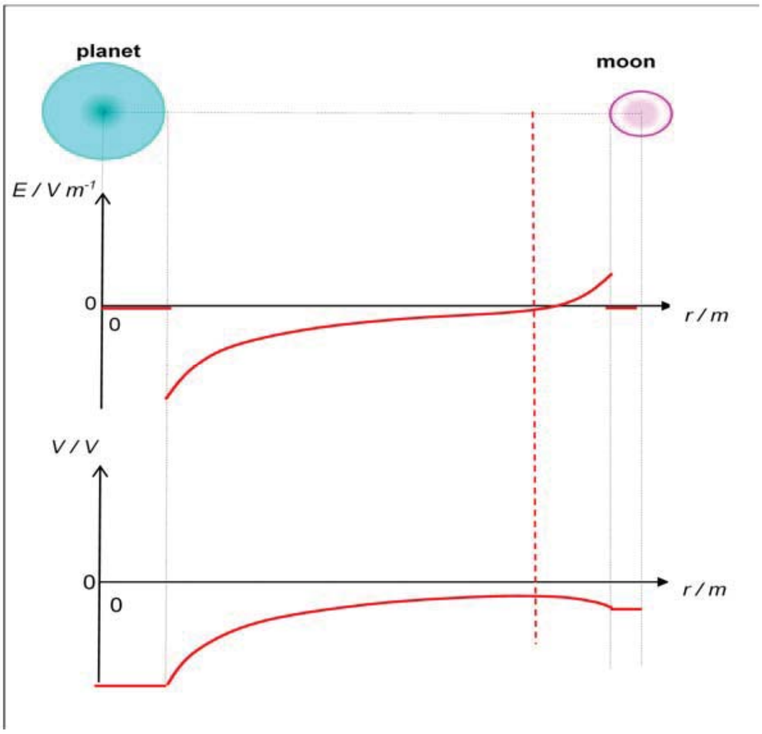
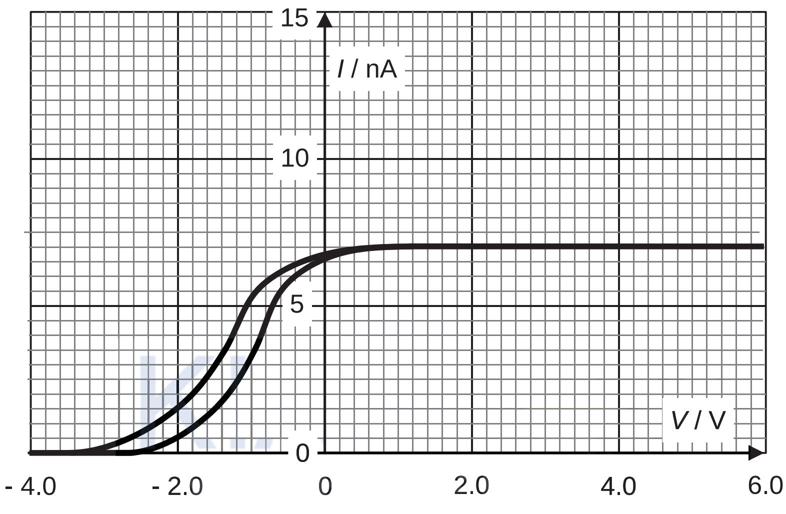


Fig. 4.1(a)

Fig. 4.1(b)

Fig. 4.1(c)

	(b)	Inside mass : both graphs E_1 and E_2 are correct
		Outside mass : both graphs E_1 and E_2 are correct
		E_3 is correct based on graphs E_1 and E_2
	(c)	
		E graph is correct, magnitude of *E* near earth > magnitude of *E* near moon
		V graph is correct, magnitude of *V* near earth > magnitude of *V* near moon
		E = 0 coincides with $\frac{dV}{dr} = 0$
	(d)	$F = qE$ $a_y = \frac{qV}{m_e d} = \frac{(1.6\times10^{-19})(80)}{(9.11\times10^{-31})(4\times10^{-3})}$ $= 3.51\times10^{15}\,ms^{-2}$
		$S_y = u_y t + \frac{1}{2}a_y t^2$ $2\times10^{-3} = \frac{1}{2}(3.51\times10^{15})t^2$ $t = 1.07\times10^{-9}\,s$
		$S_x > 0.05$ $u_x t > 0.05$ $u_x > \frac{0.05}{1.07\times10^{-9}}$ $= 4.673\times10^{7}\,ms^{-1}$
		$u_x = 4.68\times10^{7}\,ms^{-1}$

5(a) (i)	dip in intensity at specific wavelengths
	Absorption spectrum
(ii)	Transition is least energetic transition out of all the transitions to n=2, i.e. transition giving rise to 656 nm line.
	$\Delta E_{656nm} = \dfrac{(6.63\times10^{-34})(3.0\times10^{8})}{656\times10^{-9}}$ $= 3.03\times10^{-19}$
	$E_3 = E_2 + \Delta E_{656nm}$ $= -5.44\times10^{-19} + 3.03\times10^{-19}$ $= -2.41\times10^{-19}$ J / -1.51eV
(b) (i)	EM waves will continuously transfer energy to the electrons to overcome the work function.
	Even if lower frequency waves are used, the electrons can accumulate energy over time to gain enough energy to overcome the work function
	Hence no minimum frequency should exist.
(ii)	Stopping potential correctly identified: -2.6V or -2.7V
	$\phi = \dfrac{hc}{\lambda} - eV_s$ $= \dfrac{(6.63\times10^{-34})(3.0\times10^{8})}{(184\times10^{-9})} - (1.60\times10^{-19})(2.6)$
	$\phi = 6.65\times10^{-19}$ J(2.6V) $= 6.49\times10^{-19}$ J(2.7V)
(iii)	

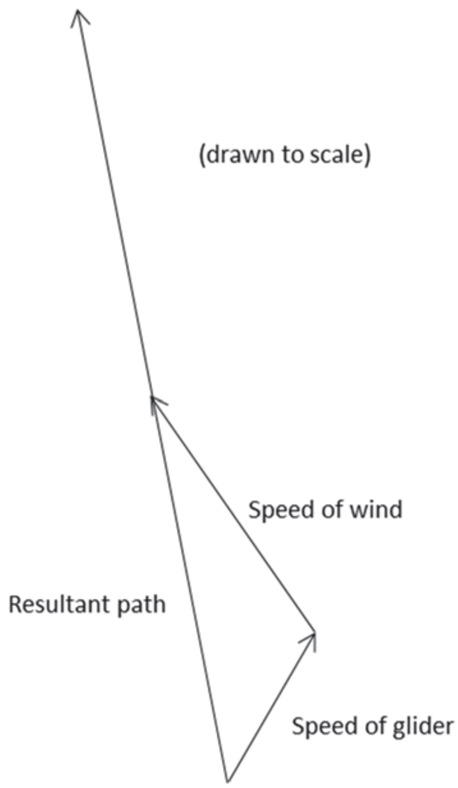
6(a) (i)	$\left(E = BE_{products} - BE_{reac\tan ts}\right)$ E = (BE per nucleon of C) x 12 – 3 x (BE per nuceon of He x 4) $E = \left[12\times(7.680) - 3\times(4\times 7.074)\right]$	
	7.272 MeV	
(ii)	$P = \frac{E_{total}}{t}$ $= \frac{\text{number of reactions} \times E_{\text{each reaction}}}{t}$ $\frac{\text{number of reactions}}{t} = \frac{P}{E_{\text{each reaction}}} = \frac{2.75\times 10^{26}}{7.272\times 10^{6}\left(1.6\times 10^{-19}\right)}$ $\left(= 2.3635\times 10^{38}\ \text{s}^{-1}\right)$	
	$\frac{n}{t} = \frac{\text{number of reactions}}{t} \times 3 = \left(2.3635\times 10^{38}\right)(3)$	
	$\frac{n}{t} = 7.09\times 10^{38}$ helium nuclei per second	
(b)	The energy released that is converted into KE of the products is constant	
	The total momentum of the system before and after the reaction is conserved.	
	Since the electron is found to have a range of KE, this means that there must be a third element present in order for COE and COM to be upheld	
(c)	$N_{Rn;initial} = \frac{m}{A_r} \times N_A = \frac{2.0}{220} \times 6.02\times 10^{23}$ $\left(= 5.4727\times 10^{21}\right)$	
	$N_{Rn;\,final} = N_{Rn;initial} e^{-\frac{\ln 2}{t_{1/2}}(t)} = 5.47272\times 10^{21}\left(e^{-\frac{\ln 2}{56}(60\times 5)}\right)$ $= 1.3352\times 10^{20}$	
	$m_{left} = \left(N_{ini} - N_{final}\right)\times \frac{A_{r\,Po}}{N_A} + N_{final} \times \frac{A_{r\,Rn}}{N_A}$ $= \left(5.4727\times 10^{21} - 1.3352\times 10^{20}\right)\left(\frac{216}{6.02\times 10^{23}}\right) + \left(1.3352\times 10^{20}\right)\left(\frac{220}{6.02\times 10^{23}}\right)$	
	$= 1.96$ g	

7)a)i)	- Difficult to locate good heat reservoir - Difficult in drilling	
ii)	- Wind condition of the farm - Cost of transmission	
iii)	- unreliable in terms of supply as most are weather dependent - More mature technology which translate into higher efficiency	
b)i)	When the air molecules are incident on the blade, they experience a change in momentum	
	Therefore, by N2L, the blade must have exerted a force on the air molecules	
	By N3L, the air molecules must exert a force of the same magnitude on the blades and thereby turning the blade	
ii)	Mass of air per sec passing thru the turbine= ρV $= 1.23(\pi(50)^2(13.5))$ $= 1.30 \times 10^5$ kg	
	$E = \frac{1}{2}mv_i^2 - \frac{1}{2}mv_f^2$ $= \frac{1}{2}(1.30 \times 10^5)(13.5)^2 - \frac{1}{2}(1.30 \times 10^5)(12.8)^2$ $= 1.20 \times 10^6$ W	
	$= 1.20 \times 10^6$ W	
iii)	Energy requirement of town per month = 4100×2000 $= 8.2 \times 10^6 kWh$	
	No. required = $\frac{8.2 \times 10^6}{1.2 \times 10^3 \times 24 \times 30 \times 0.22}$ = 43.14	
	Minimum number required is 44	
c)i)	The slope of the wind lens forces the air inwards at the front of the wind lens and outwards at the exit of the wind lends thereby generating a region of high pressure in front of the wind lens and a region of low pressure behind the wind lens	
	The difference in air pressure in front of and behind the wind turbine exerts an additional force on the air thereby increasing the wind speed.	
ii)	$P_{\text{with lens}} = 2.50$ $P_{\text{without lens}} = 1.00$	
	Difference 2.50 – 1.00 = 1.5 kW	
iii)	$P = kv^n$ $\frac{0.20}{1.00} = (\frac{5.50}{9.50})^n$	
	n = 2.94	

	$P = kv^n$ $1.00 = k(9.50)^{2.94}$ $k = 1.34 \times 10^{-3}$	

H2 P3 Prelim MS

Q			Mark Scheme
1	(a)		$\text{unit of D} = (\text{units of k})(\text{units of d})$ $\text{units of k} = 1$
			$\text{unit of Q} = (\text{units of C})(\text{units of }\rho)(\text{units of }\sqrt{g})(\text{units of D})^{3/2}$
			$\text{kg s}^{-1} = (\text{units of C})(\text{kg m}^{-3})(\sqrt{\text{m s}^{-2}})(\text{m}^{3/2})$ $\text{units of C} = \text{m}$
	(b)	(i)	$\rho = \frac{\text{mass}}{\text{volume}}$ $= \frac{0.2125}{\pi(\frac{0.036}{2})^2(0.024)}$ $= 8.70 \times 10^3 \text{ kg m}^{-3}$
			$\rho = \frac{\text{m}}{\text{v}}$ $= \frac{\text{m}}{\pi(\frac{\text{d}}{2})^2 h}$ $\pm\frac{\Delta\rho}{\rho} = \pm(\frac{\Delta m}{m} + 2\frac{\Delta d}{d} + \frac{\Delta h}{h})$
			$= \pm(\frac{0.1}{212.5} + 2(\frac{0.2}{3.6}) + \frac{0.2}{2.4})$ $= \pm 0.195$
			$\pm\Delta\rho = \pm 1.70 \times 10^3$ $\approx \pm 2 \times 10^3 \text{ kg m}^{-3}$ $\therefore \rho \pm \Delta\rho = (9 \pm 2) \times 10^3 \text{ kg m}^{-3}$
	(b)	(ii)	Diameter as the term $2\frac{\Delta d}{d}$ has the largest contribution to the uncertainty of density.

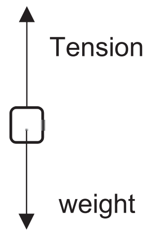
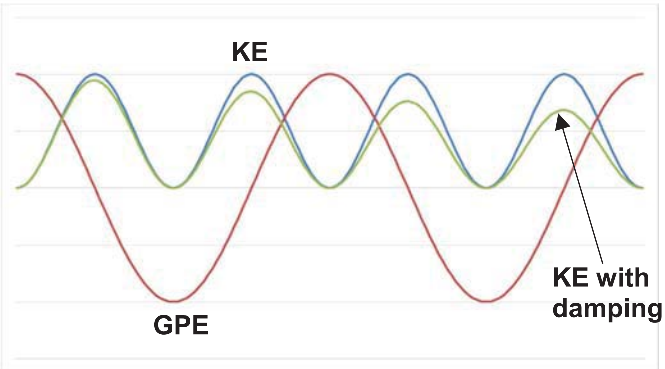
	(c)		(drawn to scale) Speed of wind Resultant path Speed of glider

2	**(a)**	**(i)**	$v_y{}^2 = u_y{}^2 + 2a_y s_y$ $s_y = \dfrac{(38 sin 40°)}{2(9.81)}$
			$= 30.4m$
			$s_y = 30.4 + 1 = 31.4m$
		(ii)	$\frac{1}{2}mv^2 = \frac{1}{2}mu^2 + mgh$ $v^2 = u^2 + 2gh$ $= (38)^2 + 2(9.81)(1)$
			$v = 38.26ms^{-1}$
		(iii)	Horizontal distance of second half of curve less than half compared to first half, not symmetrical
			Starting point 1m, max height less than 31.4m
	(b)	**(i)**	$S_y = u_y t + \frac{1}{2}a_y t^2$ $0 = (38 sin 40°)t + \frac{1}{2}(-9.81)t^2$ $t = 4.98s$
			$S_x = u_x t$ $= (38 cos 40°)(4.98)$ $= 145m$
			$Speed = \dfrac{145 - 25}{4.98}$ $= 24ms^{-1}$
		(ii)	No, as the fastest 100m sprint time is 10 ms^{-1}

3	**(a)**		Gravitational force provides the satellite with centripetal force
			$\frac{GMm}{r^2} = \frac{mv^2}{r}$
			$v = \sqrt{\frac{GM}{r}}$
			$v = \sqrt{(\frac{6.67\times10^{-11})(5.98\times10^{24})}{7.01\times10^{6}}}$
			= 7.54 x 10^3 m s^{-1}
	(b)	**(i)**	Gravitational force provides the satellite with centripetal force
			$\frac{GMm}{r^2} = \frac{mv^2}{r}$ $\frac{1}{2}mv^2 = \frac{GMm}{2r}$
			$TE = KE + GPE$ $= \frac{GMm}{2r} - \frac{GMm}{r}$ $= -\frac{GMm}{2r}$
		(ii)	$Total\ \ Energy\ = -\frac{GMm}{2r}$
			$Total\ \ Energy\ = -\frac{(6.67\times10^{-11})(5.98\times10^{24})(220)}{2(7.01\times10^{6})}$
			= – 6.26 x 10^9 J
		(ii)	Total Energy after 1500 orbits = – 6.26 x 10^9 – (1500)(1.4 x 10^5)
			= – 6.47 x 10^9 J
			$New\ orbit\ = -\frac{GMm}{2(-6.47\times10^{9})}$
			= 6.78 x 10^6 m
		(iii)	Loss in Total Energy = (Ave retarding force)(ave distance of 1500 orbit)
			Ave retarding force = Loss in TE / average distance
			= 1.4 x 10^5 / 2π [6.895 x 10^6]
			= 3.23 x 10^{-3} N

4	**(a)**	**(i)**	The coulomb is the amount of charge that passes through a cross sectional area when a current of 1 ampere passes through it for 1 s.
		(ii)	Charge consists of integer multiples of the elementary charge
	(b)	**(i)**	The loss in EPE of the conduction electrons is converted into KE and the collision with neighbouring atoms causes it to lose KE
			Rate of EPE loss and rate of loss of KE is the same, therefore average drift velocity remains the same
		(ii)	Current in both wires are the same
			Electrons in the smaller cross-sectional area wire **A** is higher than the drift velocity compare to wire **B**
		(iii)	The resistances of the wires are high compared to the internal resistance so that current flowing through internal resistance is very small
	(c)	Potential drops across battery, potential increases across resistors and the potential at the beginning and end of graph is the same	
		Increase in potential of thinner wire is twice that of thicker wire.	

5	**(a)**	**(i)**	The reader produces a varying magnetic field in the area around the card reader.
			The antenna of the card will experience a changing magnetic flux linkage and an emf will be induced
			Since the antenna is a closed circuit, the current will flow into the microchip
		(ii)	The induced magnetic field should be out of the card reader, and
			the induced current is anticlockwise
	(b)	**(i)**	$P = V_{rms} \times I_{rms}$ $I_{rms} = \frac{2}{5} = 0.4A$
			$\frac{V_{rms,pri}}{V_{rms,\sec}} = \frac{I_{rms,\sec}}{I_{rms,pri}}$ $I_{rms,pri} = \frac{5}{240}(0.4)(\frac{1}{0.95}) = 8.77mA$
			$I_{peak,pri} = \sqrt{2}(8.77) = 12.4mA$
		(ii)	With lamination, the paths for eddy current to flow is narrower
			Therefore, eddy current is greatly reduced and hence power loss is reduced

6	**(a)**		
	(b)	**(i)**	mg = kx Fnet = ma mg - T = ma
			mg - k(e + x) = ma - ke = ma
			$a = -\frac{k}{m}e$
		(ii)	*a* is directly proportional to *e* as k/m is a constant
			a is always directed towards the equilibrium point as indicated by the negative sign
		(iii)	$KE = \frac{1}{2}mv^2 = \frac{1}{2}m(wx_o)^2 = \frac{1}{2}m((\frac{k}{m})x_o)^2$ $= \frac{1}{2}(0.2)((\frac{2.0}{0.2})(0.095))^2$
			=9.03 mJ
		(iv)	 *
			Sin^2 or cos^2 graph for KE (note freq and 2 cycles)
			Cosine (if ke is sin^2) or sine (if ke is cos^2) graph for gpe (note freq and 2 cycles)
		(v)	Sin^2 or cos^2 graph with decreasing amplitude, to follow graph in (iv)

7	**(a)**	It states that total momentum is conserved before and after the collision,
		provided there is no net external force acting on the system.
	(b)	Before and after collision,
		Applying PCOM, $m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$ $(6) - 2 = 3v_1 + v_2$ $4 = 3v_1 + v_2 \quad \cdots\cdots\cdots\cdots(1)$
		As relative speed of approach = relative speed of separation, $u_1 + u_2 = v_2 - v_1$ $4 = v_2 - v_1 \quad \cdots\cdots\cdots\cdots(2)$
		$v_1 = 0\ ms^{-1}$; $v_2 = 4\ ms^{-1}$
		$m_1 v_1 = 0\ Ns$; $m_2 v_2 = 4\ Ns$
		During collision,
		At max compression, $v_B = v_A$ $(m_1 + m_2)\, v_f = 4$ $v_f = 1\ ms^{-1}$
		$m_1 v_1 = 3\ Ns$; $m_2 v_2 = 1\ Ns$
	(c)	After S collides with R, $\dfrac{4m_x m_y}{(m_x + m_y)^2} = \dfrac{4(3)(1)}{(4)^2} = 0.75$ $KE_S = (1 - 0.75)(2) = 0.5\ J$ $v_S = \dfrac{2(0.5)}{1} = 1\ ms^{-1}$ $p_S = 1 Ns$
		After R collides with Q, and Q collides with P, $\dfrac{4m_x m_y}{(m_x + m_y)^2} = \dfrac{4(4)(4)}{(4+4)^2} = 1$ Shows KE is fully transferred from R to Q and Q to P $v_R = v_Q = 0$ $KE_R = KE_Q = 0$ $p_R = p_Q = 0$
		$KE_P = 2 - 0.5 = 1.5\ J$ $v_P = \dfrac{2(1.5)}{3} = 1\ ms^{-1}$ $p_P = -3\ Ns$ as momentum is conserved

	(d)	**(i)**	**1.**	It states that when a body is wholly or partially immersed in a fluid, it experiences an upthrust that is equal to the weight of the body.
			2.	It states that the upthrust on a body when it is wholly or partially immersed in a fluid is equal to the weight of the displaced fluid.
	(d)	**(ii)**	**1.**	$\vec{F}_W = \dfrac{d\,\overrightarrow{mv}}{dt}$ $= \dfrac{\rho A l}{t} v$
				$= \dfrac{\rho(\pi r^2)l}{t} v$
				$= \pi \rho r^2 v^2$
			2.	$F_B = \dfrac{P}{v}$ $= \dfrac{112000}{18} = 6220 N$
				$\vec{F}_W = \pi L^2 \rho v^2$ $6220 = \pi (0.25)^2 (1000)(v)^2$
				$v = 5.63\ ms^{-1}$
	(d)	**(iii)**	**1.**	$\text{Upthrust on boat} = \text{weight of boat}$ $\rho V g = m g$ $(1000)(6.0)(2.0) d g = (1400) g$
				$d = 0.117\ m$
			2.	The length of the wetted surface is reduced, and hence the drag is reduced.

8	(a)	(i)	Stationary waves are set up as a result of the superposition of two progressive waves of the same type, having same amplitude and travelling in the opposite directions.	
			The 2 waves must have the same speed and wavelength.	
		(ii)	Show understanding of how the stationary of one open and one close if formed via 2 diagrams	
			$\lambda_1 (\frac{n}{2}+\frac{1}{4}) = D$ $\lambda_2 (\frac{n+1}{2}+\frac{1}{4}) = D$ $\frac{343}{70.6}(\frac{n}{2}+\frac{1}{4}) = \frac{343}{90.8}(\frac{n}{2}+\frac{3}{4})$ $n = 3$	
			$D = 8.50\ m$	
	(b)	(i)	The principle of superposition states that the net displacement at a given place and time caused by two or more waves which traverse the same space and meet is	
			the vector sum of the displacement which have been produced by the individual waves separately at that position and instant of time	
		(ii)	1.	The intensity of signal is lower as the signal travels further spreads over a larger surface area as it is further from the AGV,
				The signal is from Emitter B.
			2.	$\frac{\pi}{3}$ or 60^0
			3.	Dist. from A to AGV = $\sqrt{7^2+50^2}$ = 50.488 m Dist. from B to AGV = $\sqrt{5^2+50^2}$ = 50.249m
				Path Difference = $\frac{\lambda}{6}$ = 50.488 – 50.249 = 0.238m λ = 1.429 m
				$f = \frac{3\times10^8}{2.124}$
				= 2.10×10^8 Hz (2 to 3 sf)
			4.	Since the two radio waves are in phase, along the middle line is the line of constructive interference with maximum amplitude,
				the computer should search for the line of constructive interference with the maximum amplitude and align itself to the line.

	(c)	**(i)**	$$d\sin\theta = n\lambda$$ $$d\left(\frac{0.845}{\sqrt{0.845^2+2.00^2}}\right) = 2\left(486.5\times10^{-9}\right)$$ $$d = 2.5\times10^{-6}$$
			No. of lines per m = $\frac{1}{d} = \frac{1}{2.5\times10^{-6}}$ = 4.00×10^5 lines/m = 400 lines/mm
			The larger angle of diffraction can be measured experimentally with a lower percentage error with a measuring instrument of a certain precision.
			As it has lower intensity, it is more difficult to determine the centre of the bright fringe.

Mark Scheme - Determination of Gravitational Field Strength (Question 1)

Section	Skills Assessed	Description	Checklist
MMO Collection	Making measurements	l and angle θ correctly measured with units to the right precision. T correctly measured with units with evidence of repeat readings for value of T with $nT > 20$ s.	1
MMO Collection	Set up apparatus correctly and follow instructions given in the form of written instructions or diagrams	Collected at least 6 or more sets of data (θ, t) w/o assistance/ intervention.	2[6][c]
PDO Table	Layout: Column headings (raw & calculated quantities)	Each column heading must contain an appropriate quantity and unit. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit.	1[6][c]
PDO Table	Table of results: Raw data	Consistency of no. of decimal places for raw readings, based on precision of measurement technique used. For each value of t, $nT > 20$ s.	1[6][c]
PDO Collection	Table of results: Calculated quantities	For each calculated value, the no. of sf should reflect the no. of sf in the raw readings from which it is calculated. All values must be given to an appropriate no. of sf for this mark to be awarded.	1[6][c]
ACE Analysis	Table of results: Calculated quantities	Correct values in calculated quantities. All values should be correct for this mark.	1[6][c]
ACE Analysis	Analysing trend, accuracy and uncertainty	Correct answer - Calculation of difference between max and min T - difference between max and min > uncert	2
ACE Analysis	Linearising Equation	Linearising equation and deriving expressions equating unknowns to gradient & y-intercept of graph.	1[3][e]
PDO Graph	Graph: Layout	Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions. Axes must be labelled with the quantity (plus relevant unit indicated) which is being plotted.	1[3][grp]
PDO Graph	Graph: Plotting of points	All observations must be plotted. Work to an accuracy of half a small square.	1[3][grp]
PDO Graph	Graph: Trend of graph	Line of best fit drawn. There must be a fair scatter of points on either side of the line.	1[3][grp]
ACE Analysis	Interpretation of Graph	Gradient – the hypotenuse of the Δ sufficiently large (ie greater than half the length of the drawn line). Read-offs must be accurate to half a small sq. Check for $\Delta y/\Delta x$. Value of gradient provided with appropriate units	1[3][e]
ACE Analysis	Interpretation of Graph	Vertical intercept must be read off to nearest half a small sq or determined from $y = mx + c$ using a point on the line. Value of vertical intercept provided with appropriate units.	1[3][e]
ACE Conclusion	Interpretation of Graph	Value of g determined correctly with appropriate units with methods clearly shown.	1
MMO Observation	Identifying of Anomaly	Anomalous data/results, if any, must be identified. Appropriate justification must be given. Otherwise comment on absence of anomalous data.	1
ACE Evaluation	Sources of Errors	Stated and discussed how an error affected the results.	1
ACE Evaluation	Improvements	Stated and discussed how an improvement addressed the error/limitation given above.	1
ACE Evaluation	Interpretation of Graph	Correct graph drawn. - Gradient is less steep with lower vertical-intercept	1

Possible errors
- difficulty in measuring the angle as moving the protractor near string will likely touch the setup and cause it to oscillate, affecting the accuracy of the angle
- difficulty in determining the exact start and end time of the oscillation as the oscillation is too fast

Possible improvements
- clamp the protractor on a retort stand and move it close to the setup close to measure the angle
- take a measure of the setup and measure the angle using the picture
- use a video to record the oscillation and determine the timing using the playback function

Practical Preliminary Examination (Question 2)

(a)	**(i)**	Measurement of depth x of salt in container A to the appropriate precision with repeat readings	1
	(ii)	Correct method of calculation to get percentage uncertainty rounded to the correct significant figure.	1
	(iii)	Measurement of depth of salt (y) in container B to the appropriate precision with repeat readings	1
		Correct calculation of m_A, $m_A = \dfrac{x}{x+y}(90)$ g	1
		Correct calculation of m_B by subtraction.	1
	(iv)	Use a narrower and taller containers A and B	1
(b)	**(i)**	Measurement of t_A and recorded with the appropriate precision with repeat readings	1
	(ii)	Absolute uncertainty in t_A in the range 0.2 – 0.4 s. Correct method of calculation to get percentage uncertainty rounded to the correct significant figure.	1
(c)		Mass flow rate calculated correctly with unit	1
(d)		Derived of $\pm\dfrac{\Delta f}{f} = \pm(\dfrac{\Delta m}{m} + \dfrac{\Delta t}{t})$	1
		Correct answer based on the fractional uncertainty	1
(e)		Measurement of t_B and recorded with the appropriate precision with repeat readings.	1
		Second mass flow rate calculated correctly and a correct unit	1
		Correct calculation of the difference in the first and second mass flow rate	1
		Sensible comment relating to the calculated mass flow rates, testing against a criterion specified by the candidate.	1
(f)		ANY ONE 1. Adjust the vibration of the hopper 2. Adjustable size of the opening 3. Stirring the mixture at adjustable rate	1
		Total	15

Practical Preliminary Examination (Marking Guide to Question 3)

(a)	Correct circuit diagram. Dry cell, multi-meter and A (or B) in series.	1
	Correct calculation of the value of resistane X.	1
	Correct calculation to obtain resistance of components in B	1
	Correct calculation of value of resistance Y.	1
(b)	Correct value of resistance X	1
	Correct value of resistance Y	1
(c)	Internal resistance of the dry cell has not been accounted for.	1
(d)	Use another multimeter and switch the multimeter to measure voltage and connect it across (or parallel to) the boxes A (or B). Calculate the resistance by using R = $\frac{V}{I}$	1
	Total	8

<table>
<tr><td>Diagram</td><td></td><td></td></tr>
<tr><td>- must include DC circuit to power the motor
- r must be labelled on the disc</td><td>1</td><td>Max 1</td></tr>
<tr><td>Basic Procedure</td><td></td><td></td></tr>
<tr><td>Vary the angular velocity of the disc when the mass slip off. Obtain the time and number of revolution. Determine the angular velocity</td><td>1</td><td rowspan="2">Max 2</td></tr>
<tr><td>Vary the weight of the mass or vary the distance between the centre of disc to the centre of mass</td><td>1</td></tr>
<tr><td>Measurements</td><td></td><td></td></tr>
<tr><td>Count the number of revolutions made and measures the timing using a stopwatch.</td><td>1</td><td rowspan="2">Max 2</td></tr>
<tr><td>Weigh the mass of the weights using a weighing scale or measure the distance between the centre of the mass using a ruler/vernier calipers</td><td>1</td></tr>
<tr><td>Controlled variable</td><td></td><td></td></tr>
<tr><td>Distance when varying mass and mass when varying distance</td><td>1</td><td rowspan="2">Max 2</td></tr>
<tr><td>Same disc and identical masses has to be used, to ensure constant coefficient of friction</td><td>1</td></tr>
<tr><td>Analysis</td><td></td><td></td></tr>
<tr><td>$\omega = kr^x m^y$
$\ln\omega = \ln(kr^x) + y\ln(m)$ when varying mass,
where y is the gradient and $\ln(kr^x)$ is the vertical intercept
<u>OR</u>
$\omega = kr^x m^y$
$\ln\omega = \ln(km^y) + x\ln(r)$ when varying distance,
where x is the gradient and $\ln(km^y)$ is the vertical intercept</td><td>1</td><td rowspan="2">Max 2</td></tr>
<tr><td>- Linearise the other variable that was not mentioned earlier</td><td>1</td></tr>
<tr><td>Additional Details</td><td></td><td></td></tr>
<tr><td>Ensure that the distance is from the centre of disc to centre of the mass to ensure a more accurate reading of r</td><td>1</td><td rowspan="2">Max 3 out of which max 1 for safety</td></tr>
<tr><td>Mention way to improve accuracy in recording the timing of time, eg via the use of a light gate with datalogger, etc</td><td>1</td></tr>
</table>

Ensure the timing for the revolutions is long enough to minimize the random error when taking the timing	1	
Ensure the disc is parallel to the horizontal after loading of the mass by ensuring the height at both ends of the disc is the same	1	
Safety		
Wear safety google to prevent mass from hitting the eyes	1	
Place shielding around the setup to prevent the mass to hitting people after slipping from the disc	1	