Candidate's name ………………………………………….   CTG …………….

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2017

PHYSICS **9749/1**

HIGHER 2 **15th September 2017**

1 hour

Paper 1 Multiple Choice

Additional Material:
Optical Mark Sheet

READ THESE INSTRUCTIONS FIRST

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

Write your name and CTG on the Optical Mark Sheet in the spaces provided.
Shade your NRIC in the space provided.

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

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

Read the instructions on the Optical Mark Sheet carefully.

INFORMATION FOR CANDIDATES
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

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}

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	=	$T/°C + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
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	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The intensity of a beam is defined as the energy delivered per unit area per unit time.

What is the base unit of intensity?

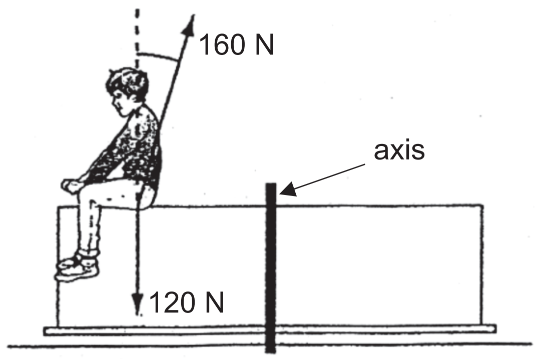
A kg m^2 s^{-3} **B** kg m s^{-3} **C** kg s^{-2} **D** kg s^{-3}

2 Car A and car B were having a race along a straight line towards the finishing line. Car A was moving at a speed of 40 m s^{-1} and car B was moving at a speed of 50 m s^{-1} when car B overtook car A. After 1.0 s of reaction time, car A accelerated to 55 m s^{-1} uniformly in another 1.0 s. Car A then moved at that constant speed.

What is the total time taken for car A to catch up with car B? Assume that car B maintained a constant velocity throughout.

A 1.3 s **B** 2.2 s **C** 4.5 s **D** 17.5 s

3 A child is sitting on a playground turntable and is rotating about its axis with uniform angular velocity.



The resultant force that the turntable exerts on the child is 160 N and the weight of the child is 120 N.

What is the acceleration of the child?

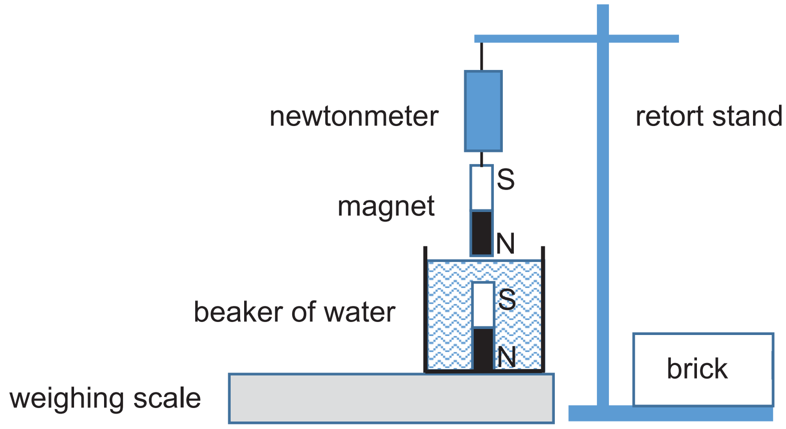
A 0.88 m s^{-2}

B 3.3 m s^{-2}

C 8.7 m s^{-2}

D 84 m s^{-2}

4 A beaker of water of total weight J is placed onto a weighing scale and a magnet of weight Q is added into it. An identical magnet is suspended just above the surface of the water and is supported by a newtonmeter hanging from a retort stand. The newtonmeter registers a reading of S.



Which of the following shows the reading on the weighing scale?

A 2Q + J – S

B Q + J + S

C Q + J – S

D J + S

5 An alpha particle and a beta particle move in a straight line towards the east with a constant speed of 7.2×10^7 m s^{-1} and 3.6×10^4 m s^{-1} respectively. They move independently of each other and are under the influence of electric, magnetic as well as gravitational fields. They both moved a distance of 1.0 m.

Which of the following statements is true?

A There is no net work done on either of them.

B There is more net work done on the alpha particle than the beta particle.

C There is more net work done on the beta particle than the alpha particle.

D The net work done on the beta particle is positive while the net work done on the alpha particle is negative.

6 A lorry of mass 2000 kg has an engine which can deliver a maximum power of 50.0 kW.

What is the minimum time in which the lorry can be accelerated from rest to a speed of 100 km h^{-1} along a flat road? Ignore all resistive forces acting on the lorry.

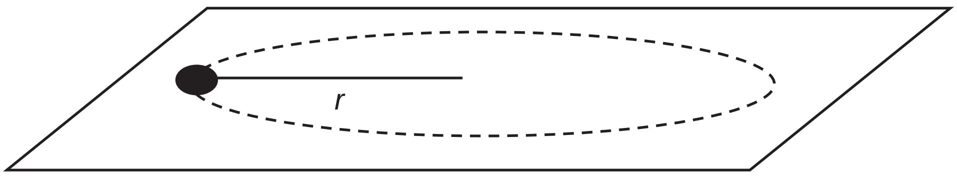
A 11.3 s **B** 15.4 s **C** 30.9 s **D** 200 s

7 Mass m moves in a horizontal circle of radius r at constant angular speed ω.

Which pair of values correctly gives the work done by the centripetal force and the change in linear momentum of the body in the duration of π / ω?

	work done	change in linear momentum
A	$2mr^2\omega^2$	$2mr\omega$
B	$\pi mr^2\omega^2$	$2mr\omega$
C	0	0
D	0	$2mr\omega$

8 An object is tied to a string and is swung around in horizontal circular motion of radius r at increasing speeds. The string breaks when the speed of the object is v.

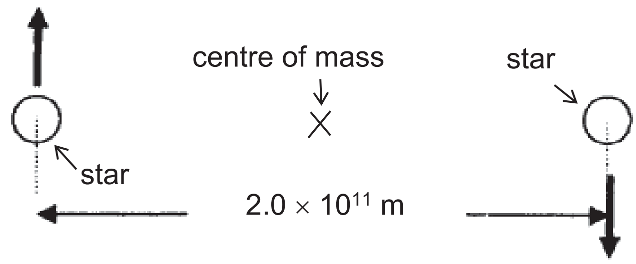


The object is now tied using two strings instead and is swung around with the same radius.

What is the speed of the object when the string breaks?

A 0.707 v **B** 1.41 v **C** 2.00 v **D** 4.00 v

9 A binary star system consists of two stars, each of mass 4.0×10^{30} kg, separated by a distance of 2.0×10^{11} m. The stars rotate about the centre of mass of the system.



What is the period of rotation of each star?

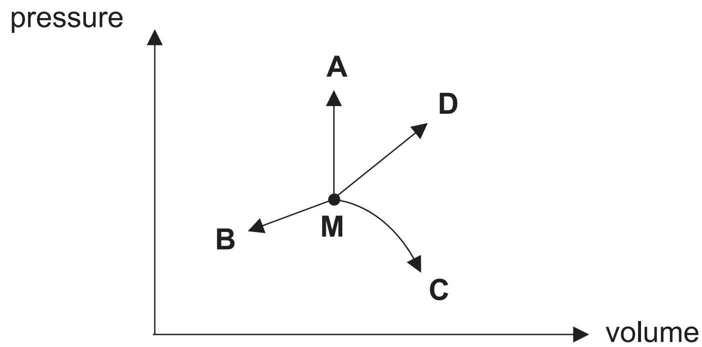
A 1.2×10^7 s **B** 1.7×10^7 s **C** 2.4×10^7 s **D** 3.4×10^7 s

10 The radius of planet X is R and its density is ρ. Planet Y has a radius of $5R$ and a density of ¼ ρ. The escape speed of an oxygen molecule at planet X's surface is v.

The escape speed of the oxygen molecule at the surface of planet Y is

A 0.22 v **B** 0.40 v **C** 2.5 v **D** 4.5 v

11 A gas, which is initially at state M can be made to undergo four different thermal processes, namely A, B, C and D.



Which one of the processes results in the greatest work done on the gas?

12 How would the internal energy of an ideal gas change if it undergoes the following processes separately?

Process 1: compressed at constant pressure

Process 2: heated at decreasing volume

	Process 1	Process 2
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

13 A gas at a temperature of 30 °C is heated such that the root-mean-square speed of its molecules increases by 5%.

What is the new temperature of the gas?

A 32 °C **B** 33 °C **C** 45 °C **D** 61 °C

14 The frequency of a body moving with simple harmonic motion is doubled.

If the amplitude remains the same, which of the following quantities is also doubled?

A time period

B total energy

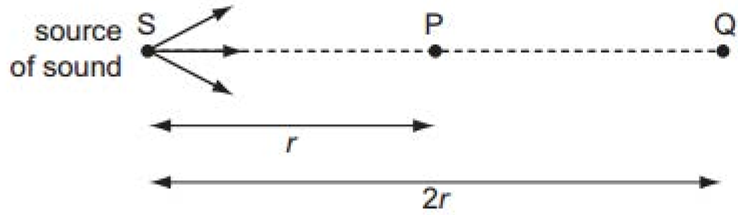
C maximum velocity

D maximum acceleration

15 When a particle performs simple harmonic motion, the velocity leads the displacement by a phase angle of

A $\frac{\pi}{2}$ rad **B** $\frac{\pi}{4}$ rad **C** π rad **D** zero

16 A point source S is emitting sound waves in all directions.



Air molecules at P, a distance r from S, oscillate with amplitude 8.0 μm. Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

17 In a double-slit experiment, the slit separation is 2.0 mm, and two wavelengths of light, 750 nm and 900 nm, illuminate the slits. A screen is placed 2.0 m from the slits.

What is the minimum distance from the central maximum on the screen that a maximum from one pattern coincide with the maximum from the other?

A 1.5 mm **B** 3.0 mm **C** 4.5 mm **D** 6.0 mm

18 Two coherent wave-trains of monochromatic light arrives at a point on a screen.

Which of the following statements must be true?

A They are in phase.

B They have a constant phase difference.

C They interfere constructively.

D They interfere destructively.

19 Diagram 1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet.

Diagram 2 shows the same tank with a slit of greater width.

In each case, the pattern of waves incident on the slit and the emergent pattern are shown.

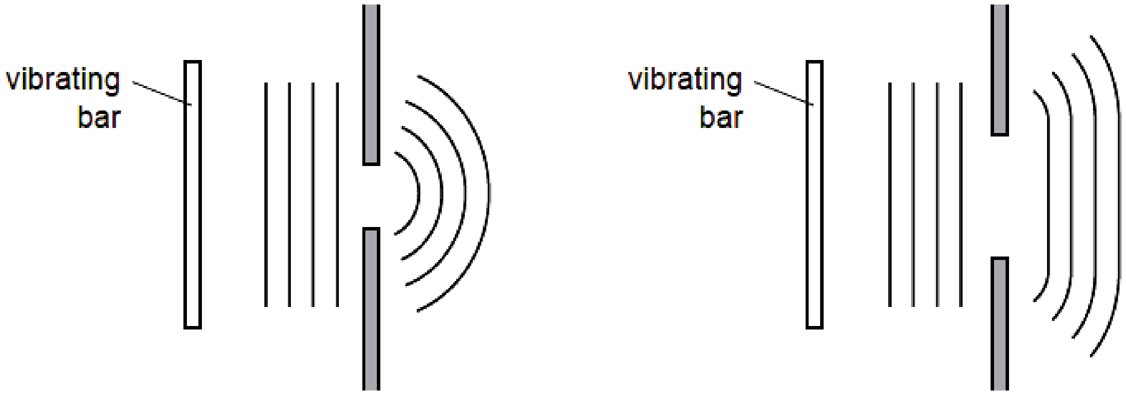


diagram 1 diagram 2

Which of the following changes would cause the waves in diagram 2 to diffract more and produce an emergent pattern closer to that shown in diagram 1?

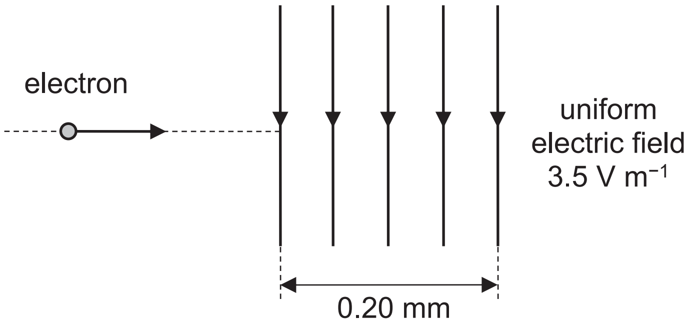
A Reduce the length of the vibrating bar

B Reduce the amplitude of vibration of the bar

C Increase the frequency of vibration of the bar

D Increase the speed of the waves by making the water in the tank deeper

20 An electron travels horizontally at a speed of 5500 m s^{-1} and enters a uniform vertical electric field of strength 3.5 V m^{-1}, which is directed downwards and acts over a horizontal distance of 0.20 mm.



What is the speed of the electron when it exits the electric field?

A 5.50×10^{3} m s^{-1}

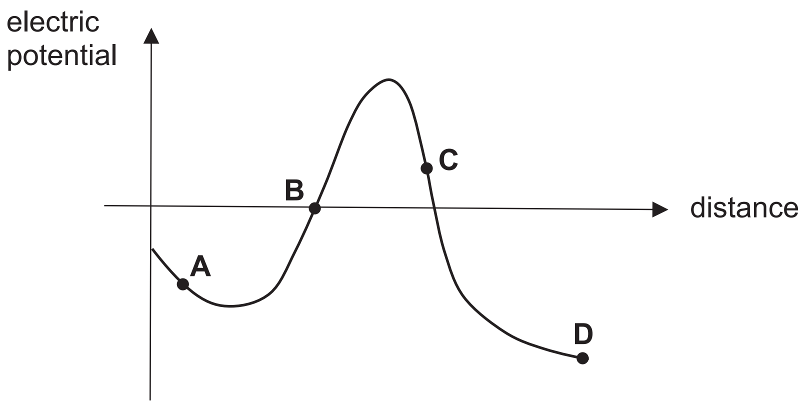
B 2.24×10^{4} m s^{-1}

C 2.31×10^{4} m s^{-1}

D 2.79×10^{4} m s^{-1}

21 The diagram below shows the variation of electric potential with distance along a straight line in a region of electric field.

Which of the following positions represents a point with maximum electric field strength?



22 Aluminium and copper cylindrical rods are designed to have the same length and the same resistance. The resistivity of copper is half that of aluminium and its density is three times that of aluminium.

What is the ratio of the mass of the copper rod to the mass of aluminium rod?

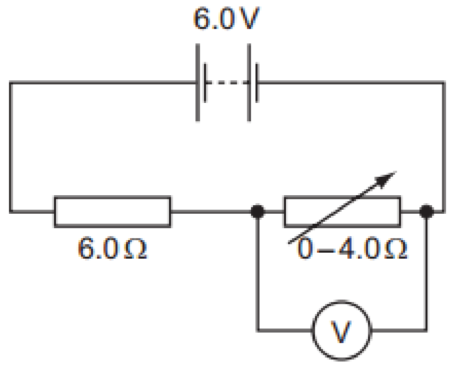
A 0.167 **B** 0.667 **C** 1.50 **D** 6.00

23 A current flows in a wire of circular cross-section of radius r with the free electrons travelling at drift velocity v.

What is the drift velocity for the same current in a wire of the same material but of half the radius?

A $0.25\,v$ **B** $0.5\,v$ **C** $2\,v$ **D** $4\,v$

24 An ideal 6.0 V e.m.f source is connected in series with a 6.0 Ω resistor and a variable resistor. The resistance of the variable resistor is varied between 0 Ω and 4.0 Ω.



What is the range of the voltmeter reading?

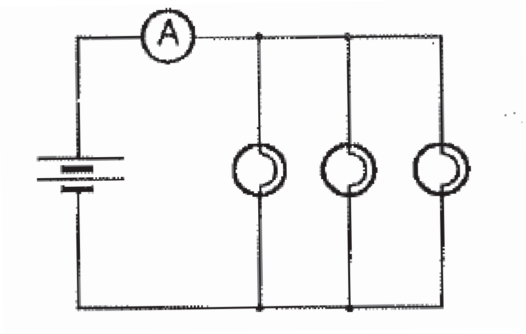
A 0 V to 2.4 V

B 0 V to 3.6 V

C 2.4 V to 6.0 V

D 3.6 V to 6.0 V

25 Three similar light bulbs are connected to a constant voltage d.c. supply of negligible internal resistance. Each bulb operates at normal brightness and the ideal ammeter register a steady current.



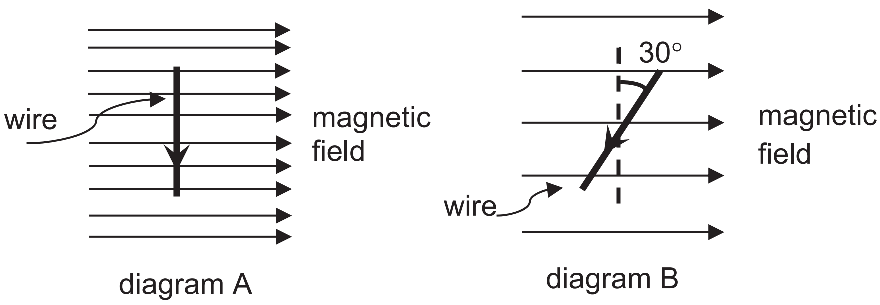
The filament of one of the bulbs breaks.

What happens to the ammeter reading and the brightness of the remaining bulbs?

	ammeter reading	bulb brightness
A	decreases	decreases
B	decreases	remains unchanged
C	increases	remains unchanged
D	increases	increases

26 A straight current-carrying wire lies at right angles to a horizontal magnetic field as shown in diagram A. The field exerts a force of 8.0 mN on the wire.

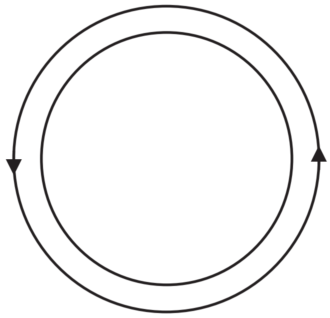
The wire is now rotated, in its horizontal plane, through 30° and the flux density of the magnetic field is halved, as shown in diagram B.



What is the direction and magnitude of the force acting on the wire?

	direction	magnitude
A	into the plane	2.0 mN
B	out of the plane	2.0 mN
C	into the plane	3.5 mN
D	out of the plane	3.5 mN

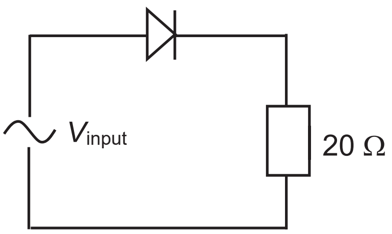
27 A small circular coil lies inside a big coil as shown. These two coils are horizontal and concentric. When an anti-clockwise current flows through the big coil suddenly, the small coil experiences an induced current at the same instant.

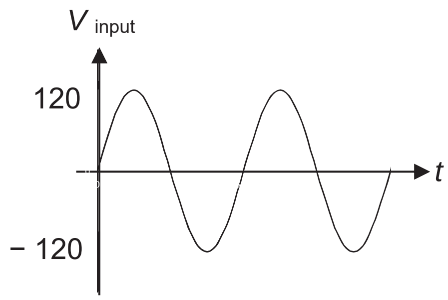


Which of the following describes the direction of the induced current in the small coil and its effect on the size of the small coil?

	direction of induced current	effect on size of small coil
A	clockwise	smaller
B	clockwise	bigger
C	anti-clockwise	smaller
D	anti-clockwise	bigger

28 An alternating input voltage is connected across a 20 Ω resistor through a rectifying diode.





What is the mean rate of heat dissipated in the resistor?

A 0 W **B** 180 W **C** 360 W **D** 720 W

29 Light falls on a metal surface and emits photoelectrons by photoelectric effect. If the frequency of the light is doubled while keeping the intensity of the light constant,

A the stopping potential will also be doubled, if the metal remains unchanged.

B the photoelectric current will be reduced by half.

C the threshold frequency of the metal also needs to be doubled so that the maximum kinetic energy of the photoelectrons remains unchanged.

D the maximum speed of the photoelectrons will also be doubled, if the metal remains unchanged.

30 At time $t = 0$, there are 7.0×10^{11} atoms of a radioactive element U of half-life 14 hours in a container.

After time t ', the number of atoms inside the container is 6.03×10^{11}. K number of atoms of U are then added to the container. The activity of the radioactive source from the container is found to be 3.62×10^{6} Bq after 27 hours from time t '. The value of K is

A 3.99×10^{11} **B** 4.62×10^{11} **C** 6.03×10^{11} **D** 6.34×10^{11}

--- End of paper ---

Candidate's name …………………………………………. CTG …………….

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2017

PHYSICS **9749/2**

HIGHER 2 **25th August 2017**

2 hours

Paper 2 Structured Questions

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

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

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

For Examiner's Use	
Paper 2 (30.0%)	
1	/3
2	/4
3	/5
4	/5
5	/9
6	/10
7	/11
8	/8
9	/5
10	/20
Penalty	
Total	
	/ 80

For Examiner's Use

Data

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temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
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	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots\ldots$
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	=	$\frac{\mu_o I}{2\pi d}$
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radioactive decay,	x	=	$x_o \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 The density of the material of a rectangular block was determined by measuring the mass and linear dimensions of the block. Below shows the measurements obtained, together with their absolute uncertainties.

- mass = (25.0 ± 0.1) g
- length = (5.00 ± 0.01) cm
- breadth = (2.00 ± 0.01) cm
- height = (1.00 ± 0.01) cm

The density, ρ was calculated to be 2.500 g cm^{-3}.
Express the value of ρ together with its absolute uncertainty $\Delta\rho$.

($\rho \pm \Delta\rho$) = (………………….. ± …………………..) g cm^{-3} [3]

For Examiner's Use

2 The variation of the force F with time t acting on a body of mass 200 g is as shown in Fig. 2.1.

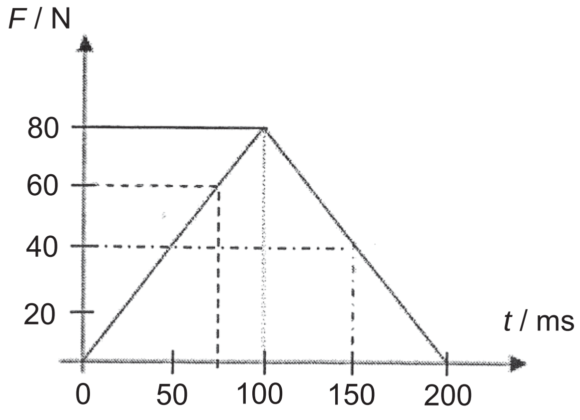

Fig. 2.1

(a) With reference to Fig. 2.1, calculate the change in momentum of the body from t = 100 ms to t = 150 ms.

change in momentum = …………………..kg m s^{-1} [2]

(b) Using your answer in **(a)** or otherwise, calculate the velocity of the body at t = 150 ms, given that the velocity of the body at t = 100 ms is 15 m s^{-1}.

velocity = ………………….. m s^{-1} [2]

For Examiner's Use

3 A block of mass 12 kg is released from rest and slides down a 30° frictionless incline plane as shown in Fig. 3.1. It is stopped by a spring with spring constant, *k*.

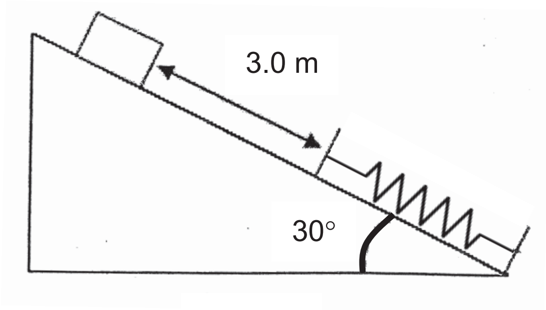

Fig. 3.1

The initial distance between the point of release and the uncompressed spring is 3.0 m. After the block comes to rest momentarily, the spring is compressed by 1.3 m.

(a) Describe the energy transformation from the time the block is released from rest to the time whereby the spring is compressed by 1.3 m.

....

....

....

....

....

....

....

....

.... [3]

(b) Calculate the value of *k*.

k = ... N m^{-1} [2]

[Turn over

4 Part of an arch bridge made of stone is shown in Fig. 4.1.

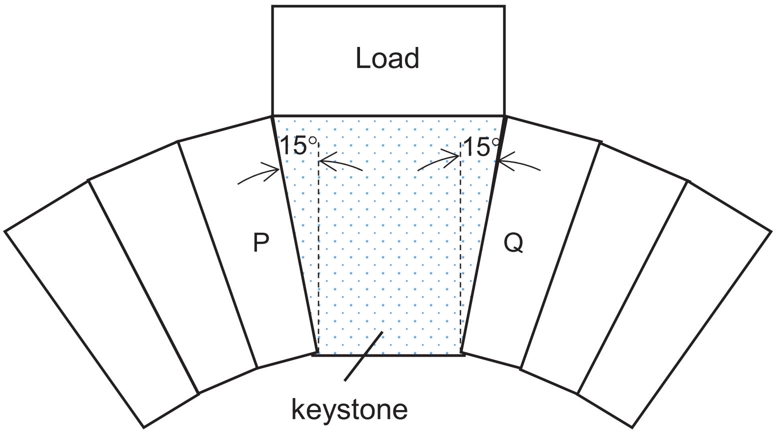

Fig. 4.1

The central stone is known as a keystone and has a weight of 500 N. The keystone is supporting a load of 5700 N. The sides of the keystone make an angle of 15° to the vertical. The two stones P and Q, which are next to the keystone, exert forces at right angles to the sides of the keystone.

In Fig. 4.2, the vector *L* represents the force the load exerts on the keystone to a scale of 1 cm : 1000 N. By completing the scaled vector diagram for the system of forces acting on the keystone, determine the value of the force that stone P exerts on the keystone.

Label your forces clearly.

Fig. 4.2

Force exerted by stone P = …………………………… N [5]

For Examiner's Use

5 **(a)** A plastic container is filled with 2.5 kg of water at a temperature of 30 °C. Two students decided to add 500 g of ice cubes at – 5.0 °C and 200 g of steam at 100 °C to the container of water simultaneously, to investigate their combined effect on the temperature of water.

Assuming that there is no heat gain or loss to the surrounding and plastic container, and given the following values:

- Latent heat of fusion of ice = 3.33×10^5 J kg^{-1}
- Latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}
- Specific heat capacity of water = 4.20×10^3 J kg^{-1} K^{-1}
- Specific heat capacity of ice = 2.05×10^3 J kg^{-1} K^{-1}

Determine the final temperature of water in the container.

final temperature = …………………. °C [4]

For Examiner's Use

(b) State the *first law of thermodynamics*.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(c) On a warm afternoon, two identical bubbles of ideal gas rise from the bottom of a pond to the surface. As the water pressure is much lower at the surface of the pond compared to the bottom, the bubbles expand as they rise. However, bubble A rises very quickly so that there is no heat exchange between it and the water. On the other hand, bubble B does not rise as quickly because it is slowed down by water plants and as a result, its temperature always remains in thermal equilibrium with the water.

State and explain which of the two bubbles, A or B, will be larger by the time they reach the surface of pond.

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

For Examiner's Use

6 **(a)** A string, tied to a sinusoidal oscillator at P and running over a support at Q, is stretched by a block of mass *m* as shown in Fig. 6.1. The amplitude of the motion at P is small enough for that point to be considered a node. A node also exists at Q.

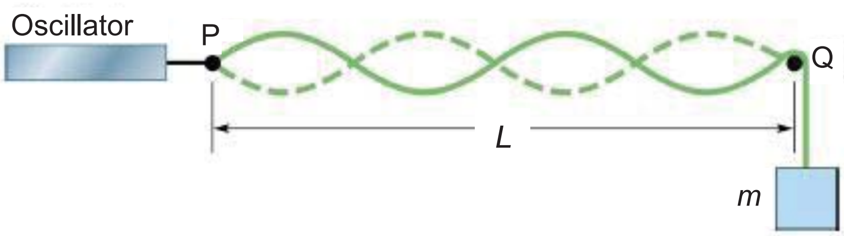

Fig. 6.1

(i) Explain how stationary waves are formed along the string.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

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

(ii) In terms of phase change, explain why a node is formed at Q.

……………………………………………………………………………………...

……………………………………………………………………………………...

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

(iii) The frequency of the oscillator is set at 120 Hz. A stationary wave is formed when the length *L* is 1.20 m. The maximum amplitude of the antinode is 0.80 cm. The length is slowly increased and the stationary wave disappears. The stationary wave is again formed when *L* is increased by 0.30 m.

1. Determine the velocity of the wave in the string.

velocity = ………………….. m s^{-1} [2]

[Turn over

For Examiner's Use

2. Point X is at one of the antinodes when L is 1.50 m. Point Y is at a distance $\lambda/8$ away from point X, where λ is the wavelength of the wave.

Determine the phase difference between the two points.

phase difference = ………………….. rad [1]

(b) A car, with its headlights turned on, is approaching a camera which has an aperture that receives light into its body. Photographs of the two headlights are taken at several time intervals.

Explain why when the car is far away, the headlights are barely distinguishable whereas when the car is nearer, the headlights can be seen as separate entities in the photographs.

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

For Examiner's Use

7 **(a)** Define *electric potential* at a point in an electric field.

………………………………………………………………………………………….

………………………………………………………………………………………….

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

(b) Point charges P and Q of +6.0 μC and −9.0 μC respectively are placed 50 mm apart along a straight line as shown in Fig. 7.1. Along the straight line, there is a neutral point where there is no net electric strength.

Fig. 7.1

(i) Indicate the position of the neutral point along the straight line in Fig. 7.1, by putting a cross and "N". [1]

(ii) Determine the separation between the neutral point and point charge P.

separation = ………………….. m [2]

(iii) Calculate the work done to move point charge P to the neutral point.

work done = ………………….. J [2]

For Examiner's Use

(c) As shown in Fig. 7.2, a charged sphere of mass 5.0 g and charge −2.5 mC is held in between two parallel plates of +4.0 V and –1.0 V placed 10 cm apart. When the sphere is released from rest, it experiences acceleration due to the forces acting on it.

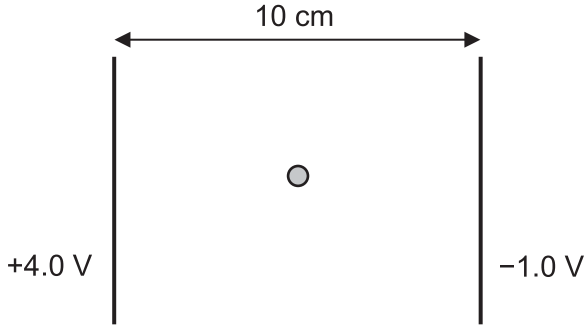

Fig. 7.2

(i) Determine the acceleration of the sphere upon release.

acceleration = ………………….. m s^{-2} [2]

(ii) Hence calculate the displacement of the sphere after 50 ms upon release.

displacement = ………………….. cm

direction of displacement = ………………………………….. [3]

For Examiner's Use

8 **(a)** The I-V characteristic graph of a given tungsten filament lamp is shown in the Fig. 8.1.

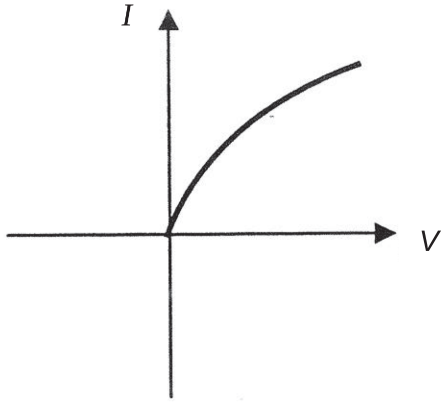

Fig. 8.1

With the aid of a labelled diagram, describe how the above I-V characteristic graph can be obtained.

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

For Examiner's Use

(b) A high potential is applied between the electrodes of a gas discharge tube so that the gas is ionised (both electrons and positive charged particles are present). The gas carries a current of 8.16 mA and the number of electrons passing any point in the gas per unit time is 2.58×10^{16} s^{-1}.

(i) Calculate the current due to the electrons.

current = ………………………..A [2]

(ii) If the charge on each positively charged particle is 3.2×10^{-19} C, determine the number of positively charged particles passing any point in the gas per unit time.

number per unit time = ………………………..s^{-1} [2]

For Examiner's Use

9 A light source of power 1.2 W gives out monochromatic light of wavelength 530 nm. The light is incident on a metal surface which has a work function of 1.9 eV.

(a) Determine the rate of photons incident on the metal surface.

rate of photons = ………………… s^{-1} [2]

(b) Determine whether photoelectrons will be emitted from the metal surface.

……………………………………………………………………………………… [1]

(c) Assuming that all photons are incident normally to the metal surface of area 3.8×10^{-6} m^2 and absorbed by the metal, calculate the radiation pressure acting on the surface.

radiation pressure = ………………… Pa [2]

For Examiner's Use

10 X-rays are emitted when a metal target is bombarded by high energy electrons. The X-ray spectrum consists of a broad continuous spectrum and a series of sharp lines known as the line or characteristic X-ray spectrum as shown in Fig. 10.1.

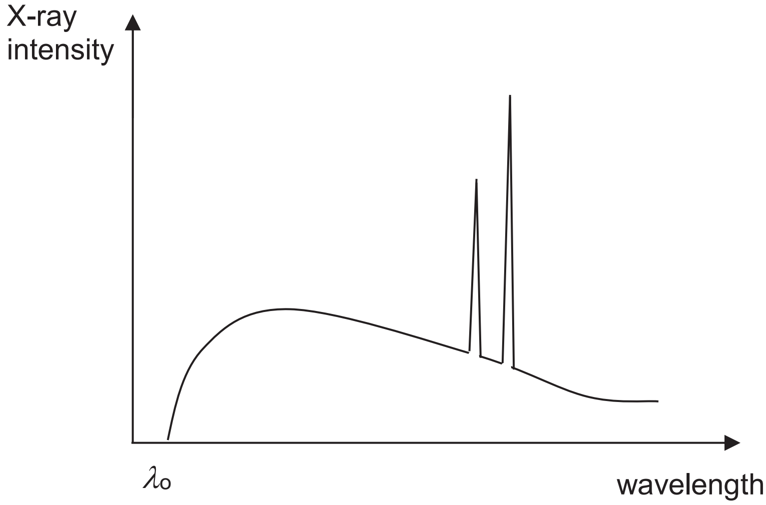

Fig. 10.1

(a) **(i)** Explain how the continuous spectrum is formed.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(ii) Explain why there is a minimum wavelength λ_o for the continuous spectrum.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) In 1913, a British physicist Henry G.J, Moseley measured the wavelength of the characteristic X-rays from a number of elements. He noted that for a particular type of emitted X-ray, the frequency *f* varied in a regular way with the atomic number *Z* of the element according to an empirical relation, known as Moseley's law:

$$f = a(Z - b)^2,$$

where *a* and *b* are positive constants, and *Z* is the atomic number.

In multiple-electron atoms, the energy of an electron in any shell (measured in electron−volts) is given by:

$$E_n = -\frac{13.6(Z_{eff,n})^2}{n^2}$$

For Examiner's Use

where

Shell	n	Maximum no. of electrons in shell
K	1	2
L	2	8
M	3	8

$Z_{eff,n}$ is used instead of atomic number Z because of the shielding effect of the orbital electrons beneath the nth shell when n > 1. $Z_{eff,n}$ can be computed by:

$Z_{eff,n}$ = Z for n = 1

= Z – number of electrons present in all shells below the nth shell, for n > 1

(i) Suggest what is meant by an *empirical relation*.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Determine the units of constants a and b.

units of a = ………………………..

units of b = ……………………….. [1]

(iii) Suggest why a material with a large atomic number is preferred over one with smaller atomic number in the production of X-rays.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

For Examiner's Use

(c) **(i)** In the space below, sketch the graph of $\sqrt{f}$ against Z for positive values of $\sqrt{f}$. Show clearly how the relationship for the graph is derived. [2]

(ii) Use the graph to explain how energy of a particular type of X-rays from elements is related to atomic number of the elements.

………………………………………………………………………………………

………………………………………………………………………………………

……………………………………………………………………………………… [2]

(d) When an electron which has been accelerated through a large potential strikes a tungsten target (Z = 74), it can displace an electron in the K-shell, leaving behind a vacancy. A characteristic X-ray photon will be emitted if an electron from the M-shell drops into the vacancy.

(i) Calculate the energy of an electron in the K-shell.

energy of electron = ……………………. J [2]

For Examiner's Use

(ii) Calculate the energy of the X ray photon that is produced from the transition of an electron from the M shell after an electron from the K-shell has been displaced.

energy of X-ray photon = …………………… J [5]

(e) **(i)** The characteristic lines in Fig. 10.1 are formed either due to an electron transition from the L-shell to the K-shell (K_α), or due to a transition from the M-shell to the K-shell (K_β).

Label, in Fig. 10.1, the 2 transitions K_α and K_β. [1]

(ii) Suggest why the intensity of one of the peaks is higher than the other.

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

--- End of paper ---

Candidate's name …………………………………………. CTG …………….

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2017

PHYSICS **9749/3**

HIGHER 2 **13th September 2017**

2 hours

Paper 3 Longer Structured Questions

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

For Examiner's Use	
Paper 1 (15%)	
	/30
Paper 2 (30%)	
	/80
Paper 3 (35%)	
Section A	
1	**/10**
2	**/10**
3	**/10**
4	**/10**
5	**/10**
6	**/10**
Section B	
7	**/20**
8	**/20**
Penalty	
	/ 80
Paper 4 (20%)	
	/ 55
Overall Percentage (%)	

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

Write your answers in the spaces provided on the question paper.
For numerical answers, **all** working should be shown clearly.

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

This question paper consists of 25 printed pages.

For Examiner's Use

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}

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/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle C^2\rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
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	=	$R_1 + R_2 + \ldots\ldots\ldots$
resistors in parallel,	$\frac{1}{R}$	=	$\frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots$
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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 A stone is projected with a speed of 5.0 m s^{-1} from a cliff on a faraway planet. It travels from point A, through point B and to point D as shown in Fig. 1.1.

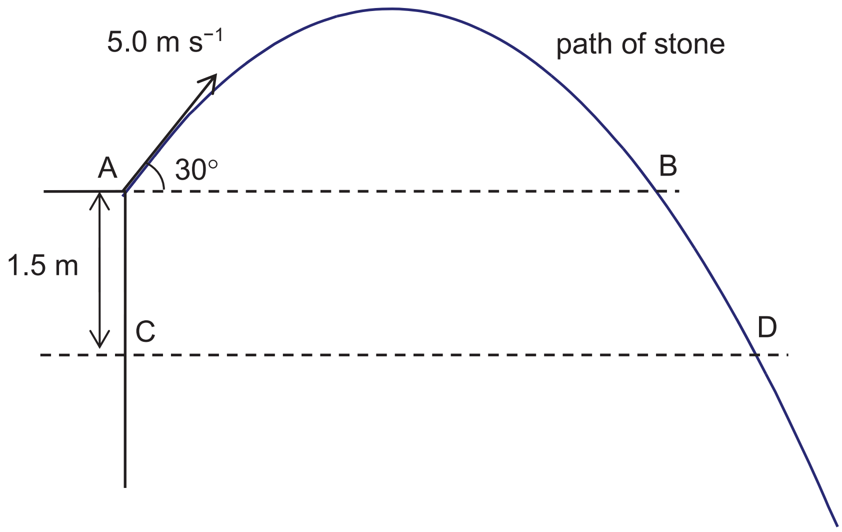

Fig. 1.1

Fig. 1.2 shows the variation of the stone's vertical velocity v with time t.

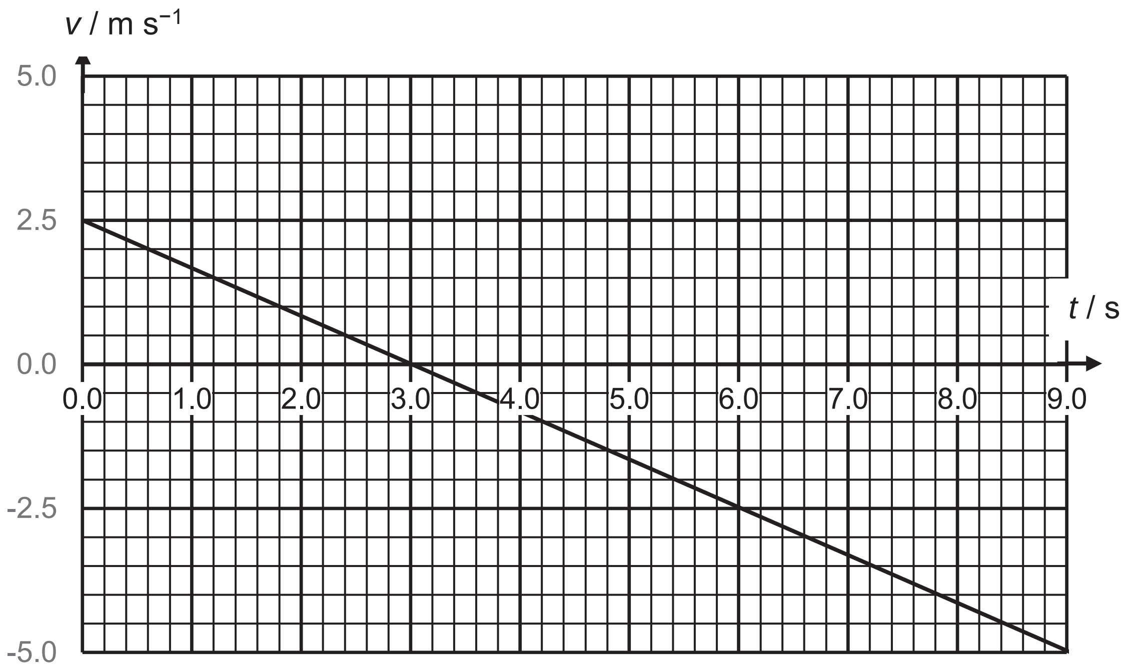

Fig. 1.2

(a) Determine the acceleration in the vertical direction.

acceleration = ………………….. m s^{-2} [1]

(b) Determine the vertical velocity of the stone at point D.

vertical velocity = ………………….. m s^{-1} [2]

(c) Shade in Fig. 1.2, the area corresponding to the vertical displacement between point B and D. [2]

(d) Mark on the line with ' **X** ' in Fig. 1.2, the instant when the stone is moving 45° to the horizontal axis. Explain how you derived your answer clearly in the space provided below.

[3]

(e) Sketch in Fig. 1.2, the variation of the stone's vertical velocity with time when the effect of air resistance is not negligible. [2]

For Examiner's Use

2 **(a)** State the principle of conservation of momentum of a system.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(b) A 0.0200 kg object travelling towards the right at 8.0 m s^{-1} collides <u>head on</u> with another 0.0100 kg object travelling towards the right at 5.0 m s^{-1}. After collision, the 0.0200 kg object travels towards the left at 2.0 m s^{-1}.

(i) State what is meant by **<u>head on</u>** collision in this context.

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [1]

(ii) Calculate the speed of the 0.0100 kg object after collision.

speed = ………………… m s^{-1} [2]

(iii) State the direction of motion of the 0.0100 kg object after collision.

direction: …………………… [1]

For Examiner's Use

(iv) If the impact time is 0.120 s, calculate the average force exerted on the 0.0100 kg object by the 0.0200 kg object during collision.

force = ………………….. N [2]

(v) Explain why it is not possible for both objects to stop at the same instant during the collision.

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……………………………………………………………………………… [2]

For Examiner's Use

3 Fig. 3.1 shows the variation with height h near the Earth's surface of the gravitational potential ϕ.

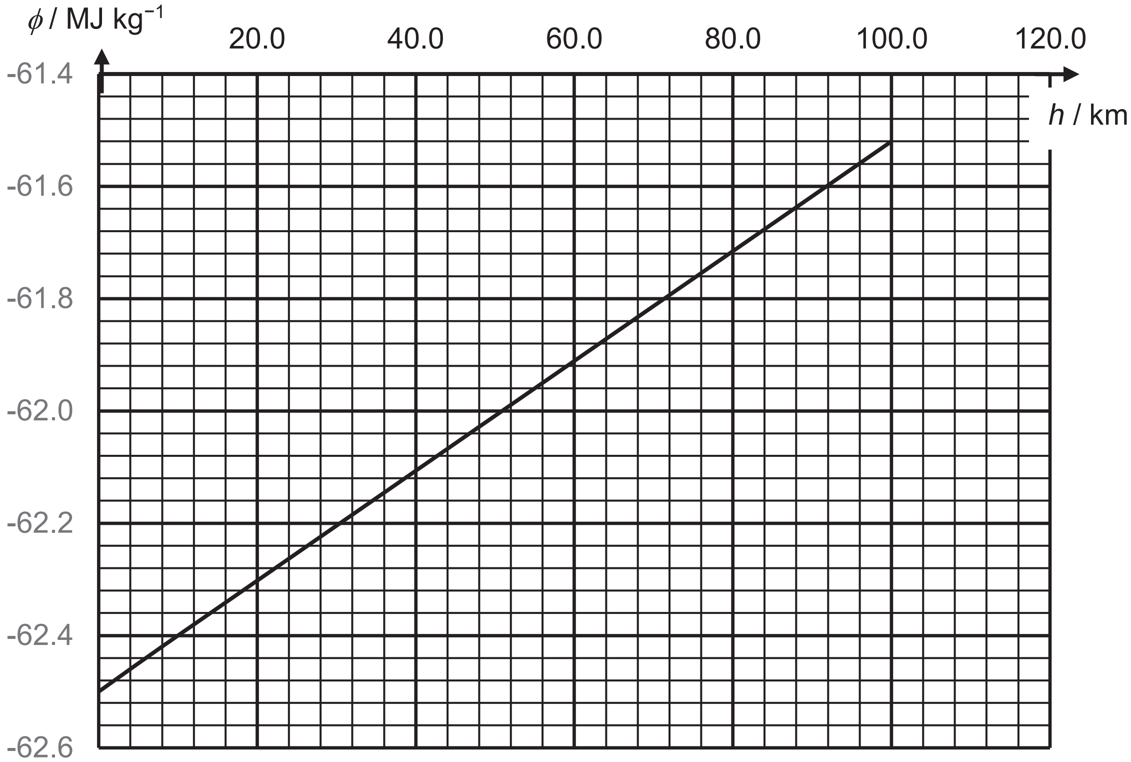

Fig. 3.1

(a) Explain how the graph shows that the gravitational field strength is approximately constant near the Earth's surface.

………………………………………………………………………………………….

………………………………………………………………………………………….

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

(b) A space shuttle of mass 4200 kg is moved from a height of 10 km to 100 km above the Earth's surface. Using the values from the graph, calculate the work done on the shuttle.

work done = ………………….. J [2]

For Examiner's Use

(c) The space shuttle is made to orbit with an angular velocity of 1.2×10^{-3} rad s^{-1} around the Earth at a height of 100 km above the Earth's surface. The gravitational field strength at that height is 9.7 N kg^{-1}.

(i) Determine the period of the space shuttle.

period = ………………….. s [1]

(ii) Determine the radius of the Earth.

radius = ………………….. m [2]

(d) Another space shuttle of different mass is made to orbit around the moon at a height such that its distance from the centre of the moon is the same as the distance of the space shuttle in **(c)** from the centre of the Earth.

Explain how the period of this shuttle would be compared to the period of the shuttle in **(c)**.

……………………………………………………………………………………….

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……………………………………………………………………………………….

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

For Examiner's Use

4 **(a)** The defining equation for simple harmonic motion is

$$a = -\omega^2 x$$

(i) State the relation between ω and the frequency f.

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

(ii) State the significance of the negative (−) sign in the equation.

………………………………………………………………………………………...

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

(b) A frictionless trolley of mass m is held on a smooth horizontal surface by means of two similar springs each of spring constant k. The springs are attached to fixed points, as illustrated in Fig. 4.1.

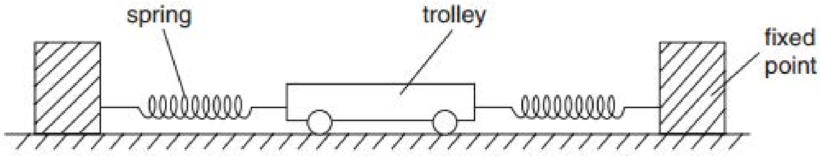


Fig. 4.1

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

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

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

$$F = 2kx$$

[2]

[Turn over

For Examiner's Use

(ii) The trolley is then released. Show that the angular frequency, ω of the trolley is given by

$$\omega^2 = \frac{2k}{m}$$

[2]

(c) Fig. 4.2 shows two identical polarising filters, A and B, and an unpolarised light source. The arrows indicate the plane is which the electric field of the wave oscillates.

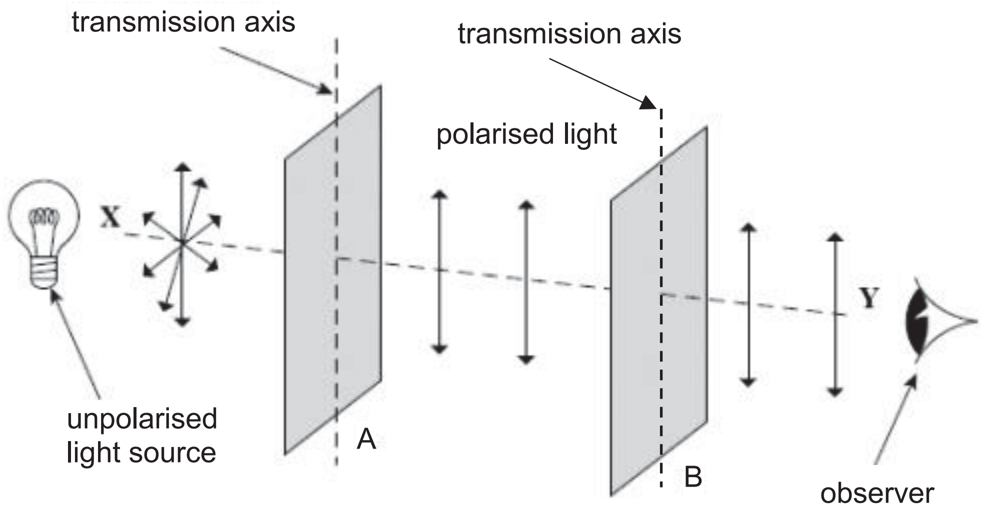
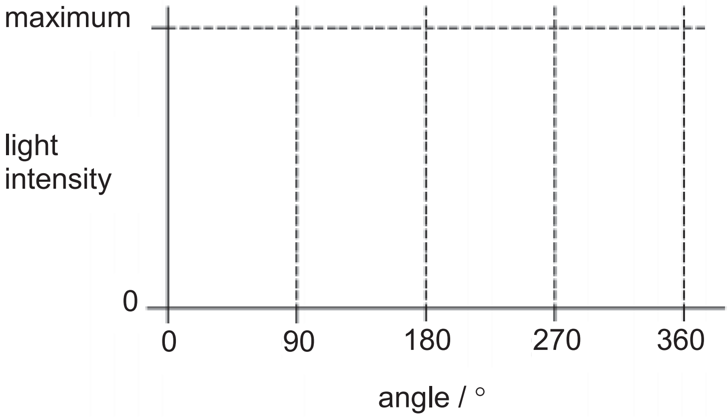


Fig. 4.2

For Examiner's Use

(i) The polarising filter B is then rotated clockwise through 360° (viewed from the observer's perspective) about the line XY from the position shown in Fig. 4.2. On the axes below, sketch how the light intensity reaching the observers varies.



[2]

(ii) State one application, other than in education, of a polarising filter.

………………………………………………………………………………………...

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

(iii) Explain why longitudinal wave cannot be polarised.

………………………………………………………………………………………...

………………………………………………………………………………………...

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

For Examiner's Use

5 **(a)** Explain what is meant by *electromotive force of a source* and *potential difference between two points of a circuit*.

....

....

....

....

.... [2]

(b) The circuit in Fig. 5.1 consists of three fixed resistors, each of which has a safe power rating of 0.80 W.

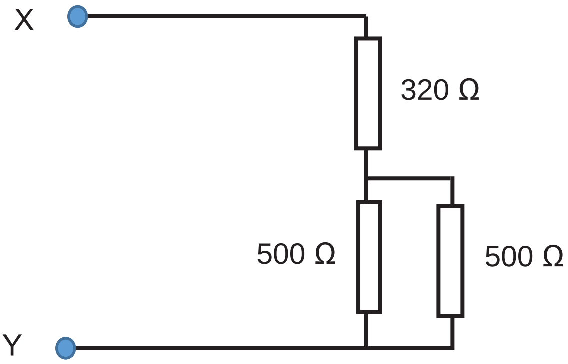


Fig. 5.1

Determine the maximum potential difference that can be applied between X and Y without damage to any of the resistor.

maximum potential difference = ……………………V [4]

For Examiner's Use

(c) A car battery is used to power up four lamps as shown in Fig. 5.2. The resistance of each lamp should be 180 Ω when it is working under normal conditions.

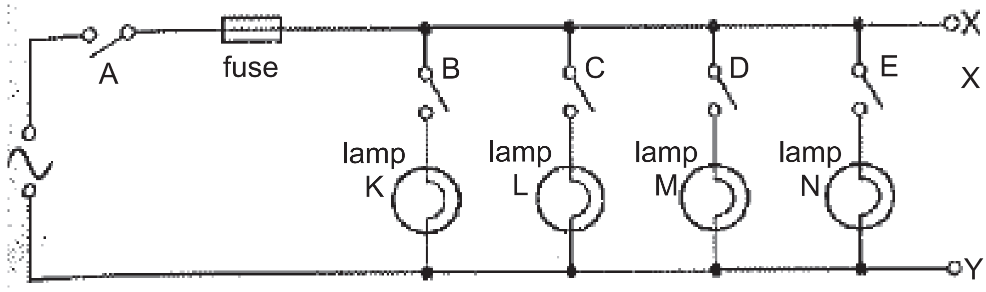


Fig. 5.2

A fault is discovered in the circuit, so switch A is open and the fuse is removed for safety. An electrician uses a resistance meter, an equipment which can be used to measure the effective resistance across any two points in a circuit, to check the lamps. He connected the resistance meter between the points X and Y and the readings obtained for different switch positions are shown in Fig. 5.3.

Switches					
A	B	C	D	E	Resistance meter reading/Ω
open	open	open	open	open	14 000 000
open	open	open	open	closed	180
open	open	open	closed	closed	90
open	open	closed	closed	closed	60
open	closed	closed	closed	closed	0.2

Fig. 5.3

(i) Based on the readings in Fig. 5.3, explain which lamp is faulty in the circuit. Show your workings clearly.

faulty lamp = ……………………… [2]

For Examiner's Use

(ii) Suggest what could have happened to the faulty lamp.

…………………………………………………………………………………...

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

(iii) Suggest why there is still a reading of 14 MΩ on the resistance meter when all the switches are open.

…………………………………………………………………………………...

…………………………………………………………………………………...

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

6 **(a)** Define *magnetic flux density*.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(b) An electron moving with a speed v in a magnetic field of flux density B, will experience a magnetic force F. By means of a simple diagram, show the relative directions of F, B and v. Write an equation for the magnitude of the force experienced relating to your diagram.

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

For Examiner's Use

(c) In 1879, the American physicist E. H. Hall found that when a current, I was flowing in a conductor, a magnetic field at right angles to the current caused a very small potential difference to be induced across the conductor of depth, d and width, w. This discovery led to the invention of a hall probe.

Fig. 6.1 shows the diagram of how a simple hall probe works.

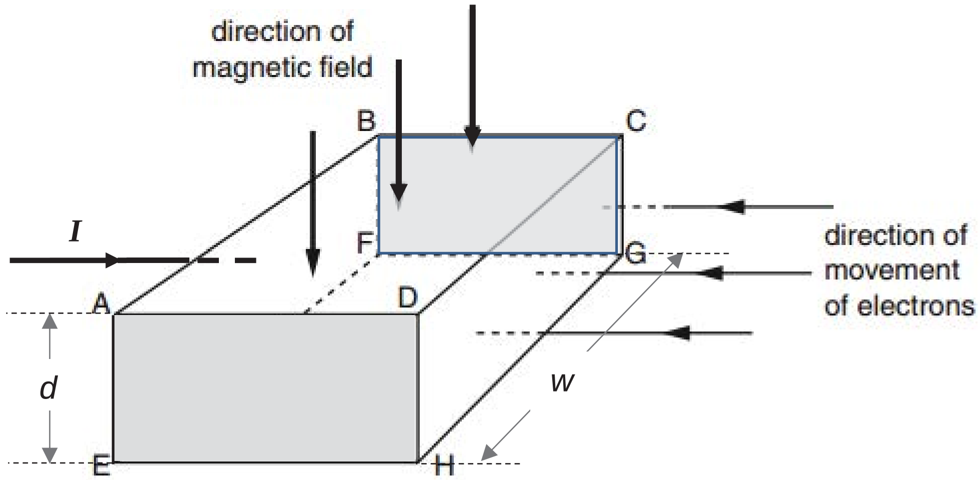


Fig. 6.1

The magnetic field is normal to face ABCD in the downward direction.

Electrons enter face CDHG at right-angles to the face. As the electrons pass through the conductor, they experience a force due to the magnetic field.

As electrons drift across the conductor at a certain drift velocity v, an electric field will be set up.

(i) By considering the movement of the electrons, explain why a potential difference (the Hall potential difference) exists between the shaded faces of the conductor.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) Hence or otherwise, deduce the polarity of the potential difference by stating which face (ADHE or BCGF) has a positive potential.

…………………………………………………………………………………… [1]

For Examiner's Use

(iii) By considering the magnitude and direction of the electric force and magnetic force acting on the electrons, show that the magnitude of the Hall potential difference, V_H is

$$V_H = \frac{IB}{ned}$$

where

n is the number of free electrons per unit volume in the conductor

e is the elementary charge of electron

d is the depth of conductor

B is the magnetic flux density

I is the current flowing through the conductor

[3]

(d) Experiments to demonstrate the Hall effect normally involve the use of a semiconductor sample instead of metallic conductor. Suggest a reason.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

Section B

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

7 **(a)** State *Lenz's law*.

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(b) A pair of parallel metal rails of negligible resistance are placed 12 cm apart in an uniform magnetic field of strength 0.65 T applied perpendicularly to the rails out of paper, as shown in Fig. 7.1. Two 15 cm long metal rods, AB and CD, are placed on top of the rails and can slide smoothly along the rails. Rod AB has an electrical resistance of 8.0 Ω while rod CD has an electrical resistance of 10 Ω. Rod AB is pulled to the left by an external force at a constant speed of 2.0 m s^{-1} while rod CD is pulled to the right at a constant speed of 3.0 m s^{-1}.

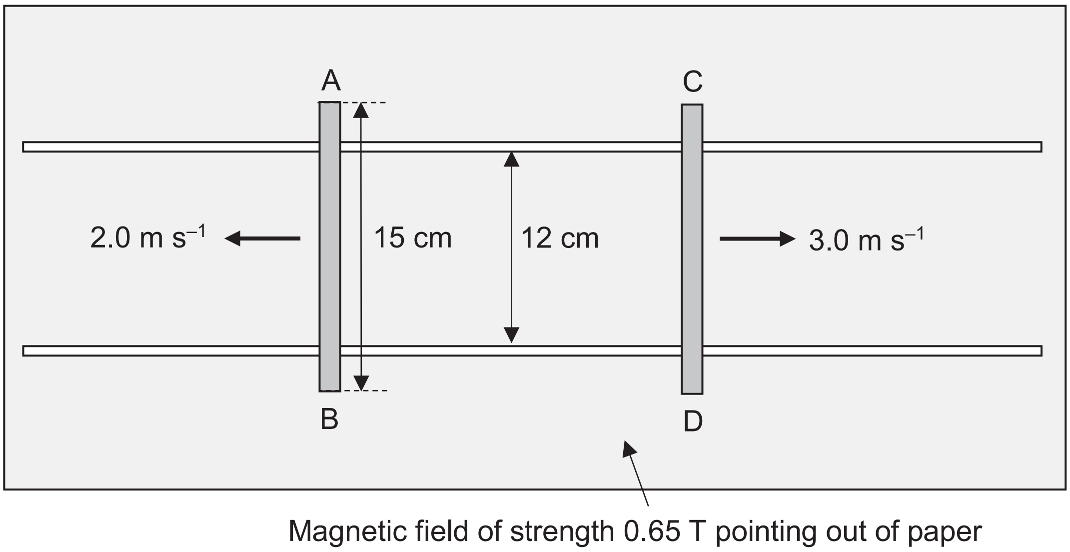


Fig. 7.1

(i) State which end of rods AB and CD has a higher potential.

Rod AB: ……….

Rod CD: ………. [2]

For Examiner's Use

(ii) Determine the induced e.m.f. across each rod.

e.m.f. of rod AB = ………………… V

e.m.f. of rod CD = ………………… V [2]

(iii) Determine the induced current flowing in the rods.

induced current = ………………… A [2]

(iv) Hence calculate the total power dissipated in both rods.

total power = ………………… W [2]

For Examiner's Use

(v) By considering your answer in **(iv)**, show that energy is conserved during this induction process.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [3]

(c) State what is meant by *root-mean-square current*.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(d) An ideal transformer is used to step up an alternating voltage V_{in} as shown in Fig. 7.2. The secondary coil of the transformer is connected to a resistor of 4.0 Ω.

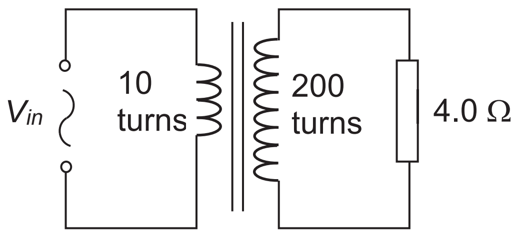


Fig. 7.2

For Examiner's Use

Fig. 7.3 shows the variation of the power input at the primary coil with respect to time t.

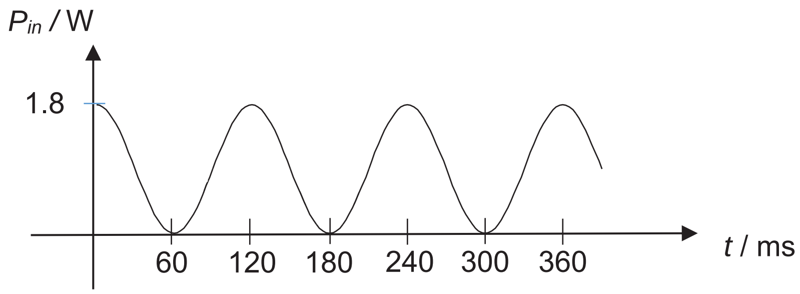


Fig. 7.3

(i) Determine the root-mean-square voltage in the secondary coil.

root-mean-square voltage = ………………… V [2]

(ii) Determine the root-mean-square current flowing in the primary coil.

root-mean-square current = ………………… A [2]

For Examiner's Use

(iii) Sketch the variation of input current I_{in} at the primary coil with respect to time t, in Fig. 7.4 and indicate the value of peak input current. [2]

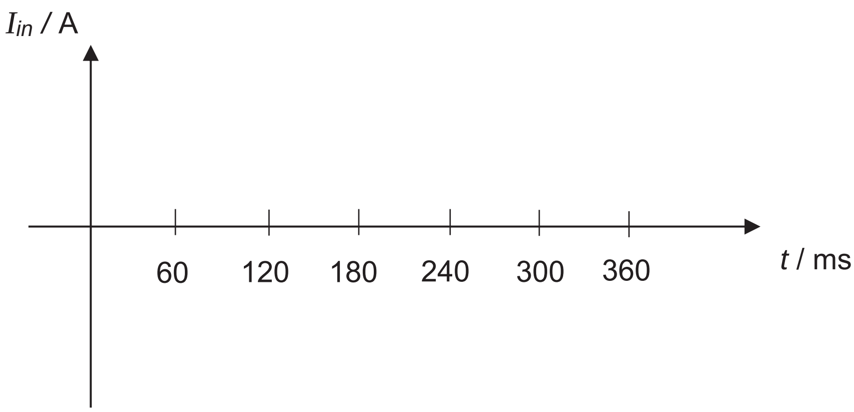


Fig. 7.4

(iv) State the equation showing how input current I_{in} varies with time t.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

[Turn over

For Examiner's Use

8 **(a)** Explain what is meant by

(i) *half-life* of a radioactive isotope

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(ii) the *decay constant*

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(iii) *random* nature of the radioactive decay

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

(b) A milk sample is to be tested for evidence of radioactive contamination with the radioactive nuclide strontium-90, using a Geiger-Muller tube. The two stages involved in the decay of strontium-90 are described by the equations:

Stage 1: $^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + \beta$

Stage 2: $^{90}_{39}Y \rightarrow {}^{90}_{40}Zr + \beta$

At each stage, a beta particle is emitted. The half-life for the second stage is 64 hours and the final product zirconium-90 is stable.

The decay constant for the beta decay of strontium-90 is 7.75×10^{-10} s^{-1}.

Data:

Mass of Strontium-90	89.907738 u
Mass of Yttrium-90	89.907150 u
Mass of beta particle	0.0005485 u

For Examiner's Use

(i) Given that the parent strontium-90 nucleus is initially at rest, calculate the speeds of the two daughter products in Stage 1.

speed of Yttrium: …………………. m s^{-1}

speed of beta particle: ………………… m s^{-1} [4]

(ii) State and explain the difficulties involved in attempting to measure the half-life of the beta decay of the strontium-90 experimentally.

……………………………………………………………………………………

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……………………………………………………………………………………

…………………………………………………………………………………… [3]

For Examiner's Use

(iii) State two precautions that must be taken in order to obtain an accurate value of the activity of the milk sample.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iv) Explain why and how it is dangerous for human, particularly pregnant ladies, to be exposed to the above radioactive product.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

(v) Suppose a beta particle from the strontium-90 decay moves in a gas along a straight line OA. A uniform magnetic flux density 3.0×10^{-4} T is applied when the particle reaches A. Fig. 8.1 shows the subsequent path of the particle in a plane perpendicular to the magnetic field.

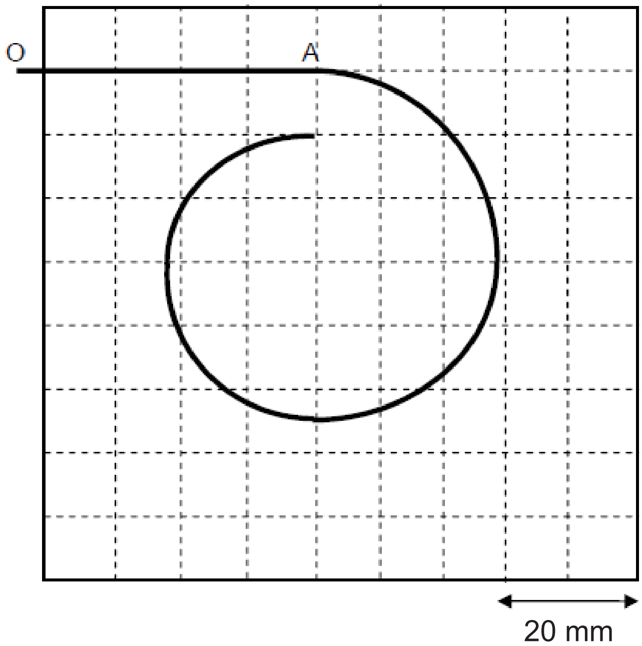


Fig. 8.1

1. State the direction of the applied magnetic field.

………………………………………………………………………………… [1]

2. Explain why the path of the beta particle is a spiral.

…………………………………………………………………………………

…………………………………………………………………………………

………………………………………………………………………………… [2]

3. By estimating the radius of the curvature at A using Fig. 8.1, calculate the speed of the particle as it passes A.

speed = ………………… m s^{-1} [2]

--- End of paper ---

Candidate's name ………………………………..……… CTG ……………

YISHUN JUNIOR COLLEGE
JC 2 PRELIMINARY EXAMINATIONS 2017

PHYSICS **9749/4**

HIGHER 2 **18th August 2017**

2 hours 30 minutes

Paper 4 Practical Test

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

READ THESE INSTRUCTIONS FIRST

Write your name and CTG in the spaces provided on this cover page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.

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

You may lose marks if you do not show 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.

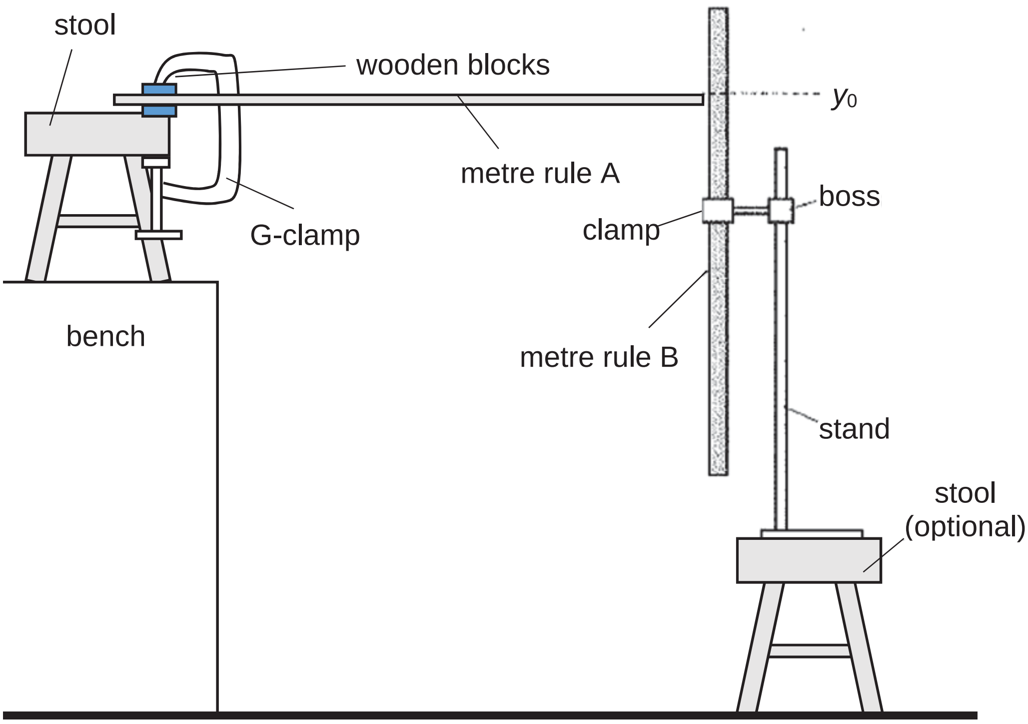
Shift
Laboratory

For Examiner's Use	
1	/13
2	/10
3	/20
4	/12
Total	
	/ 55

For Examiner's Use

1 In this experiment, you will investigate the deflection of a loaded metre rule.

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



y_0 is the point on rule B level with the top of rule A.

Fig. 1.1

(ii) Record the reading y_0.

y_0 = ...[1]

(iii) Place a 200 g mass on the end of rule A as shown in Fig. 1.2.

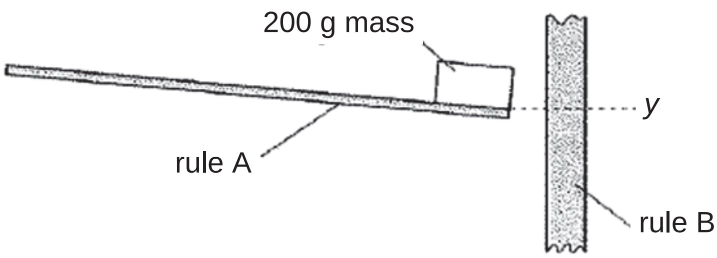


Fig. 1.2

y is the point on rule B level with the top of rule A.

(iv) Record the reading y.

y = ...[1]

For Examiner's Use

(v) Remove the 200 g mass from rule A.

(vi) Calculate the deflection ($y - y_0$).

($y - y_0$) = ……………………………[1]

(vii) Determine the percentage uncertainty in ($y - y_0$).

percentage uncertainty in ($y - y_0$) = ……………………………[1]

(b) **(i)** Repeat **(a)(ii)**.

y_0 = ……………………………

(ii) Place the 200 g mass at a position approximately half way along rule A.

(iii) Repeat **(a)(iv)**, **(a)(v)** and **(a)(vi)** with the 200 g mass placed at a position approximately half way along rule A.

y = ……………………………

($y - y_0$) = ……………………………[2]

(c) **(i)** It is suggested that:

"If both masses are placed on rule A in different positions at the same time, the deflection will equal the sum of the deflections for each mass on its own."

Take more readings to investigate this suggestion. Present your results in a table.

[3]

(ii) State and explain whether or not the results of your experiment support the suggestion.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

For Examiner's Use

(d) **(i)** State a significant source of error in this experiment.

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………[1]

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

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………[1]

[Total: 13 marks]

For Examiner's Use

2 In this experiment, you will investigate an oscillating rod.

(a) **(i)** You have been provided with a wooden rod with five holes.

The distance *x* is between the end of the rod and the first hole as shown in Fig. 2.1.

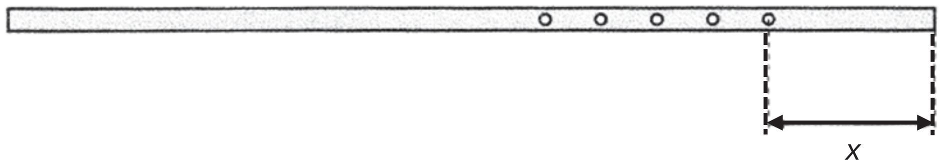


Fig. 2.1

(ii) Measure and record *x*.

x = ……………………………[1]

(iii) Push the wooden block onto the wooden rod so that its centre is the same distance *x* from the end of the rod as shown in Fig. 2. 2.

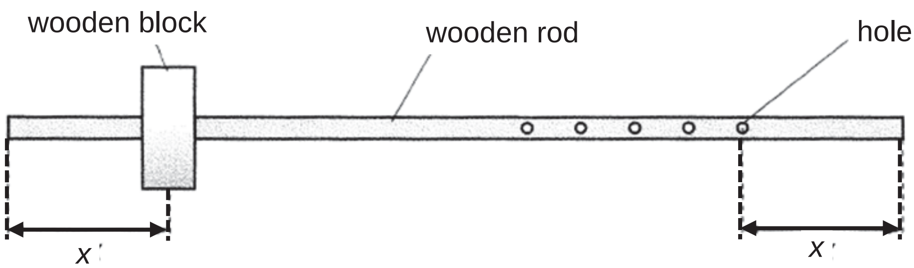


Fig. 2.2

(iv) Explain how you ensured that the distance measured between the centre of the wooden block and the end of the rod was equal to *x*.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………….[1]

For Examiner's Use

(b) **(i)** Assemble the apparatus as shown in Fig. 2.3 with the nail through the first hole.

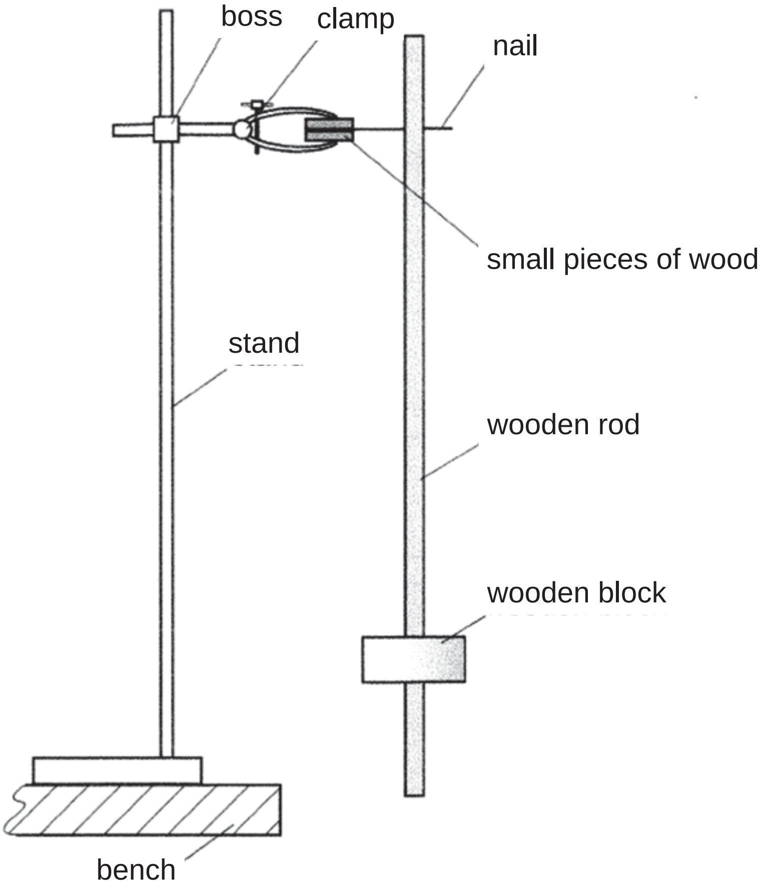


Fig. 2.3

(ii) Pull the bottom of the rod towards you.

Release the rod and allow it to oscillate.

Determine the period T of these oscillations.

T = ……………………………[2]

For Examiner's Use

(c) **(i)** Repeat **(a)(ii)**, **(a)(iii)** and **(b)** using all the other holes.

Present your results in a table.

[4]

(ii) Estimate the value of x for which T has a minimum value.

x = ……………………………[1]

(iii) Explain how you estimated your value of x in **(c)(ii)**.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………[1]

[Total: 10 marks]

For Examiner's Use

3 In this experiment, you will investigate constantan wire.

(a) **(i)** You have been provided with two lengths of constantan wire attached to mountings labelled M and N, an unknown resistor Y, and six resistors labelled with their resistance values in ohms.

Connect the circuit as shown in Fig. 3.1.

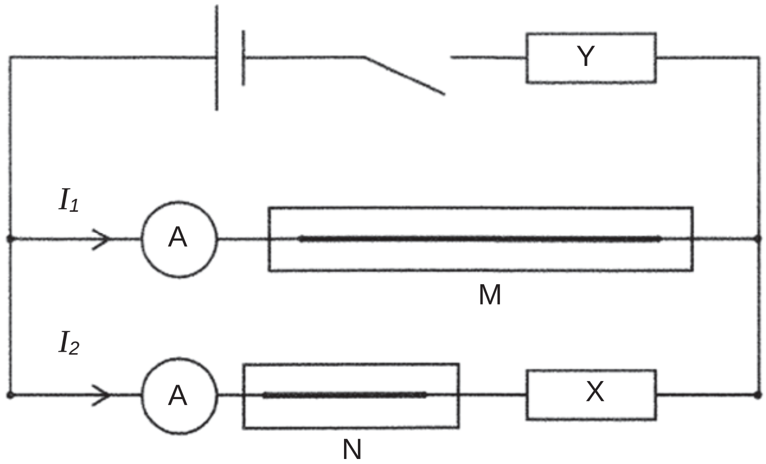


Fig. 3.1

The resistor X should be one of the resistors provided which has its value attached.

(ii) Record R, the resistance of X.

R = ………………………………

(iii) When the switch is closed, the current through M is I_1 and the current through N is I_2.

Close the switch and record I_1 and I_2.

I_1 = …………………………[1]

I_2 = ………………………………

(iv) Open the switch.

[Turn over

For Examiner's Use

(b) Change X and repeat **(a)(ii)**, **(a)(iii)** and **(a)(iv)** for further values of R.

[5]

(c) I_1, I_2 and R are related by the expression

$$\frac{I_1}{I_2} = PR + Q$$

where P and Q are constants.

(i) Draw a graph of $\frac{I_1}{I_2}$ against R.

(ii) Determine the gradient of the line.

gradient = ……………………………[1]

(iii) Determine the y-intercept of the line.

y-intercept = ……………………………[1]

For Examiner's Use

[3]

(d) Use values from **(c)(ii)** and **(c)(iii)** to determine values for P and Q.

P = ……………………………[1]

Q = ……………………………[1]

(e) Standard wire gauge (swg) describes the diameter of a wire.

The data in the table shows the diameter d and resistance per metre R' for constantan wire of different swg.

swg	d / mm	R' / $\Omega\ m^{-1}$
26	0.46	3.0
28	0.38	4.4
30	0.32	6.3
32	0.27	8.3
34	0.23	11.4
36	0.19	16.8
38	0.15	27.0
40	0.12	40.0
42	0.10	62.0
44	0.081	95.0

Theory suggests that resistance of wire M = $\dfrac{1}{P}$.

Use the value from **(d)** and the data in the table to identify the wire used in this experiment.

Explain your reasoning.

……………………………………………………………………………………………

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……………………………………………………………………………………………

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swg ……………………………[3]

For Examiner's Use

(f) Theory suggests that $Q = \dfrac{\text{length of wire N}}{\text{length of wire M}}$.

Explain whether your results support the theory.

……………………………………………………………………………………………

……………………………………………………………………………………………

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……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………[2]

(g) **(i)** The experiment is repeated with the length of wire M increased but the swg of the wire used for M and N kept the same.

On the graph grid on page 11 sketch a second graph to represent the new results. Label it Z. [1]

(ii) State a problem that might arise if both wires M and N are shortened and constantan wire of an swg 26 is used.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………[1]

[Total: 20 marks]

4 An air riffle can be used to fire small metal pellets onto an absorbent material which is placed some distance away from the riffle. The faster the pellet move, the deeper it is embedded into the absorbent material.

It is suggested that the depth, *d* the pellet is embedded into the absorbent material is related to the velocity *v* of the pellet at the instant it hits the material.

Design a laboratory experiment to investigate how the depth the pellet is embedded in the absorbent material varies with the speed of the pellet.

Your answer should include a diagram and make particular reference to

(a) the equipment to be used,
(b) the procedure to be followed,
(c) how the speed of the pellets may be changed (assuming that that the pellets leave the rifle with a fixed speed),
(d) how the depth the pellet is embedded in the absorbent material is to be measured,
(e) the control of variables,
(f) any precautions that would be taken to improve the accuracy and safety of the experiment.

You may assume that the following equipment are available, together with any other standard laboratory apparatus that would be found in a school or college science laboratory.

Mounted air rifle

Connecting wires

Stopwatch

Power supply unit

Light gates and data logger

Sheets of absorbent material (e.g. cork)

Thin aluminium foil

For Examiner's Use

Diagram:

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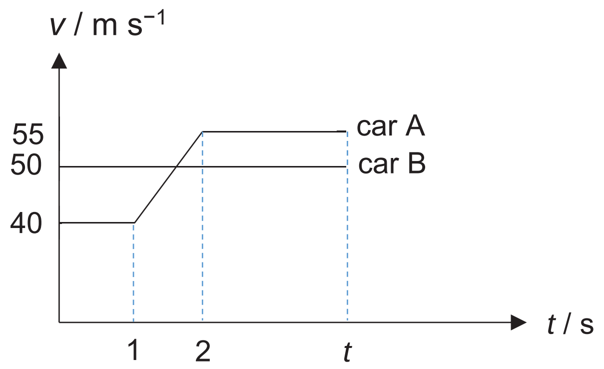
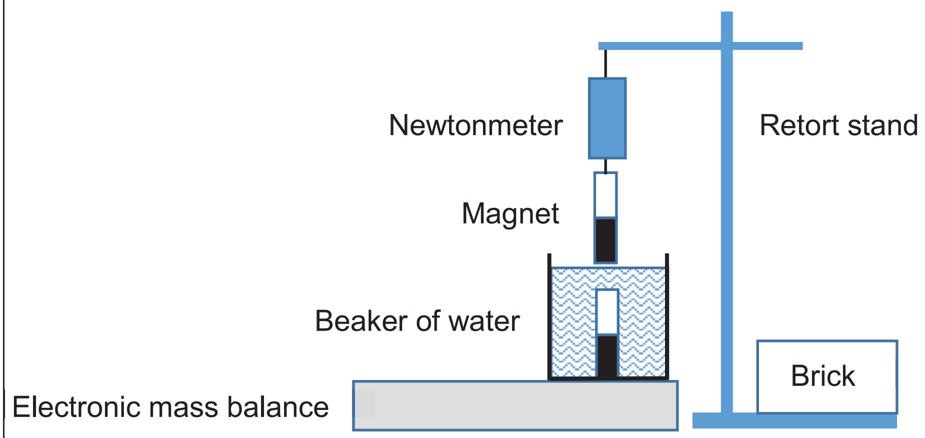
For Examiner's Use

....[12]

--- End of paper ---

2017 9749 JC2 H2 Physics Prelim Paper 1 Solutions

S/N	Ans	Explanation
1	**D**	Intensity = Power/Area = Energy/(Time × Area) [Intensity] = [Energy]/([Time] × [Area]) = ([Force] ×[displacement]/ ([Time] × [Area]) = (kg m s^{-2} × m)/(s × m^2) = kg s^{-3}
2	**C**	 For car A to catch up with car B, the distance travelled by both cars will be the same. $50t = (40\times1) + ½\,(40+55)(1) + 55(t - 2)$ t = 4.5 s Incorrect answers Option D: If students did some careless mistakes $50t = (40\times1) + ½\,(40+55)(1) + 55(t)$ t = 17.5 s Option B: did not understand the use of relative speed Distance travelled by B in 2s = 50 × 2 = 100 m Distance travelled by A in first second = 40(1) Distance travelled by A in second second = 40(1) + ½ (55-40)$(1)^2$ =47.5 m Distance between A & B = 100 – (40 + 47.5) = 12.5 m Time taken to catch up by A = 12.5 / 55 = 0.23 s (failed to see that the relative speed between A & B is 5 m s^{-1}, hence should use 12.5 / 5 = 2.5 s Total time = 2 + 0.23 = 2.2 s Option A: did not understand the question Distance travelled by B = $50t$ Distance travelled by A = $ut + ½\,(at)^2$ $= 40t + ½\,(55-40)t^2$ $50t = 40t + ½\,(55-40)t^2$ t = 1.3 s

3	**C**	Vertically: $\Sigma F_y = 0$ $N - W = 0$ $N = W = 120$ N $R = \sqrt{N^2 + f^2}$ $160 = \sqrt{120^2 + f^2}$ $120^2 + f^2 = 25600$ $f = 105.83$ N Horizontally: $\Sigma F_x = m\, a_x$ $f = (W/g)\, a_x$ $105.83 = (120/9.81)\, a_x$ $a_x = 8.7$ m s^{-2}
4	**A**	 Reading = Wm + Ww – Mm Mm = T – Wm Thus reading = Wm +Ww – T + Wm = 2Wm + Ww – T. Hence reading = 2Q + J – S
5	**A**	Since the object is moving with constant velocity, there is no change in the kinetic energy of the object. Hence there is no net work down on the object.
6	**B**	$v = 100$ km h^{-1} = $(100 \times 10^3)/(60 \times 60)$ = 27.78 m s^{-1} By Work Energy Theorem: $\Sigma W = \Delta KE$ $P_{engine} \times t = ½\, m\, v^2 - 0$ $P_{engine} = (½\, m\, v^2)/t$ $t_{min} = (½\, m\, v^2)/\, P_{max}$ $= [((½\,(2000)\,(27.78)^2/(50 \times 10^3)$ = 15.4 s
7	**D**	The centripetal force is perpendicular to the displacement, hence there is no work done by the centripetal force. In time π/ω, the object would have moved half a circle. Hence the change in linear momentum = 2mv = 2mrω

8	**B**	For 1 string to support spinning motion, $T_B = mv^2/r$ For 2 string to support spinning motion, $2T_B = mv'^2/r$ V'/v = sqrt(2) V' = sqrt(2) v **Ans: B**
9	**C**	$\frac{GMm}{r^2} = mr'(\frac{2\pi}{T})^2$ $\frac{G(4.0\times10^{30})}{(2.0\times10^{11})^2} = (1.0\times10^{11})(\frac{2\pi}{T})^2$ $T = 2.4\times10^7\ s$ Incorrect answers Option A: If student thought that radius of rotation is the same as the distance between the two stars and used 1.0×10^{11} m as the radius. (1.2×10^7 s) Option B: If student thought that the centripetal force is the twice the gravitational force. (1.7×10^7 s) Option D: If student thought that radius of rotation is the same as the distance between the two stars and used 2.0×10^{11} m as the radius. (3.4×10^7 s)
10	**C**	$\frac{1}{2}mv_{esc}^2 - \frac{GMm}{r} = 0$ $v_{esc} = \sqrt{\frac{2GM}{r}} = \sqrt{\frac{2G\left(\frac{4}{3}\pi r^3\rho\right)}{r}}$ $v_{esc}\ \alpha\ r\sqrt{\rho}$ $\frac{v_{esc}planetX}{v_{esc}planetY} = \frac{R\sqrt{\rho}}{5R\sqrt{0.25\rho}}$ $v_{esc}planetY = 2.5v_{esc}planetX$ Incorrect answers Option B : careless hence chose 0.4 instead. Option A & D: when the relationship is $v_{esc} = \sqrt{\frac{2G\rho V}{r}}$ and hence $v_{esc}\ \alpha\ \sqrt{\frac{\rho}{r}}$
11	**B**	<u>Largest area</u> under graph and a <u>decrease in volume</u>

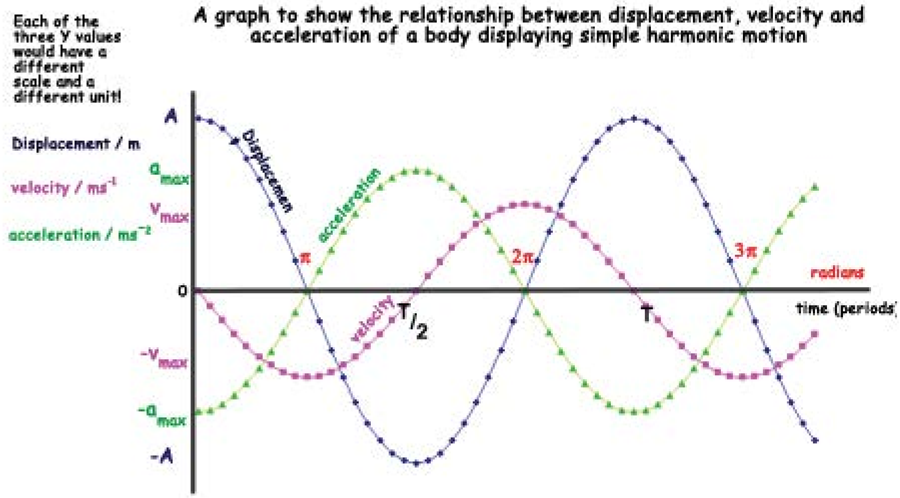
<table>
<tr><td>12</td><td>C</td><td>Process 1: Compressed at constant pressure results in lower temperature and hence <u>lower</u> internal energy

Process 2: Heated (+Q) and decreasing volume (+W) results in <u>higher</u> internal energy</td></tr>
<tr><td>13</td><td>D</td><td>Since $\frac{3}{2}$ K T = $\frac{1}{2}$ m $(v_{rms})^2$, T is proportional to $(v_{rms})^2$

Since v_{rms} is increased by 1.05 (5%), T is increased by $(1.05)^2$

New temperature = (30 + 273) $(1.05)^2$ = 334 K = 61 °C</td></tr>
<tr><td>14</td><td>C</td><td>OSCILLATIONS
acceleration $a = -(2\pi f)^2 x$
displacement $x = A\cos(2\pi f t)$
speed $v = \pm 2\pi f\sqrt{A^2 - x^2}$
maximum speed $v_{max} = 2\pi f A$
maximum acceleration $a_{max} = (2\pi f)^2 A$
for a mass-spring system $T = 2\pi\sqrt{\frac{m}{k}}$
for a simple pendulum $T = 2\pi\sqrt{\frac{l}{g}}$

Time period would halve as T = 1/f
Energy is related to v^2 (KE = $^1/_2\, mv^2$) - therefore energy would increase by a factor of root 2.
Max velocity would double as v and f are proportional.

Acceleration relates to square of frequency so that is incorrect. It would increase by a factor of four.</td></tr>
<tr><td>15</td><td>A</td><td>
</td></tr>
<tr><td>16</td><td>D</td><td>I α A^2 and I α $1/r^2$
Therefore, Aα1/r
Hence $\frac{A_Q}{A_P} = \frac{r}{(2r)}$
A_Q = 1/2 (8.0)= 4.0 μm</td></tr>
<tr><td>17</td><td>C</td><td>$\lambda = ax / D$

$x_1 = \frac{\lambda_1 (D)}{a}$ $\quad$ $x_2 = \frac{\lambda_2 (D)}{a}$

For them to coincide,</td></tr>
</table>

		$n_1\lambda_1 = n_2\lambda_2$ where n is the order of the bright fringes Ratio of n_1 / n_2 = 900 / 750 The smallest n_1 such that both n_1 and n_2 are integers is 6. Therefore, Smallest distance is $6x_1 = 6\ (750 \times 10^{-9})(2.0) / (2.0 \times 10^{-3})$ $= 4.5 \times 10^{-3}$ m
18	**B**	Coherence = constant phase difference.
19	**D**	Option D : $v = f\lambda$ By increasing v, λ will be larger, f being constant. The larger λ will be more comparable to the slit width and hence the diffraction will be more significant. Incorrect answers Option A & B: It will not change anything Option C: Increasing the f will reduce the λ, v being constant.
20	**C**	$a = Eq/m = (3.5)\ (1.6 \times 10^{-19}) / 9.11 \times 10^{-31}$ $= 6.15 \times 10^{11}$ $S_x = v_x\ t$ $t = 0.0002/5500 = 3.64 \times 10^{-8}$ s $v_y = (6.15 \times 10^{11})\ (3.64 \times 10^{-8}) = 22386$ m s^{-1} $v = \sqrt{(22386^2 + 5500^2)} = 2.31 \times 10^4$ m s^{-1}
21	**C**	Electric field strength is proportional to the rate of change in electric potential with respect to distance. Hence maximum electric field strength occurs at the <u>steepest</u> gradient.
22	**C**	$R = \rho L/A$ $A = \rho L/R$ --- (1) $D = M/V = M/LA$ ⇨ $M = DLA$ --- (2) Substitute (1) into (2): $M = D\rho L^2/R$ $M \propto D\ \rho$ (L & R = constant) $M_C/M_A = (D_C/D_A) \times (\rho_C/\rho_A)$ $M_C/M_A = (3D_A/D_A) \times (0.5\ \rho_A/\rho_A)$ $= 3 \times 0.5$ $= 1.50$

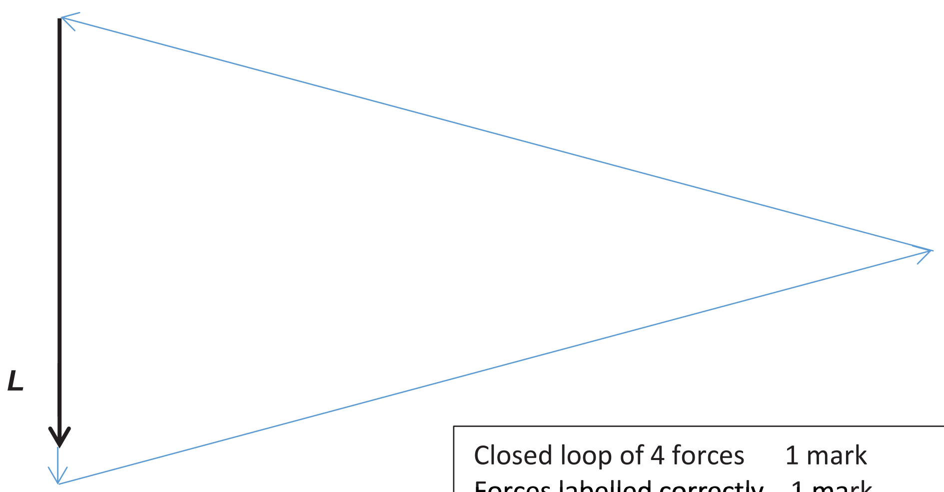
23	**D**	$I = n\,q\,A\,v$ $I = n\,q\,(\pi\,r^2)\,v$ $v = I / \pi\,n\,q\,r^2$ $v \propto 1/r^2$ (I, n & q are constants) $v'/v = (r/r')^2$ $v'/v = (r / 0.5\,r)^2$ $v' = 4\,v$
24	**A**	P.d across variable resistor (R=0) = 0 V P.d across variable resistor (R= 4) = (4/4+6)(6) =2.4 V
25	**B**	Suppose each bulb resistance is R. The initial combined resistance is R/3. Current through each bulb is E/R, ammeter reading is 3(E/R) Power of each bulb is E^2/R After one bulb breaks, The combined resistance is R/2. Current through each bulb is E/R, ammeter reading is 2(E/R) Power of each bulb is E^2/R
26	**D**	Using FLHR, the force is out of the plane $F = (B/2)IL \cos 30^o = 4.0 \cos 30^o = 3.5$ mN
27	**A**	When the small coil experiences increasing flux pointing out of paper, it will induce flux pointing into paper and hence induces a <u>clockwise</u> current. The coil experiences forces pointing into the centre and hence causing it to become <u>smaller</u>.
28	**B**	$V_{rms} = 120 / 2 = 60$ V Mean power = $60^2 / 20 = 180$ W
29	**B**	When the frequency of light is doubled while the intensity remains unchanged, rate of photon incident on metal surface will be halved. This will reduce the photoelectric current by half.
30	**A**	To calculate time t: $N = N_o\, e^{-(\ln 2/t_{1/2})t}$ $(6.03 \times 10^{11}) = (7.0 \times 10^{11})\, e^{-(\ln 2/14)t}$ t = 3.0128 hrs Activity of Original sample after t+27hrs $= (\lambda N_o)\, e^{-(\ln 2/t_{1/2})t}$ $=(\ln 2/(14*3600) * 7.0 \times 10^{11})\, e^{-(\ln 2/14)30.0128}$

		$=2.1785 \times 10^6$ Bq Activity of new sample K after 27 hours $= 3.62 \times 10^6 - 2.1785 \times 10^6$ $= 1.4415 \times 10^6$ Bq Original activity of K: $A/A_o = (1/2)^{(27/14)}$ $A_o = A / (1/2)^{(27/14)} = 5.4876 \times 10^6$ Bq Hence value of K $= A_o/\lambda = (5.4876 \times 10^6)/(\ln 2/(14*3600)) = 3.99 \times 10^{11}$ **Ans: A**

2017 9749 JC2 H2 Physics Prelim Paper 2 Solution

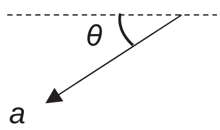
1		$\rho = M/V = M/(LBH)$ $\Delta\rho/\rho = \Delta M/M + \Delta L/L + \Delta B/B + \Delta H/H$ $\Delta\rho/2.50 = 0.1/25.0 + 0.01/5.00 + 0.01/2.00 + 0.01/1.00$ $\Delta\rho = 0.0525$ g cm^{-3} $\Delta\rho = 0.05$ g cm^{-3} or 0.06 g cm^{-3} If they leave it as 1 sf or 3 sf here, no marks deducted $(\rho \pm \Delta\rho) = (2.50 \pm 0.05$ or $0.06)$ g cm^{-3}	 C1 A1 A1
2	(a)	Change in momentum = Δp = area under F-t graph $= ½ [80 + 40] \{[150 – 100] \times 10^{-3}\}$ $= 3.00$ kg m s^{-1}	 C1 A1
	(b)	Final momentum = $p_f = p_i + \Delta p$ $= m v_i + \Delta p$ $= (200/1000)(15) + 3.00$ $= 6.00$ kg m s^{-1} $v_f = 30$ m s^{-1}	 C1 A1
3	(a)	From point of released of block till point of compression in spring where net force on block is zero or point of maximum speed: Gravitational Potential Energy of block is converted to Kinetic Energy of block and Elastic Potential Energy of spring. From point of compression in spring where net force is zero or point of maximum speed till point of maximum compression: Gravitational Potential Energy of block and Kinetic Energy of block converted to Elastic Potential Energy of spring. **At the point of maximum compression, the Kinetic Energy of block is zero, the Gravitational Potential Energy of block is minimum while the Elastic Potential Energy of Spring is maximum. OR	 B1 B1 B1

		**From point of release to just before it hits the spring Gravitational Potential Energy of block converted to Kinetic Energy of block.	
	(b)	Initial Position: Where block is released Final Position: Where spring is at its maximum compression Reference Position: Where spring is at its maximum compression By Principle of Conservation of Energy: $GPE_i = EPE_f$ $mg\ h_i = \frac{1}{2}\ k\ x^2$ $mg\ (s \sin 30°) = \frac{1}{2}\ k\ x^2$ $(12)(9.81)\ (4.3 \sin 30°) = \frac{1}{2}\ k\ (1.3)^2$ $k = 300\ N\ m^{-1}$	 **M0** **C1** **A1**

4	 Closed loop of 4 forces 1 mark Forces labelled correctly 1 mark Correct arrow directions 1 mark Value of P = 12 000 N (allow 100 N off) If value of P = 11 900 N to 12 100 N → 2 marks If value of P = 11 800 N to 12 200 N → 1 mark If value of P exceeds the range → No mark for accuracy	[5]

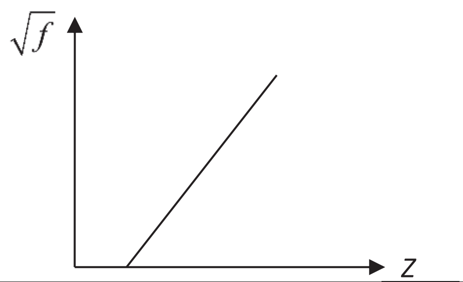
5	**(a)**	Heat exchange between water and ice: Heat gained by ice = heat lost by water (2.05×10^3) (0.5) (5 – 0) + (3.33×10^5) (0.5) + (4200) (0.5) (T – 0) = (4200) (2.5) (30 – T) T = 11.4 °C Heat exchange between water and steam: Heat gained by water = heat lost by steam (2.26×10^6) (0.2) + (4200) (0.2) (100 – T') = (4200) (3) (T' – 11.4) T' = 50.6 °C	 **1** **1** **1** **1**
	(b)	The <u>increase</u> in the internal energy of a system is equal to the sum of heat supplied <u>to</u> the system and the work done <u>on</u> the system.	**1** **1**
	(c)	Since both bubbles are identical, n must be the same. Since both bubbles experience the <u>same water pressure P</u> at the surface, the volume of the ideal gas must be proportional to its temperature. For bubble A, since there is no heat exchange, Q = 0. Therefore $\Delta U = W$. As its volume expands, W and hence <u>ΔU must be negative</u>. Since ΔU is proportional to ΔT, <u>ΔT is negative</u>. So the final temperature is lower than the initial temperature. For bubble B, since it remains in thermal equilibrium with the water, its <u>temperature will increase</u> as the surface temperature will be warmer than the temperature at the bottom. So the final temperature is higher than the initial temperature. Therefore, <u>bubble B will be larger</u> when they reach the surface.	 **1** **1** **1**

6	**(a)**	**(i)**		Formed due to superposition/interference of the incident wave from oscillator and reflected wave from Q. [1] The two waves have the same speed, wavelength/frequency, same amplitude and travel in opposite directions [1]	**1** **1**
		(ii)		There is a 180°/ π radian phase change at Q [1] since it is a fixed end, Hence there is destructive interference between the incident and reflected wave, [1] since they are π radian out of phase. – this mark given only if they are able to explain about the phase change.	**1** **1**
		(iii)	**1.**	$\frac{1}{2}\lambda = 0.30$ m $\lambda = 0.60$ m $v = f\lambda$ $= 120\ (0.60)$ $= 72$ m s^{-1}	**1** **1**
			2.	Phase difference is zero.	**1**
	(b)			***Light diffracts at the aperture, giving rise to a single slit diffraction pattern at the film or screen. or **$\theta = \lambda/b$ or $\theta = 1.22\lambda/b$ where λ is the wavelength of the light and b is the dimension of the aperture. In order to be able to observe the lights as different entities, the angle between the headlights have to be larger than a critical value, according to Rayleigh criterion. When the car is far away, the angle between the headlights are smaller than the critical θ. When the car is nearer, the angle between the headlights is larger than the critical θ.	**1** **1** **1**

7	**(a)**		Work done per unit positive charge in bringing a point charge from infinity to that point	**1**
	(b)	**(i)**	Neutral point is on the left side of P.	**1**
		(ii)	Electric field strength due to P = electric field strength due to Q $\frac{6\mu}{4\pi\varepsilon_o x^2} = \frac{9\mu}{4\pi\varepsilon_o (50+x)^2}$ x = 223 mm = 0.223 m	 **1** **1**
		(iii)	Work done = final EPE – initial EPE $= \frac{(6\mu)(-9\mu)}{4\pi\varepsilon_o}\left(\frac{1}{(223+50)\times10^{-3}} - \frac{1}{50\times10^{-3}}\right)$ = 7.9 J	 **1** **1**
	(c)	**(i)**	Electric force = $\frac{(4+1)}{0.1}(0.0025)$ = 0.125 N Weight = (0.005) (9.81) = 0.049 N Net force = $\sqrt{}(0.125^2 + 0.049^2)$ = 0.134 N a = 0.134/0.005 = 27 m s^{-2}	 **1** **1**
		(ii)	s = ut + ½ a t^2 s = 0 + ½ (27) $(0.05)^2$ s = 0.034 m = 3.4 cm θ = $\tan^{-1}$ (0.049/0.125) = 21 ° 	 **1** **1** **1**

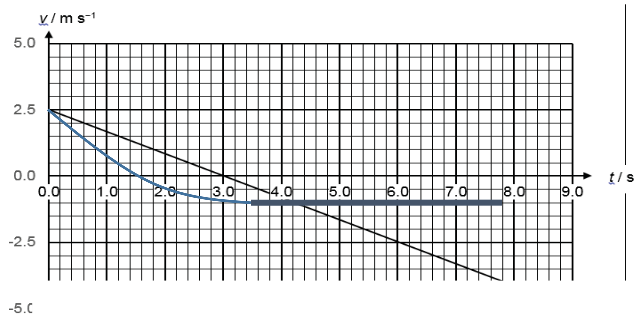
8	**(a)**		Diagram: Cell, Variable Resistor, Filament Lamp connected in series + Ammeter connected in series to Filament Lamp Voltmeter connected in parallel to Filament Lamp Correct Circuit Diagram Symbols	**B1**
			Procedures: By adjusting resistance of variable resistor to a specific value R, the current I flowing through filament lamp can be obtained from ammeter.	**B1**
			The corresponding potential difference across filament lamp V can be obtained from voltmeter.	**B1**
			Decrease or increase R to obtain another 7 sets of (V, I). Plot the I-V characteristic graph using the 8 sets of (V, I) and draw a best fit curve.	**B1**
	(b)	**(i)**	$I_1 = Q_1/t$	
			$= [(N_1)/t] \times e$	**M0**
			$= (2.58 \times 10^{16})\ (1.60 \times 10^{-19})$	**C1**
			$= 4.13 \times 10^{-3}$ A	**A1**
		(ii)	$I_T = I_1 + I_2$ $Q_2/t = I_T - I_1$	
			$[(N_2)/t] \times p = I_T - I_1$	**M0**
			$N_2)/t = (I_T - I_1)/p$	
			$= \{(8.16 - 4.13) \times 10–3\}/(3.2 \times 10^{-19})$	**C1**
			$= 1.26 \times 10^{16}\ s^{-1}$	**A1**

9	**(a)**	Power = $\frac{N_{photons}}{t}\left(\frac{hc}{\lambda}\right)$ $\frac{N_{photons}}{t} = \frac{1.2(530\times10^{-9})}{(hc)}$ $\frac{N_{photons}}{t}$ = 3.2 × 10^{18} / s	 **1** **1**
	(b)	Energy of each photon = $\frac{hc}{530\times10^{-9}}$ = 2.35 eV Since energy of photon is greater than work function, photoelectrons will be emitted.	**1**
	(c)	$p = \frac{h}{530\times10^{-9}}$ = 1.25 × 10^{-27} Pressure = $\frac{Force}{area} = \frac{rate\ of\ change\ in\ momentum}{area}$ = $\frac{(1.25\times10^{-27})(3.2\times10^{18})}{3.8\times10^{-6}}$ = 1.1 × 10^{-3} Pa	**1** **1**

10	(a)	(i)	When an electron collides with one of the target atoms, it may lose an amount of energy that corresponds to the energy of an X-ray photon. The electron may continue to lose energy in a series of collisions with other atoms, thereby giving off X-ray photons of different energies. Since different X-ray photons correspond to different wavelengths, the continuous spectrum is thus formed.	B1 B1
		(ii)	Min wavelength corresponds to max frequency and thus energy of photons. Hence max loss of energy due to most energetic (not important) electron losing all its KE to a single photon.	B1
	(b)	(i)	An empirical relation is one which is guided by experimental observations rather than by theory.	B1
		(ii)	Units of a = s^{-1} Units of b = dimensionless	B1
		(iii)	A material with a large atomic number will result in a braking radiation of higher intensity, or Elements of small atomic number will not result in large enough energy loss of the incoming electrons via braking radiation and so photons produced will not be X rays	B1
	(c)	(i)	$f = a(Z-b)^2$ $\sqrt{f} = \sqrt{a}(Z-b) = \sqrt{a}Z - \sqrt{a}b$ 	M1 A1
		(ii)	As the atomic number (Z) of elements increases, the frequency (f) of the emitted x-rays will increase. Since energy of x-rays is proportional to its frequency (E = hf), the energy of the x-rays will increase with increasing atomic number.	B1 B1
	(d)	(i)	$E_k = -\frac{13.6 \times 74^2}{1^2}$ eV $= -1.19 \times 10^{-14}$ J	M1 A1

		(ii)	When an electron from the K shell is displaced, for electron in shell M: $Z_{eff,3} = 74 - 1 - 8 = 65$ $E_M = -\frac{13.6 \times 65^2}{3^2}$ eV $= -1.02 \times 10^{-15}$ J $\Delta E = \lvert E_k - E_M \rvert$ $= \lvert(-1.19 \times 10^{-14}) - (-1.02 \times 10^{-15})\rvert$ $= 1.09 \times 10^{-14}$ J	B1 M1 A1 M1 A1
	(e)	**(i)**	Left peak : K_β Right peak : K_α	B1
		(ii)	Since the L shell is closer than the M shell to the K shell, the <u>closer transition</u> is more likely to occur. Intensity depends on the number of photons emitted per unit time and hence it is dependent on the probability of the transition. or Although the transition K_α results in the emission of a x-ray photon with lower energy, the probability of this transition happening is higher than that of transition K_β.This higher probability mitigates the lower energy of each x-ray photon emitted, resulting in higher intensity of x-ray with this wavelength being produced.	B1 B1

2017 9749 H2 Physics Prelim Paper 3 Solutions

1	(a)		acceleration = gradient of the graph $= \dfrac{-2.5-2.5}{6.0-0}$ $= -0.83$ m s^{-2}	1
		Marker's comment		
	(b)		$v^2 = u^2 + 2as$ $= [5.0 (\sin 30)]^2 + 2(-0.83)(-1.5)$ $v = 2.96$ m s^{-1}	1 1
		Marker's comment		
	(c)		The area between t = 6.02 s to point where v = calculated value of (b) 1 mark for correct starting time 1 mark for the ending time which corresponds to value of (b)	 1 1
		Marker's comment		
	(d)		$v_x = 5.0 \cos 30 = 4.33$ m s^{-1} Hence the point is at the position where the vertical velocity is also 4.33 m s^{-1} (t will be at 8.2 s) Correct point on the graph	1 1 1
		Marker's comment		
	(f)		 Correct curvature [1] The object may not have reached terminal velocity Max height is reached at a shorter time [1]	1 1

For Examiner's Use

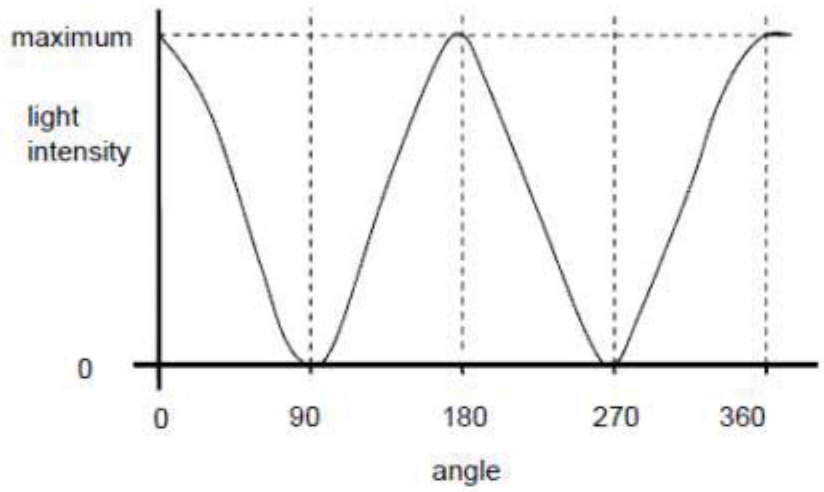
2	(a)	The principle of conservation of momentum states that total momentum in a closed system remains constant if the net external force acting on the bodies is zero.		B1 B1
		Marker's comment		
	(b)	(i)	It means that the point of impact is on the straight line connecting the centre of mass of the two objects. Or centre of mass of the two objects approaches each other in a straight line.	B1
		(ii)	Rightwards as positive: $\Sigma p_i = \Sigma p_f$ (0.0200)(8.0) + (0.0100)(5.0) = (0.0200)(-2.0) + (0.0100) v v = 25 m s^{-1}	M0 C1 A1
		Marker's comment		
		(iii)	Rightwards	B1
		Marker's comment		
		(iv)	On 0.0100 kg object: $\Sigma F = \Delta p/\Delta t$ $= m (v_f - v_i)/ \Delta t$ = (0.0100) [(+25) – (5.0)]/0.120 = 1.67 N Alternatively: On 0.0200 kg object: $\Sigma F = \Delta p/\Delta t$ = m (vf – vi)/ Δt = (0.0200) [(-2) – (+8)]/0.120 = - 1.67 N By Newton's Third Law, ΣF on 0.0100 kg object = ΣF on 0.0200 kg object = 1.67 N	M0 C1 A1 M0 C1 A1
		Marker's comment		
		(v)	If both objects stop at the same instant, the total momentum of both objects is zero at that instant. However, before the collision, the total momentum of both objects was non-zero. This violates the principle of conservation of momentum which specify that the total momentum remains non-zero.	B1 B1

[Turn over

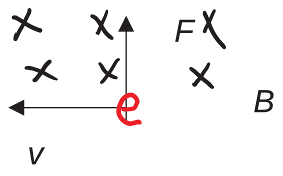
For Examiner's Use

		Marker's comment		
3	**(a)**		The gradient of the graph is constant. Since gravitational field strength g = -dϕ / dr, the field strength is constant.	**1** **1**
		Marker's comment		
	(b)		$\phi_{100\text{ km}}$ = − 61.52 MJ kg^{-1} $\phi_{10\text{ km}}$ = − 62.4 MJ kg^{-1} [1 mark for reading off correctly] Work done = change in GPE = $m(\phi_{100\text{ km}} - \phi_{10\text{ km}})$ = 4200 (− 61.52 + 62.4) × 10^6 = 3.7 × 10^9 J [1 mark for final answer. Deduct 1 mark if candidate did not read in MJ kg^{-1}]	**1** **1**
		Marker's comment		
	(c)	**(i)**	$\omega = 2\pi / T$ T = 5236 s = 5200 s	 **1**
		Marker's comment		
		(ii)	$\sum F = mr\omega^2$ $m(9.7) = m(R_E + 100 \times 10^3)\ \omega^2$ $R_E = 6.6 \times 10^6$ m	 **1** **1**
		Marker's comment		
	(d)		The mass of moon is smaller than mass of Earth The gravitational field strength experienced by moon shuttle will be smaller. [It will be incorrect to mention that the gravitational force will be larger/smaller or centripetal force will be larger/smaller since the mass of the moon shuttle is different.] The period will be longer.	**1** **1** **1**
		Marker's comment		
4	**(a)**	**(i)**	$\omega = 2\pi f$	**1**
		(ii)	Either "acceleration and displacement are always in opposite direction" Or "acceleration is always directed towards the equilibrium"	 **1**
		Marker's comment		

For Examiner's Use

	(b)	(i)	Forces in spring are $k(e+x)$ and $k(e-x)$ Resultant force = restoring force $F = k(e+x) - k(e-x)$ $F = 2kx$	1 1
		(ii)	F= ma a = 2kx/m $\lvert a \rvert = \omega^2 x$ *hence* $\omega^2 = 2k/x$	 1 1
		Marker's comment		
	(c)	(i)	 max 0, 180, 360 + min 90, 270 **(1)** **and** line reaches same minimum and maximum every time and reasonable shape **(1)**	2
		(ii)	LCD screens, camera lenses, 3-D glasses, Polarised sunglasses	1
		(iii)	For longitudinal wave, the direction of oscillations are parallel to the direction of wave propagation, hence the transmission axis will have no effect and no polarisation can be observed.	1
		Marker's comment		
5	(a)		Potential difference between two points of a circuit **is the amount of electrical energy converted per unit charge into other forms of energy** when the charge moved from one point to the other. Electromotive force of a source is defined as the **energy converted per unit charge from other forms of energy into electrical energy** when the charge is driven through the source round a complete circuit.	1 1
			Marker's comment	

	(b)		Calculate safe maximum current 500 Ω : current = $\sqrt{\frac{P}{R}} = \sqrt{\frac{0.8}{500}}$ = 0.040 A 2 x 0.040 = 0.080 A 320 Ω : current = $\sqrt{\frac{0.8}{320}}$ = 0.050 A 2 marks for calculating max current for both types of resistors. The 320 Ω resistor will be damaged first. Maximum current in circuit = 0.050 A 1 mark for recognizing the maximum current or the resistor which will be damaged first. Maximum safe p.d = 0.050 (320 + 250)= 28.5 V 1 mark for determining the maximum safe potential difference.	**1** **1** **1** **1**
			Marker's comment	
	(c)	**(i)**	Lamp K. When switches B, C, D, E are closed and switch A open, the reading should be 45 Ω. But the reading measured is 0.2 Ω.	**1** **1**
			Marker's comment	
		(ii)	The lamp is short-circuited or any other possible reason which could cause the resistance of the lamp to be reduced to near zero. Do not accept that the lamp is fused because if the lamp is fused, the resistance should be infinite (open circuit).	**1**
		Marker's comment		
		(iii)	The resistance meter has its own internal resistance of 1.4 x 10^7 when operated. (This resistance is connected in parallel to the rest of circuit. Hence when the rest of the circuit to be measured has infinite resistance, the effective resistance is its own internal resistance.) Do not accept resistance meter is non-ideal or that the resistance meter can only give a maximum reading of this value. These answers are too generic. Student should explain more clearly.	**1**
		Marker's comment		

6	(a)		The magnetic flux density of a magnetic field is defined as the force exerted on a unit length of conductor carrying a unit current placed at right angles to the field.	1
	(b)		$F = 1.6 \times 10^{-19}\,Bv$ Should use either "e" (elementary charge) or 1.6×10^{-19} for the charge instead of the generic q.  1 mark for F, v , B perpendicular to each other. 1 mark for correct direction of F using FLHR on electron	1 1 1
		Marker's comment		
	(c)	(i)	As a result of the magnetic force acting on the electrons, there will be a build-up of charges at the sides of the conductors, producing a measurable voltage, v between the two sides of the conductor.	1
		Marker's comment		
		(ii)	ADHE	1
		Marker's comment		
		(iii)	Since $I = neAv$ Hence $v = I/neA$ $(A = wd)$ At equilibrium condition, the magnetic force is balanced by an electric force. $F_B = F_E$ $Bqv = qE$ $(E = V/w)$ $B(I/neA) = V/w$ $V = \frac{IB}{ned}$ Note: V is hall p.d, v is drift velocity.	 1 1 1
		Marker's comment		
	(d)		For semi-conductors, the charge density n, is much less than for metals and hence Hall voltage or p.d is larger and easier to measure.	1
		Marker's comment		
7	(a)	The direction of the induced emf is such that the current which it causes to flow (or would flow in a closed circuit) opposes the change in magnetic flux which is producing it.		1
		Marker's comment		

For Examiner's Use

	(b)	**(i)**	Rod AB: end A has higher potential Rod CD: end D has higher potential	**1** **1**
		Marker's comment		
		(ii)	Induced e.m.f. in rod AB = B l v = (0.65) (0.12) (2) = 0.16 V Induced e.m.f. in rod CD = (0.65) (0.12) (3) = 0.23 V	 **1** **1**
		Marker's comment		
		(iii)	Induced current = Total e.m.f. / total resistance = (0.16 + 0.23) / (8 + 10) = 0.022 A	 **1** **1**
		Marker's comment		
		(iv)	Total power dissipated = I V = (0.022) (0.23 + 0.16) = 0.0086 W	 **1** **1**
		Marker's comment		
		(v)	External force = Induced magnetic force on rod AB / CD = B I L = (0.65) (0.022) (0.12) = 0.00172 N Rate of work done by external force on rod AB = F v = (0.00172) (2) = 0.0034 W Rate of work done by external force on rod CD = (0.00172) (3) = 0.0052 W Total rate of work done by external force on both rods = 0.0034 + 0.0052 = 0.0086 W	 **1** **1** **1**

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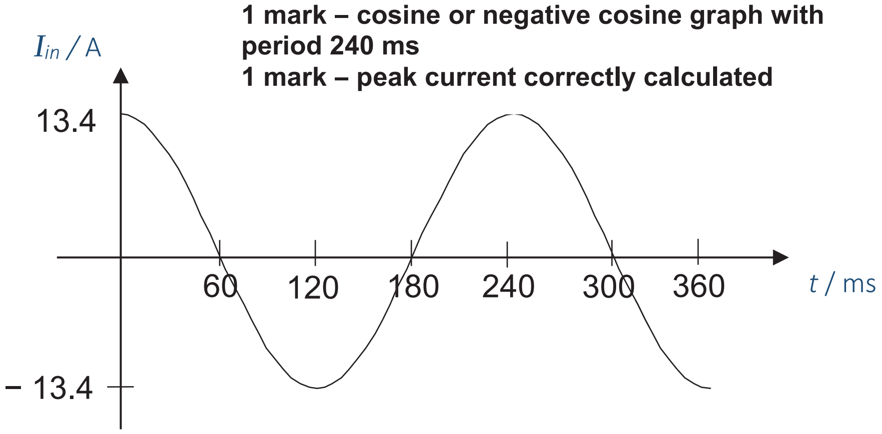
			Since rate of work done is the same as power dissipated, energy is conserved.	
		Marker's comment		
	(c)	Effective direct current that produces the same heating effect as the alternating current.		1
		Marker's comment		
	(d)	(i)	Peak output power = peak input power = 1.8 W Peak output power = V_o^2 / R V_o^2 = (1.8) (4) V_o = 2.7 V Output V_{rms} = 1.9 V	 1 1
		Marker's comment		
		(ii)	Input V_{rms} = 1.9 / 20 = 0.095 V Input I_{rms} = 0.9 / 0.095 = 9.5 A	1 1
		Marker's comment		
		(iii)	**1 mark – cosine or negative cosine graph with period 240 ms** **1 mark – peak current correctly calculated** 	2
		Marker's comment		
		(iv)	I = 13.4 cos 26 t or − 13.4 cos 26 t	1
		Marker's comment		
8	(a)	(i)	The half-life of a radioactive isotope is the average time taken for half the number of atoms in the isotope to decay.	1
		Marker's comment		
		(ii)	The decay constant is defined as the probability of decay per unit time of atoms of a radionuclide.	1
		Marker's comment		

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		(iii)	It is impossible to predict exactly which nucleus will decay next and thus the decays appear randomly throughout the sample.		**1**
		Marker's comment			
	(b)	**(i)**	Mass difference in the beta decay, Δm = (89.90774 – 89.90715 – 0.0005485) = 4.0000 × 10^{-5} u Assuming that the energy released are in the form of kinetic energy for the daughter particles, Conservation of energy: $$\frac{1}{2}m_Y{v_Y}^2 + \frac{1}{2}m_\beta{v_\beta}^2 = \Delta mc^2$$ Conservation of momentum: $$m_Y v_Y = m_\beta v_\beta$$ Solving, $v_\beta = \sqrt{\frac{2\Delta mc^2}{\frac{{m_\beta}^2}{m_Y}+m_\beta}}$ = 1.15 × 10^8 m s^{-1} v_Y = 699 m s^{-1} v_β = 1.1 × 10^8 m s^{-1}		**1** **1** **1** **1**
		Marker's comment			
		(ii)	The half-life of strontium-90 is very long (28.3 yrs). In order to have accurate measurements of half-life, measurements either have to be taken for a very long period of time (years) or to use a large quantity of the sample which would pose health hazard. Since daughter nucleus Yttrium also undergo decay, it is impossible to know an emitted beta particle is due to the decay of which nucleus.		**M1** **A1** **B1**
		Marker's comment			
		(iii)	Need to account for the background radiation, as well as the additional beta decay due to the daughter nucleus Yttrium. Keeping GM tube at a fixed distance from the source.		**1** **1**
		Marker's comment			
		(iv)	Unborn children are more vulnerable to radiation as the cells are rapidly dividing. If the DNA of the cells is affected at this stage, the subsequent cells that develop from these cells will be affected as well. The beta source is dangerous when outside the body – because they can penetrate the skin and damage the cells inside.		**1** **1** **1**
		Marker's comment			
		(v)	1.	Into the page	**1**
		Marker's comment			
			2.	The beta particles ionises the gas particles along its path.	**M0**

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				This causes it to lose energy and so lose speed. Since radius is proportional to velocity (mv/Bq), the radius continually decreases with its energy/speed.	**A1** **M1**
		Marker's comment			
			3.	Estimated radius 30-40mm $Bqv = mv^2/r$ $\therefore v = (3.0 \times 10^{-4})\ (1.6 \times 10^{-19})\ (0.030) / (9.11 \times 10^{-31})$ $= 1.58 \times 10^{6}$ m s^{-1}	**M1** **A1**
		Marker's comment			

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1 (a) (ii)</td><td>MMO
y_0 recorded to the correct precision with correct unit. (E.g. 4 d.p. in metres or 2 d.p. in centimetres.)</td><td>1</td></tr>
<tr><td>1 (a) (iv)</td><td>MMO
y recorded to the correct precision with correct unit. (E.g. 4 d.p. in metres or 2 d.p. in centimetres.)</td><td>1</td></tr>
<tr><td>1 (a) (vi)</td><td>ACE
Correct calculation of ($y - y_0$). ($y - y_0$) recorded to the correct precision with correct unit. (E.g. 3 d.p. in metres or 1 d.p. in centimetres.)</td><td>1</td></tr>
<tr><td>1 (a) (vii)</td><td>ACE
Absolute uncertainty of 2 mm to 4 mm.
Value given as 1 or 2 s.f. with % sign.</td><td>1</td></tr>
<tr><td>1 (b) (iii)</td><td>ACE
Correct calculation of ($y - y_0$). Value must be smaller than value in (a)(vi).

($y - y_0$) recorded to the correct precision with correct unit. (E.g. 3 d.p. in metres or 1 d.p. in centimetres.)</td><td>1

1</td></tr>
<tr><td>1 (c) (i)</td><td>ACE
Award 2 marks if candidate show evidence of at least 2 sets of positions of masses with deflection ($y - y_0$) recorded when the mass is placed individually in a table.

Award 1 mark if candidate show evidence of only 1 set of positions of masses with deflection ($y - y_0$) recorded when the mass is placed individually in a table.

E.g.
<table>
<tr><th>M1 position / cm</th><th>$y - y_0$ when only M1 is placed / cm</th><th>M2 position / cm</th><th>$y - y_0$ when only M2 is placed / cm</th><th>Expected $y - y_0$ when both masses are put together/ cm</th><th>Measured $y - y_0$ when both masses are put together / cm</th></tr>
<tr><td>90.0</td><td></td><td>50.0</td><td></td><td></td><td></td></tr>
<tr><td>80.0</td><td></td><td>50.0</td><td></td><td></td><td></td></tr>
</table>

Clarity of the record of the observations. Mark given only if the table headings are labelled clearly together with the units and correct d.p.</td><td>Max 2

1</td></tr>
<tr><td>1 (c) (ii)</td><td>ACE
Correct calculation of the percentage difference by
$\dfrac{Measured - Expected}{Can\ be\ either\ of\ the\ values} \times 100\,\%$. [The mark can be given if value is found in the table in (c)(i).

Correct conclusion drawn comparing the percentage difference with 10% error.</td><td>1

1</td></tr>
</table>

1(d)(i)	1. The ruler clamped to the retort stand may not be vertical when taking the *y* measurements. 2. There is a gap between the ruler with mass and the vertical ruler, hence there will be parallax error when taking the y reading. 3. Masses were not put at the same position on the rule as in a previous deflection measurement. 4. The elastic property of the rule may change if the masses are place on the rule for a long time. (Give BOD to students with elastic limit of the ruler is exceeded) 5. The ruler kept moving even after waiting for a significantly long time. (However for this error, there is no appropriate improvement)	**1**
1(d)(ii)	1. Use a spirit level against the ruler and adjust the ruler such that the bubble in the spirit level is within the specified lines before taking the *y* measurements. 1. Use a plumb line attached to the retort stand and ensure that the ruler is always parallel to the plumb line before taking the *y* measurements. 1. Measure at 2 positions of the ruler and ensure that the distance between the ruler from the vertical body of the retort stand at these positions is the same before taking the *y* measurements. 2. Use a set square to place at the bottom of ruler with mass to help in reading off from the vertical ruler. 2. Use a marker that is attached parallel to the short edge of rule A pointing towards rule B. 3. Use a pen to mark out the positions of the masses when placed on the rule. 3. Use a string to hang the masses instead of putting them on top of the ruler. 4. Remove the masses immediately after the measurement is taken. (Do not allow changing to a new ruler every time after doing the measurement)	**1**
	Total	**13**

Question	Answer	Marks
2 (a) (i)	**MMO** *x* recorded to the correct precision with correct unit. (E.g. 3 d.p. in metres or 1 d.p. in centimetres.)	1
2 (a) (iv)	**MMO** Make a marking at the centre of the wooden block, measure using a half-metre rule the distance from the edge of the rod to the marking and adjust to ensure that the distance equals to *x*. Measure the width of the block. Ensure that the distance from edge of the rod to the edge of the block is x minus half of the width of the block.	1
2 (b) (ii)	**MMO** Evidence of repeated reading + correct precision + correct unit [Evidence can be obtained from the table] Number of oscillations n must be taken such that n*T* is more than 10 s.	1 1
2 (c) (i)	**MMO** • Award 1 marks only if candidate has successfully collected all 5 sets of data (*x*, *T*) without assistance/intervention. **PDO** Clear heading with correct units in the headings of the table. The value of N (no. of oscillations) must be shown. (Allow words in the headings) **PDO** All values of raw data are recorded to the correct precision. Eg *x*/m (3 decimal places), *t*/s (1 decimal place). **PDO** For each value of calculated quantity, the number of significant figures should be the same as the number of significant figures in the raw data. Eg *T*/s (3 or 4 significant figures) [	1 1 1 1
2 (c) (ii)	**ACE** Value of *x* given can be the x where *T* is minimum or it can be in the interval just before the mimimum *T* (to highlight and discuss) or it can be in the interval just after the minimum *T* *x* recorded with the correct unit. (Precision is not emphasised here since it is an estimate)	1
2 (c) (iii)	**ACE** Since there is a decreasing trend of *T* as x increases to ____ (the *x* value when *T* is minimum) and an increasing trend of *T* for x greater than _____, the value of x is minimum point or there exists a minimum point in the interval between the x = ____ and the next x value.	1
	Total	**10**

Question	Answer	Marks
3 (a) (iii)	**MMO** I_1 and I_2 recorded to the correct precision with correct unit. (E.g. 1 or 2 d.p. in mA)	1
3 (b)	**MMO** • Award 2 marks if candidate has successfully collected 6 or more sets of data (R, I_1, I_2) (including the set obtained in previous part) without assistance/intervention. • Award 1 mark if candidate has successfully collected 5 sets of data (R, I_1, I_2) without assistance/intervention. • Award zero mark if candidate has successfully collected 4 or fewer sets of data (R, I_1, I_2) without assistance/intervention. • Deduct 1 mark if candidate requires some assistance/intervention but has been able to do most the work independently. • Deduct 2 marks if candidate has been unable to collect data without assistance/intervention.	**2** **Minimum Mark = 0**
	PDO Each column heading (raw data and calculated/derived quantities) must contain a quantity and unit. Eg R/Ω, I_1/mA, I_2/mA, $\frac{I_1}{I_2}$ (no units).	1
	PDO For each value of calculated quantity, the number of significant figures should be the same as the number of significant figures in the raw data. E.g. $\frac{I_1}{I_2}$ follows least significant figures of I_1 and I_2.	1
	ACE Derived quantities $\frac{I_1}{I_2}$ calculated correctly. Allow a maximum of 1 slip for each derived quantity.	1
3 (c) (i)	**PDO (Graph)** Sensible scales must be used. Awkward scales (eg. 3:10) are not allowed. Scales must be chosen so that plotted points occupy at least half the graph grid in both x and y directions. Axes must be labelled with the quantity/unit which is being plotted.	1
	PDO (Graph) All observations must be plotted accurately within of half a small square.	1
	PDO (Graph) Assessed best fit line. Straight line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line.	1
3 (c) (ii)	**ACE** Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Gradient coordinates substituted correctly. Gradient calculated correctly. No unit for gradient. (Ignore unit given by candidates)	1 1

	ACE y-intercept must be read off to the nearest half small square or calculated correctly from $y = mx + c$ using a point on the line. (Ignore unit given by candidates)	
3 (d)(ii)	**ACE** P determined correctly from the value of gradient with correct unit. (E.g. Ω^{-1}) Q determined correctly from the y-intercept with no unit.	**1** **1**
3 (e)	**ACE** The length of the wire M measured using the metre rule is ______ m. Hence R' calculated for wire M is _______ Ω m^{-1}. (1/P $\times$ length) Correct choice of swg of wire M.	**1** **1** **1**
3 (f)	**ACE** Percentage difference between theoretical Q and Q from (d) = $\frac{\textit{Q from (d) - Theoretical Q from (f)}}{\textit{Either of the Q value}}$. Since the percentage difference is < 10%, it supports. Since the percentage difference is > 10%, it does not support.	**1** **1**
3 (g) (i)	**ACE** Length of M increases → Resistance of M increases → P will decrease → gradient will be less → graph is less steep. Q will also decrease → y-intercept will also decrease. Graph drawn is less steep with a smaller y-intercept.	**1**
3 (g) (ii)	**ACE** When the length is reduced, the resistance of the wires is reduced. With swg which has a large diameter, the resistance wires may be reduced to a value such that the current passing resistor Y will be too large and the resistor may melt due to overheating.	**1**
	Total =	**20**

Question		Answer	Marks
4	**Defining the problem (2 marks)**		
	P1	Vary *v* and measure *d*, or *v* is the independent variable and *d* is the dependent variable	**1**
	P2	Keep the mass/type of pellet and adsorbent material constant Keep the distance between rifle and absorbent material constant Award one mark for any of the above.	**1**
	Methods of data collection (5 marks)		
	M1	Diagram showing the rifle, appropriate position of absorbent material, light gates (if any)	**1**
	M2	Place aluminium foil at fixed position from rifle, vary the thickness of the aluminium to vary the speed of the pellet before reaching the material.	**1**
	M3 M4	If light gates are used, three marking points 1. Measure distance *d* between the two light gates using a metre rule 2. Record the time taken *t* from the data-logger 3. Calculate the speed v of the pellet using the formula v = d/t [2 marks. Deduct 1 mark for missing every missing point.] If speedometer is used, only 1 marking point 1. Obtain the speed *v* from the speedometer. [Only 1 mark. The other mark is placed under additional details] Note: Do not award marks for stopwatch methods. Students need to be aware that the pellet speed will be high and stopwatch method is highly unreliable in measuring high speed.	**2**
	M4	Appropriate method to determine depth that pellet is embedded e.g. using tail of Vernier callipers, or pointer (needle) inserted into the depth and make marking, remove it and measure against ruler.	**1**
	Method of analysis (2 marks)		
	A1	Propose a relationship of $d = kv^n$	**1**
	A2	Plot a graph of log d against log v. If a straight line is obtained, the relationship is correct. The value of n = gradient and log k = y-intercept.	**1**
	Additional details (2 marks) or (3 marks if speedometer is used)		**2**
	1	The position of the light gates must be near to the absorbent material.	
	2	The distance between the mounted rifles cannot be too far from the absorbent material, otherwise, the pellet will move in parabolic path and may not hit the material.	
	3	Preliminary experiment to determine suitable distance between the rifle and the material.	
	4	Repeat experiment to ensure that the speed remains can be reproduced and determine an average of d.	
	Safety considerations (1 mark)		
	S1	Precautions linked to high speed pellet and recoil of rifle	**1**