Class	Adm No

Candidate Name: ______________________________

millennia institute

2017 Promotional Examination II

Pre-university 2

H1 PHYSICS **8866/01**

Paper 1 MCQ **18 Sep 2017**

Monday **1 hour**

Additional Materials: OMR Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.

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

Write your name, class and admission number on the Answer Sheet in the spaces provided.

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

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

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This question paper consists of 15 printed pages and 1 blank page.

Data

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

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

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

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

rest mass of electron, $m_\text{e} = 9.11 \times 10^{-31}\ \text{kg}$

rest mass of proton, $m_\text{p} = 1.67 \times 10^{-27}\ \text{kg}$

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

Formulae

uniformly accelerated motion, $s = ut + \frac{1}{2}at^2$

$v^2 = u^2 + 2as$

work done on/by a gas, $W = p\Delta V$

hydrostatic pressure, $p = \rho g h$

resistors in series $R = R_1 + R_2 + \ldots..$

resistors in parallel $1/\text{R} = 1/R_1 + 1/R_2 + \ldots..$

1 The volume of liquid flowing per second is called the volume flowrate Q and has the unit $m^3\ s^{-1}$. The flowrate of blood in an artery can be estimated with the following equation:

$$Q = \frac{\pi R^{\alpha}(P_2 - P_1)}{8\eta L}$$

The length and radius of the artery are L and R, respectively. $P_2 - P_1$ gives the pressure difference between the ends of the artery. The viscosity of the blood is given by η which has the unit kg $m^{-1}\ s^{-1}$.

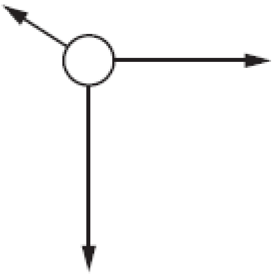
What is the value of α?

A 2
B 3
C 4
D 8

2 The external and internal diameters of a cylinder are measured. The external diameter of the cylinder is 95.0 ± 0.1 mm and the internal diameter is given by 87.0 ± 0.1 mm. What is the average wall thickness?

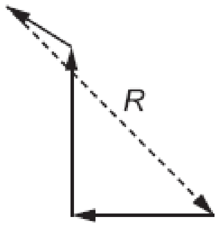
A 4.0 ± 0.1 mm **B** 8.0 ± 0.1 mm
C 4.0 ± 0.2 mm **D** 8.0 ± 0.2 mm

3 Three wires each exert a force along the same horizontal plane on a vertical pole. The top view of the pole is shown below.

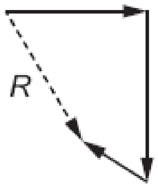


Which vector diagram shows the resultant force R acting on the pole?

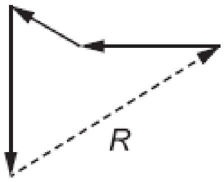
A



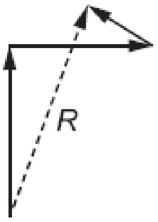
B



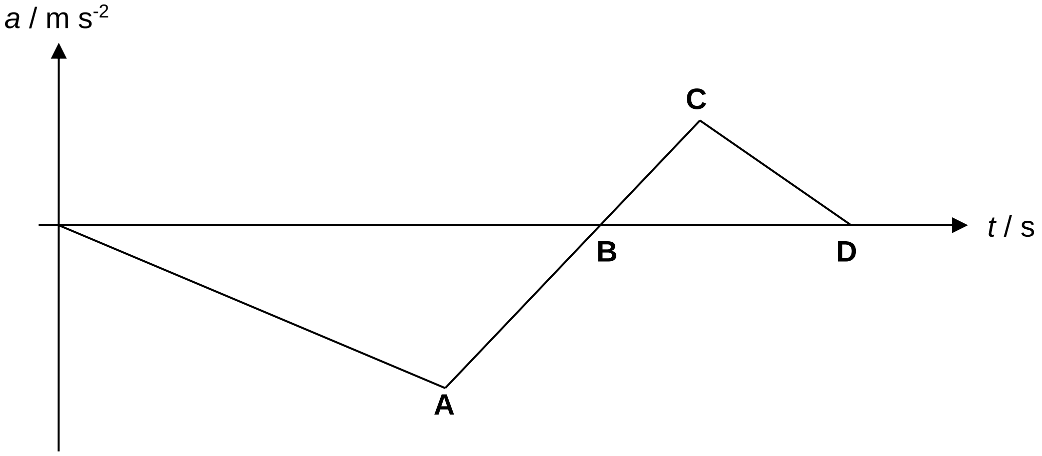
C



D



4 The acceleration-time graph of a car in a straight line is as shown below. The car started its motion from rest.



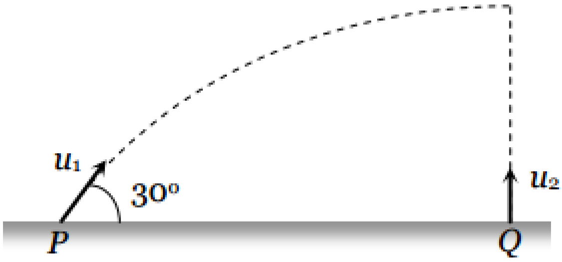
At which point is the car moving with the largest speed?

5 An object has an initial velocity u and an acceleration a. The object moves in a straight line through a displacement s and has final velocity v. These quantities are related by the equation $v^2 = u^2 + 2as$.

Which condition **must** be satisfied in order for this equation to apply to the motion of the object?

- **A** The direction of a is constant and the direction of a is the same as the direction of s.
- **B** The direction of a is constant and the direction of a is the same as the direction of u.
- **C** The magnitude of a is constant and the direction of a is constant.
- **D** The magnitude of a is constant and the direction of a is the same as the direction of v.

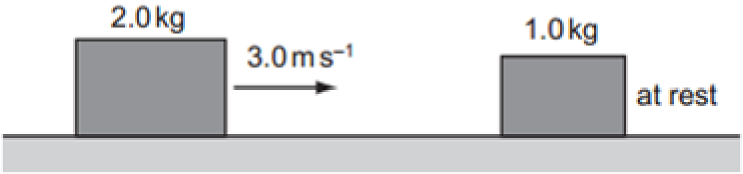
6 Two projectiles **P** and **Q** are launched at the same time. **P** is projected with velocity u_1 at an angle of 30˚ with the horizontal while **Q** is thrown vertically upwards with velocity u_2 from a point vertically below the highest point of path of **P**.



What is the necessary condition for **P** and **Q** to collide at the highest point?

A $u_1 = u_2$ **B** $u_1 = 2u_2$ **C** $u_1 = \frac{1}{2}u_2$ **D** $u_1 = 4u$

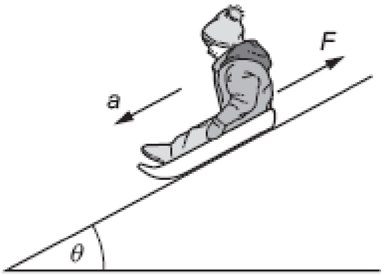
7 A 2.0 kg mass travelling at 3.0 m s^{-1} on a frictionless surface collides head-on with a stationary 1.0 kg mass. The masses stick together on impact.



How much energy is lost on impact?

A zero **B** 2.0 J **C** 2.4 J **D** 3.0 J

8 An Eskimo sitting on a sledge slides down a hill with acceleration a. The hill makes an angle θ with the horizontal.



The total mass of the Eskimo and the sledge is m. Given that the acceleration of free fall is g, what is the friction force F?

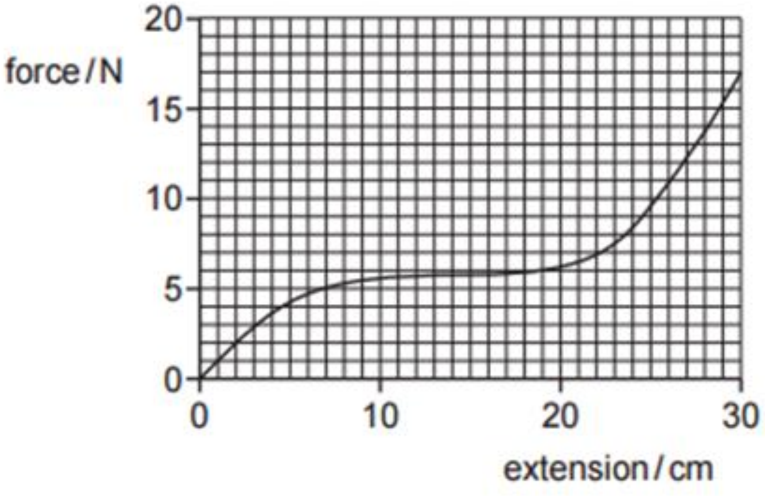
A m(g cosθ – a)

B m(g cosθ + a)

C m(g sinθ – a)

D m(g sinθ + a)

9 A elastic watch strap is stretched by hanging weights on it and the force-extension graph is plotted.



What is the best estimate of the elastic potential energy stored in the watch strap when it is extended by 30 cm?

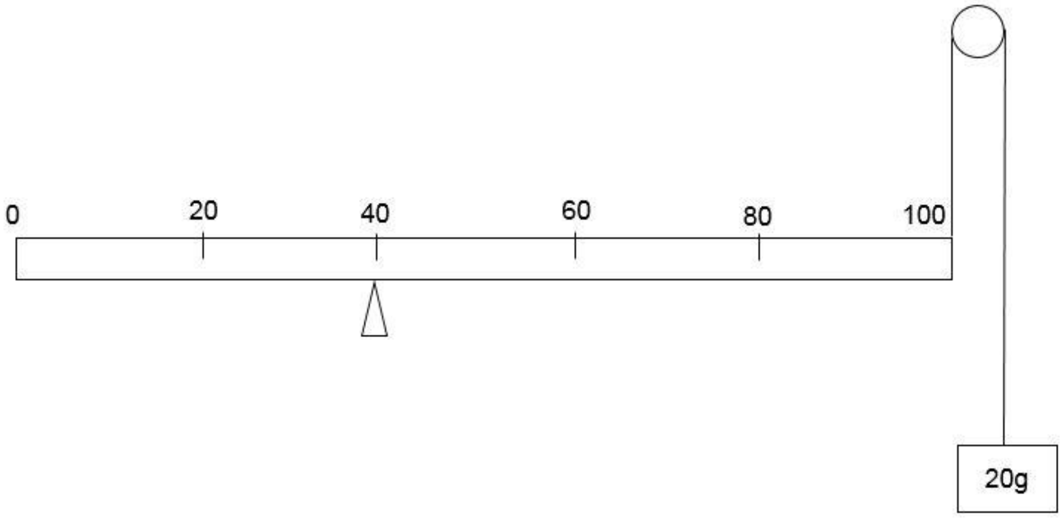
A 2.0 J

B 2.6 J

C 5.1 J

D 200 J

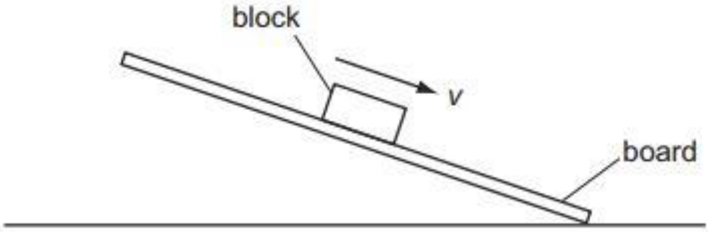
10 A uniform metre rule of mass 100 g is supported by a knife-edge at the 40 cm mark and a string at the 100 cm mark. The string passes round a frictionless pulley and carries a mass of 20 g as shown in the diagram.



At which mark on the rule must a 50 g mass be suspended so that the rule balances?

A 4 cm **B** 36 cm **C** 44 cm **D** 96 cm

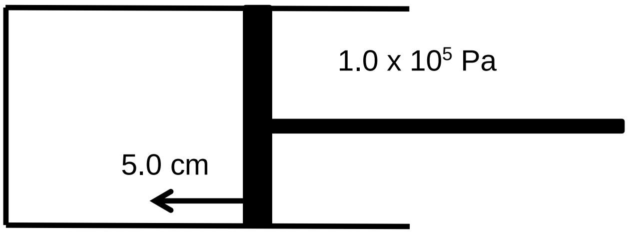
11 A wooden block rests on a rough board. The end of the board is then raised until the block slides down the plane of the board at constant velocity v.



Which row describes the forces acting on the block when sliding with constant velocity?

	frictional force on block	**resultant force on block**
A	down the plane	down the plane
B	down the plane	zero
C	up the plane	down the plane
D	up the plane	zero

12 An ideal gas within a pistol was compressed with a piston as shown below without a change in pressure within the tube. The pistol has a cross-sectional area of 2.0 x 10^{-4} m^2.



The pressure of the atmosphere is 1.0 x 10^5 Pa. What is the work done on the gas by the atmosphere, when the piston compresses the gas by 5.0 cm?

A - 0.6 J **B** 0.4 J **C** 0.6 J **D** 1.0 J

13 A body of mass 5.0 kg is initially travelling at a constant speed of 2.0 m s^{-1} on a horizontal frictionless surface. A force of 15 N acts on it and accelerates it to a final velocity of 12.0 m s^{-1}.

What is the work done by the force?

A 150 J **B** 180 J **C** 250 J **D** 350 J

14 Water from a reservoir is fed to the turbine of a hydroelectric system at a rate of 500 kg s^{-1}. The reservoir is 300 m above the level of the turbine. The electrical output from the generator driven by the turbine is 200 A at a potential difference of 6000 V.

What is the efficiency of the system?

A 8.6 % **B** 12 % **C** 24 % **D** 82 %

15 Fig. 15.1 shows the positions of equally spaced air molecules.

A longitudinal sound wave travels from left to right. At a certain instant, the displaced positions of the air molecules are shown in Fig. 15.2.

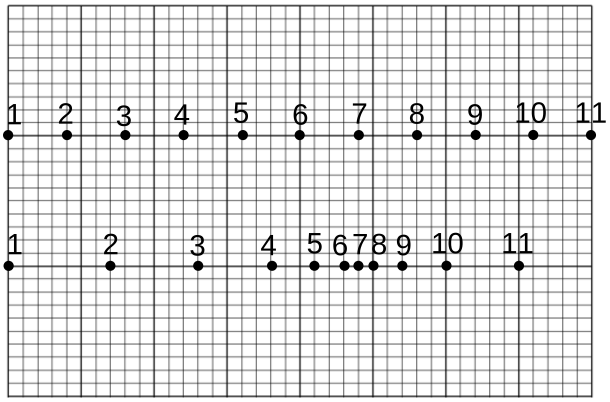


Fig. 15.1

Fig. 15.2

Immediately afterwards, what will be the directions of motion of particles 1 and 7?

	particle 1	**particle 7**
A	to the right	to the right
B	to the right	to the left
C	to the left	to the right
D	to the left	to the left

16 A point source of sound emits energy equally in all directions at a constant rate. A detector is placed 3.0 m from the source and it measures an intensity of 5.0 W m^{-2}.

The amplitude at the source is then doubled.

What is the intensity, in W m^{-2} if the detector is now placed at a distance 4.0 m from the source?

A 0.45

B 0.56

C 11

D 15

17 17.1 shows a ripple tank experiment in which plane waves are diffracted through a narrow slit in a metal sheet. 17.2 shows the same tank with a slit of greater width. In each case, the pattern of the waves incident on the slit and the emergent pattern are shown.

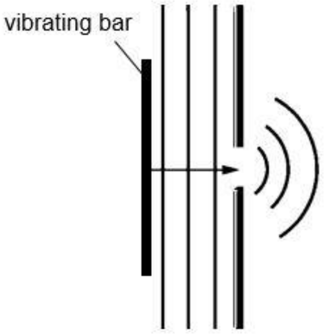


Fig. 17.1

Fig. 17.2

Which action would cause the waves in Fig. 17.1 to be diffracted less and so produce an emergent pattern shown in Fig. 17.2?

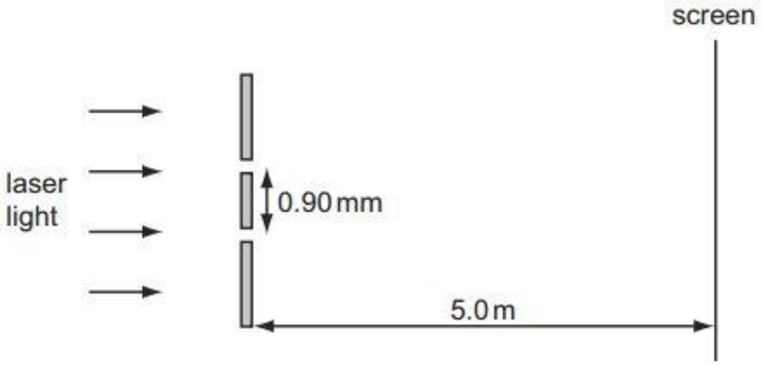
A increasing the frequency of vibration of the bar

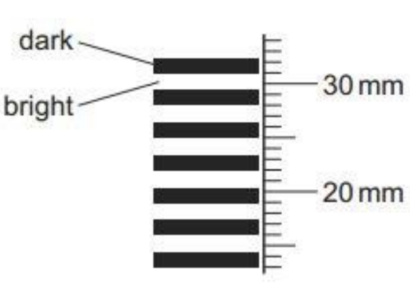
B increasing the speed of the waves by making the water in the tank deeper

C reducing the amplitude of vibration of the bar

D reducing the length of the vibrating bar

18 The diagrams show the arrangement of apparatus for a Young's slits experiment and also part of the pattern formed on the screen with a ruler placed next to it.



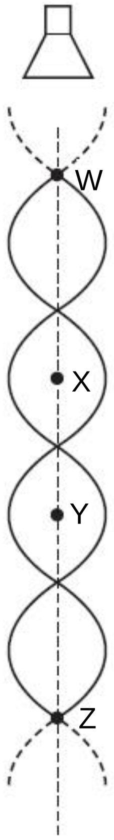


What is the wavelength of the light?

A 4.8×10^{-7} m **B** 5.4×10^{-7} m

C 3.2×10^{-6} m **D** 3.4×10^{-6} m

19 The diagram represents the pattern of stationary waves formed by the superposition of sound waves from a loudspeaker and their reflection from a metal sheet. The metal sheet is not shown in the diagram.



W, X, Y and Z are four points on the line through the centre of these waves.

Which statement about these stationary waves is correct?

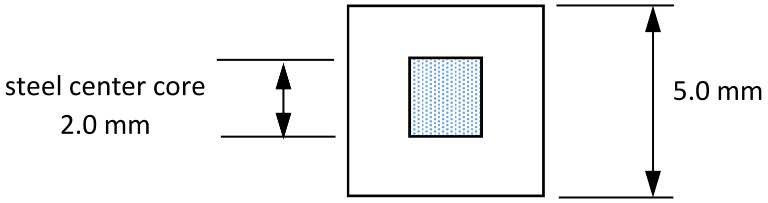
A An antinode is formed at the surface of the metal sheet.

B The oscillations at X are in phase with those at Y.

C The air particles oscillate perpendicular to the line WZ.

D A node is a quarter of a wavelength from an adjacent antinode.

20 A 5.0 mm square wire comprises a steel square center core of length 2.0 mm surrounded by a coating of aluminium.

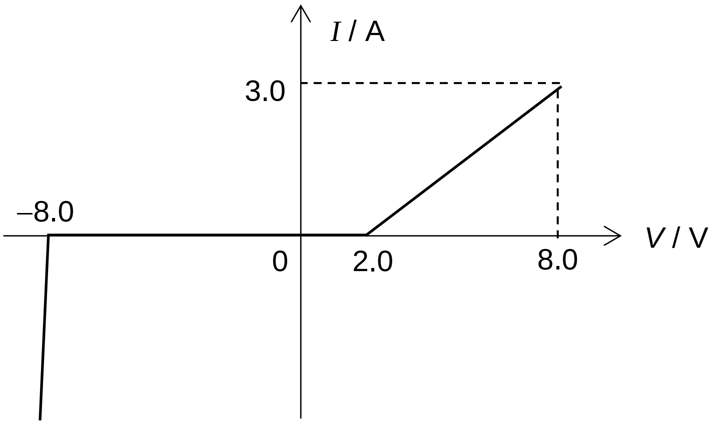


The resistivity of steel and aluminium are 1.0 x 10^{-7} Ω m and 2.8 x 10^{-8} Ω m respectively.

What is the resistance for a length of 1.0 m of such a wire?

A 1.07 mΩ **B** 1.27 mΩ **C** 2.83 mΩ **D** 26.3 mΩ

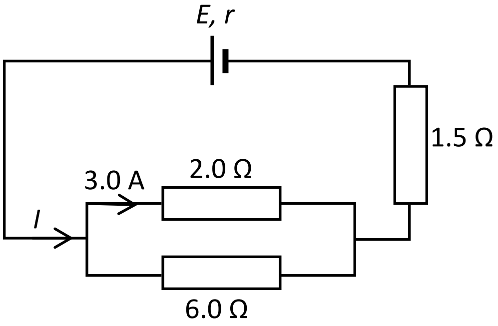
21 The *I*-*V* graph for a conductor is shown below.



What are the possible values of its resistance when a potential difference of 6.0 V is applied to it?

A zero, 2.0 Ω **B** zero, 3.0 Ω **C** ∞, 2.0 Ω **D** ∞, 3.0 Ω

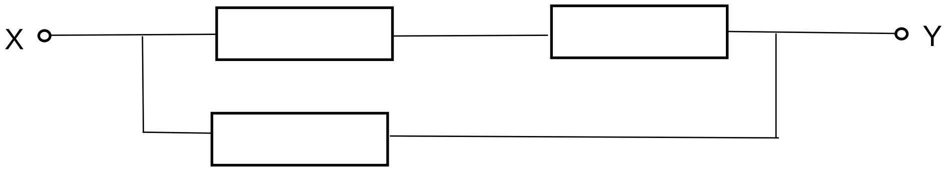
22 Two parallel resistors with resistance 2.0 Ω and 6.0 Ω are connected in series with another resistor of 1.5 Ω and a source of e.m.f. E. The source has internal resistance r. There is a current of 3.0 A in the 2.0 Ω resistor.



It is known that the source has an output efficiency of 90 % in its power delivery to the external circuit. What are the values of the current *I* delivered by the source and its e.m.f. *E*?

	***I* / A**	***E* / V**
A	3.0	12.0
B	4.0	10.8
C	4.0	13.3
D	12	18.0

23 Three resistors, each with resistance R, are connected in a network, as shown.



The total resistance between points X and Y is 8.0 Ω.

What is the value of R?

A 2.7 Ω

B 4.0 Ω

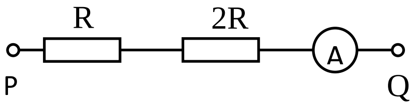
C 5.3 Ω

D 12 Ω

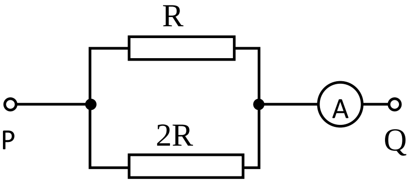
24 An ammeter with a resistance of 2R is connected differently in each of the following configurations.

The same potential difference is applied across P and Q. In which configuration does the ammeter give the smallest reading?

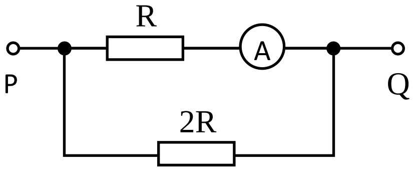
A



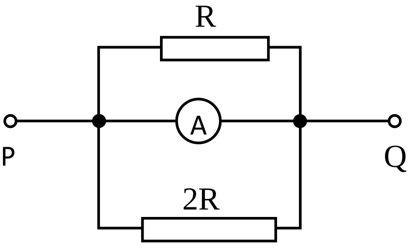
B



C



D



25 Fig. 25.1 shows a vertical square coil of 50 turns, carrying a current of 3.0 A. The length of each side of the coil is 4.0 cm. Fig. 25.2 shows a view of this coil from above when placed within a horizontal magnetic field of flux density 0.20 T.

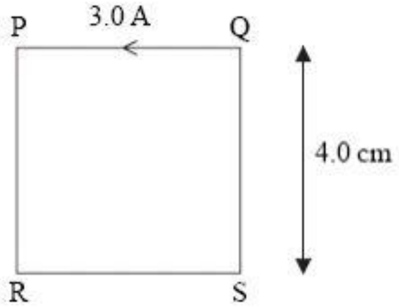


Fig. 25.1

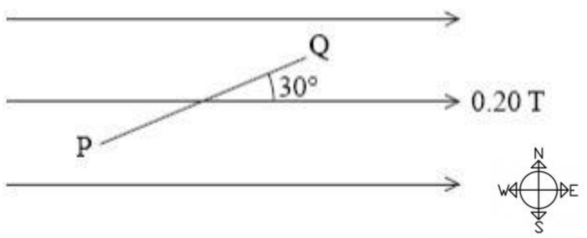
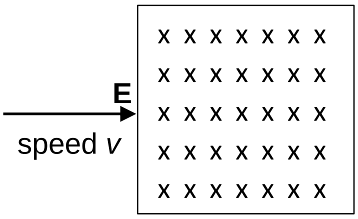


Fig. 25.2

The force on side QS is

	magnitude / N	direction
A	1.2 N	north
B	1.2 N	south
C	0.6	north
D	0.6	south

26 The figure shows a square uniform magnetic field directed into the plane of the paper. An electron with speed v is travelling in the plane of the field from point E.

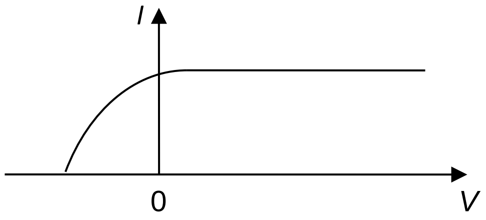


magnetic field

Which of the following correctly describes the deflection and speed of the electron with which it exits the magnetic field?

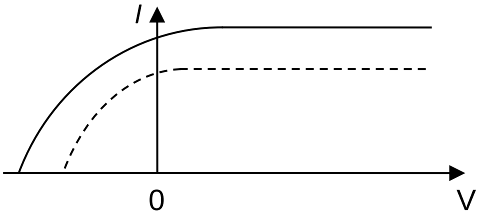
	deflection	exit speed
A	upwards	*v*
B	downwards	*v*
C	upwards	greater than *v*
D	downwards	greater than *v*

27 A metal surface in an evacuated tube is illuminated with monochromatic light causing the emission of photo-electrons which are collected at an adjacent electrode. For a given intensity of light, the way in which the photocurrent *I* depends on the potential difference *V* between the electrodes is as shown in the diagram below.

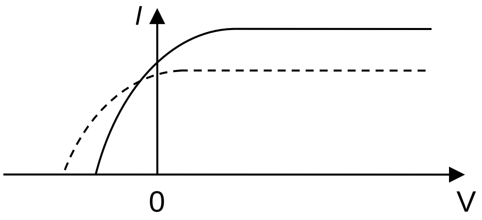


Which of the following graphs show the result when the frequency of the light is increased while the **intensity remains constant**? (The solid curve represents the original graph and the dotted curve represent the new graph.)

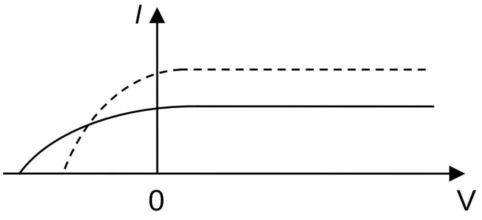
A



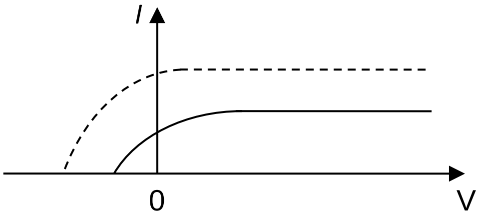
B



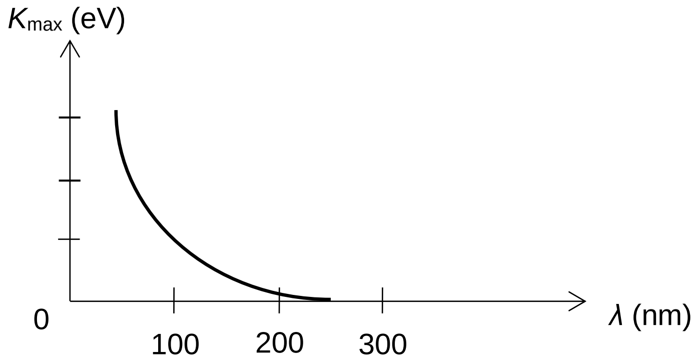
C



D

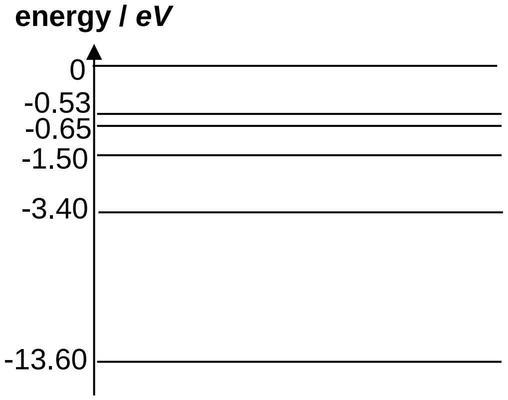


28 In a photoelectric experiment, the maximum kinetic energy of the ejected photoelectrons is measured for various wavelength of incident electromagnetic radiation. A graph of this maximum kinetic energy, K_{max}, as a function of the wavelength λ of the incident electromagnetic radiation falling on the surface of a metal is shown below. What is the work function for this metal?



A 4.97 eV **B** 6.22 eV **C** 7.96 eV **D** 24.9 eV

29 The energy level diagram for an atom is as shown below.



Which one of the following statements is correct?

A The most stable state of the atom is the level with zero energy.

B An electron can transit from the -0.53 eV level to 0 eV level by emitting an electron of energy 0.53 eV.

C An incident photon of energy 11 eV can impart part of its energy during collision with the atom and excite an electron in the atom from ground state to the -3.40 eV level. The photon will be deflected with a smaller energy of 0.8 eV.

D An incident electron of energy 11 eV can impart part of its energy during collision with the atom and excite an electron in the atom from ground state to the -3.40 eV level. The electron will be deflected with a smaller energy of 0.8 eV.

30 When an atom absorbs radiation of wavelength λ_X, the electron within the atom makes a transition from its ground state of energy E_1 to an excited state of energy E_3. Then it makes a second transition to a state of lower energy E_2, emitting radiation of wavelength λ_Y.

What is the wavelength of the radiation λ_Z emitted by the atom when it makes a third transition back to the ground state?

A $\lambda_x - \lambda_Y$

B $\lambda_X + \lambda_Y$

C $\dfrac{\lambda_X \lambda_Y}{\lambda_Y - \lambda_X}$

D $\dfrac{\lambda_Y - \lambda_X}{\lambda_X \lambda_Y}$

End of paper

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Class	Adm. No.

Candidate Name: ______________________________

H

millennia institute

2017 Promotional Examination II
Pre-university 2

H1 PHYSICS **8866/02**

Paper 2 Structured Questions **13 Sep 2017**

2 hours

Candidates answer on the Question Paper.

No additional materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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

Section A
Answer **all** questions.

Section B
Answer any **two** questions.

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

For Examiner's Use	
Section A	
1	**/ 6**
2	**/ 9**
3	**/ 5**
4	**/ 11**
5	**/ 9**
Section B	
6	**/ 20**
7	**/ 20**
8	**/ 20**
TOTAL	**/ 80**

Data

speed of light in free space	c	= 3.00 x 10^{8} m s^{-1}
elementary charge	e	= 1.60 x 10^{-19} C
the Planck constant	h	= 6.63 x 10^{-34} J s
unified atomic mass constant	u	= 1.66 x 10^{-27} kg
rest mass of electron	m_e	= 9.11 X 10^{-31} kg
rest mass of proton	m_p	= 1.67 X 10^{-27} kg
acceleration of free fall	g	= 9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
resistors in series,	$R = R_1 + R_2 + ...$
resistors in parallel	$1/R = 1/R_1 + 1/R_2 + ...$

Section A

Answer **all** the questions in this section

1 Fig. 1.1 (not to scale) shows an experimental set-up for the Young's double slit experiment in which the source is a coherent light source of wavelength λ.

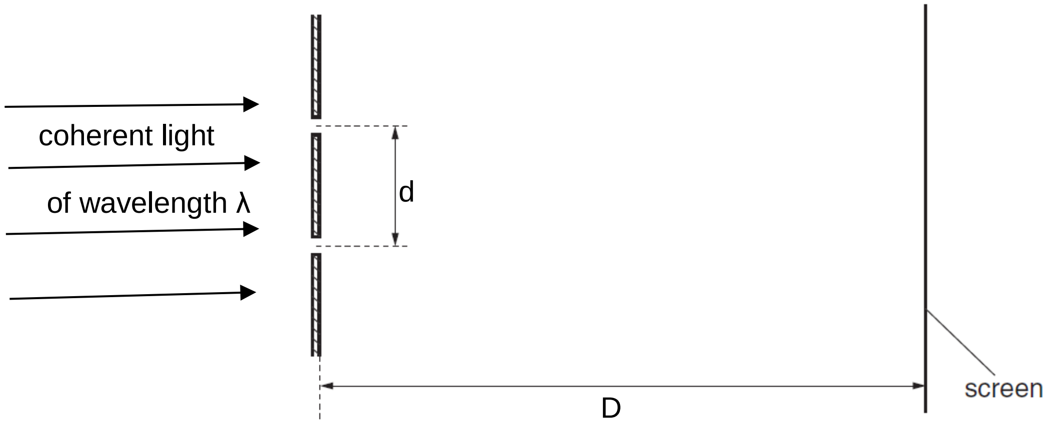


Fig. 1.1 (not drawn to scale)

The following measurements were obtained from the experiment:

slit separation, d = (0.650 ± 0.001) mm
distance between 2 bright fringes, x = (2.33 ± 0.01) mm
distance between the slits and screen, D = (2.80 ± 0.01) m

(i) Determine the wavelength λ and express it with its associated uncertainty.

λ ± Δλ = …………........... ± ……………… m [4]

(ii) Suggest, with reasons, a change to the experimental set-up that would enable the wavelength to be determined to a higher degree of precision.

……………………………………………………………………………………...

……………………………………………………………………………………...

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

2 Two identical trolleys, A and B, moved at 10.0 m s^{-1} toward each other. The two trolleys collided inelastically where 35% of the kinetic energy was dissipated.

(a) Explain why, after the collision, the trolleys moved in opposite directions at the same speed.

………………………………………………………………………………………………

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

(b) Show that the final speed of trolley A is about 8.1 m s^{-1}. [2]

(c) Fig. 2.1 shows the variation of the magnitude of the force on trolley A with time during the collision.

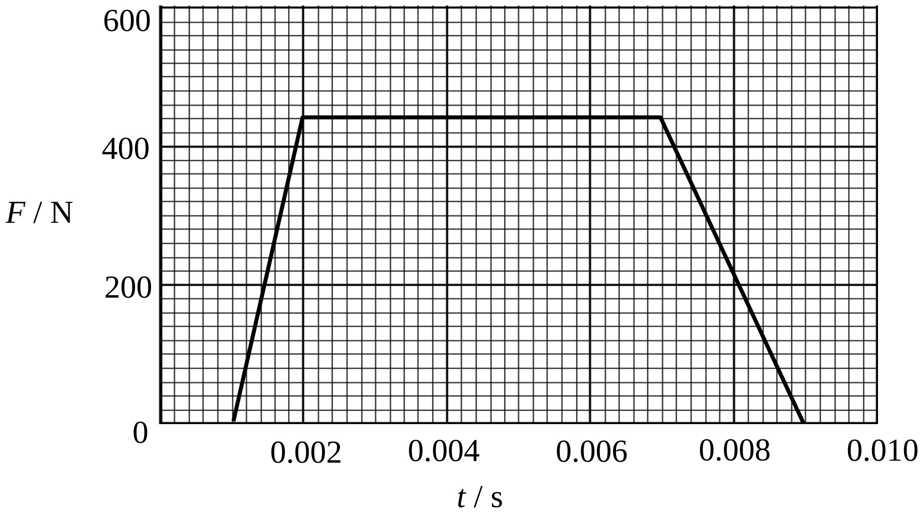


Fig. 2.1

Calculate the impulse trolley B exerts on trolley A during the collision. Give the unit with your answer.

impulse = ……………………unit:…………….. [3]

(d) Hence calculate the mass of each trolley.

mass = ………………………… kg [2]

3 Fig. 3.1 below shows a snapshot of a travelling wave moving from left to right at time t = 0 s. The frequency of this wave is 0.50 Hz.

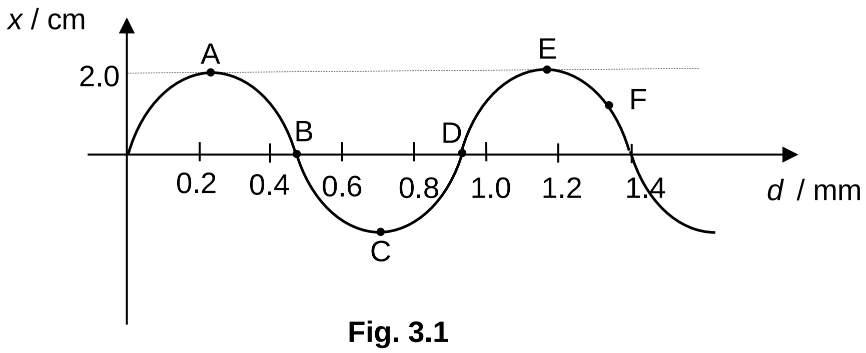


Fig. 3.1

(a) What is the speed of the wave?

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

(b) State which point is $\frac{3\pi}{2}$ rad out of phase with point E.

……………………………………………………………………………………… [1]

(c) On Fig. 3.2, sketch the variation with time t of displacement x of point F from t = 0 s to 5 s. Label all known values on both axes. [2]

Fig 3.2

4 Two long straight wires, X and Y which are at right angle to the plane PQRS, carry equal steady direct currents of 80 A in the opposite direction as shown in the Fig. 4.1. The two wires are separated by a distance of 2.0 m.

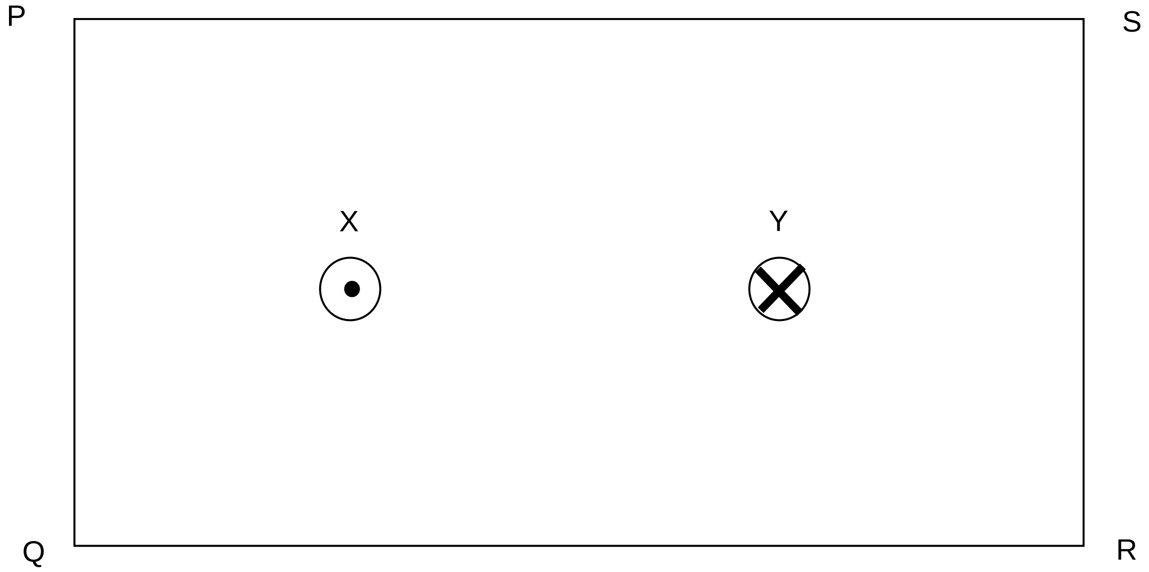


Fig. 4.1

(a) Define *tesla*.

....

.... [2]

(b) On Fig. 4.1, sketch the magnetic flux pattern around the 2 wires within the plane PQRS. [2]

(c) With reference to part **(b)**, state and explain the subsequent motion of both wires.

....

....

....

.... [2]

(d) The magnetic flux density B, due to a long straight wire, is given by the expression

$$B = \frac{\mu_o I}{2\pi r}$$

where μ_o represents the permeability of free space and $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}
I represents the current in the wire, in amperes (A)
r represents the distance from the wire, in metres (m)

Determine the magnetic flux density at Y due to X.

magnetic flux density = ……………………………….. T [2]

(e) Wire X is made into a rigid wire frame ABCD of negligible mass is supported on two knife-edges O and M so that the section OADM of the frame lies within a solenoid. Fig 4.2 shows the top view of the circuit arrangement. The side OA = MD = 15.0 cm and side AD = 8.0 cm

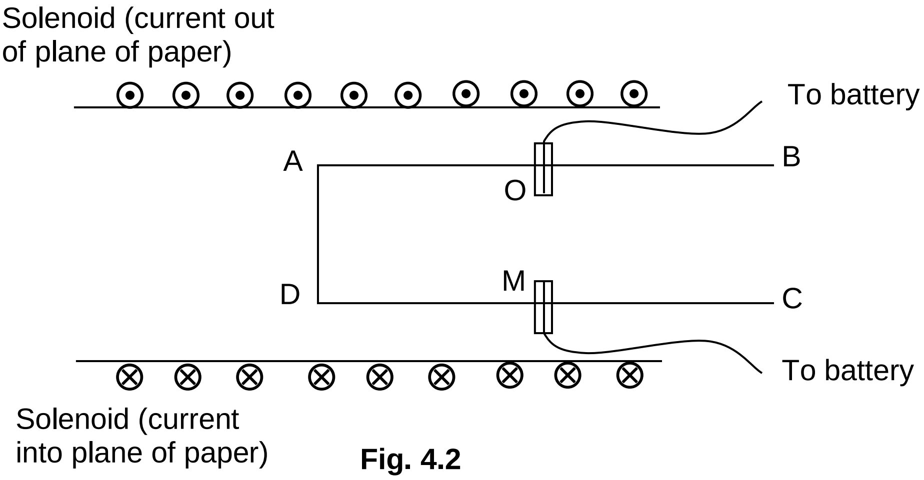


Fig. 4.2

Electrical connections are made to the frame through the knife edges so that the part OADM of the frame is connected in series with the battery.

When there is no current in the circuit, the frame is horizontal.

When the circuit is closed, it is observed that the side AD experiences a force into the page.

(i) State the direction of current flowing along the side AD.

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

(ii) A non-conducting rod of mass 5.0 g is placed across BC to keep the frame horizontal as shown in Fig. 4.3.

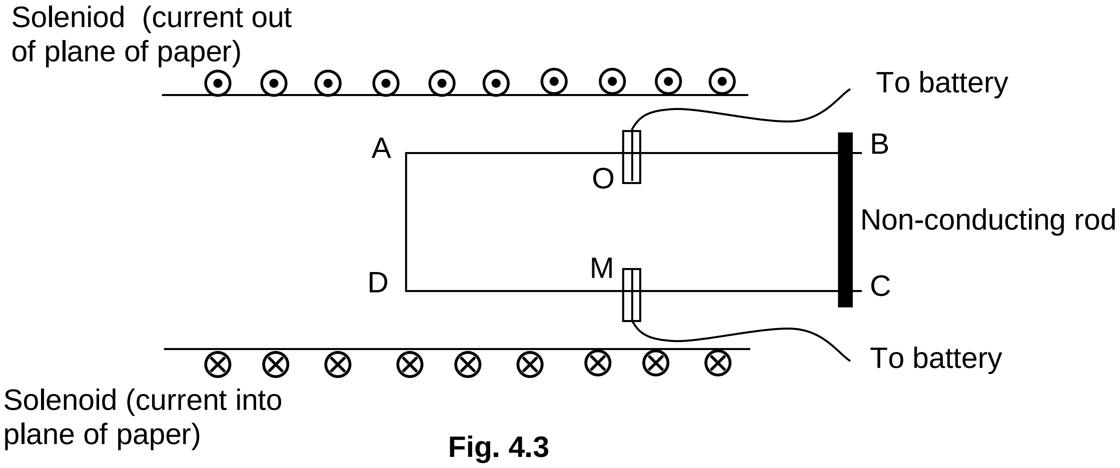


Fig. 4.3

Given that the uniform magnetic flux density in the solenoid is 0.30 T and the current in the circuit is 0.90 A, determine distance OB from the non-conducting rod to the knife edges such that the frame is kept horizontal.

distance OB = ……………….… cm [2]

5 Lucas notices that it is easier to lift up his buddy in water than in air. It is commonly observed that objects submerged in a liquid seems to “lose weight”. He decided to investigate the upward force that a liquid exerts on an object by immersing a rectangular block into water.

The block is attached to a force sensor which allows Lucas to record the weight of the block in the air, T_1. The reading of T_1 is 0.90 N.

Lucas then immerses the same block into water while it is still attached to the force sensor. By varying the submerged depth, h of the block, he obtained a series of new readings T_2 from the force sensor. The experimental setup is shown in Fig. 5.1.

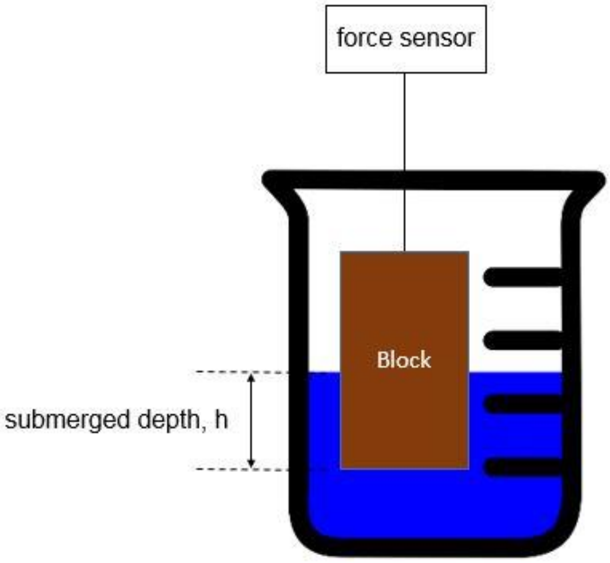


Fig. 5.1

(a) Draw a well-labelled free body diagram of the block to show all the forces acting on the block when it is partially immersed in the water and is still attached to the force sensor. [1]

(b) The variation of T_2 and submerged depth of the block in water, h, is shown in Fig. 5.2.

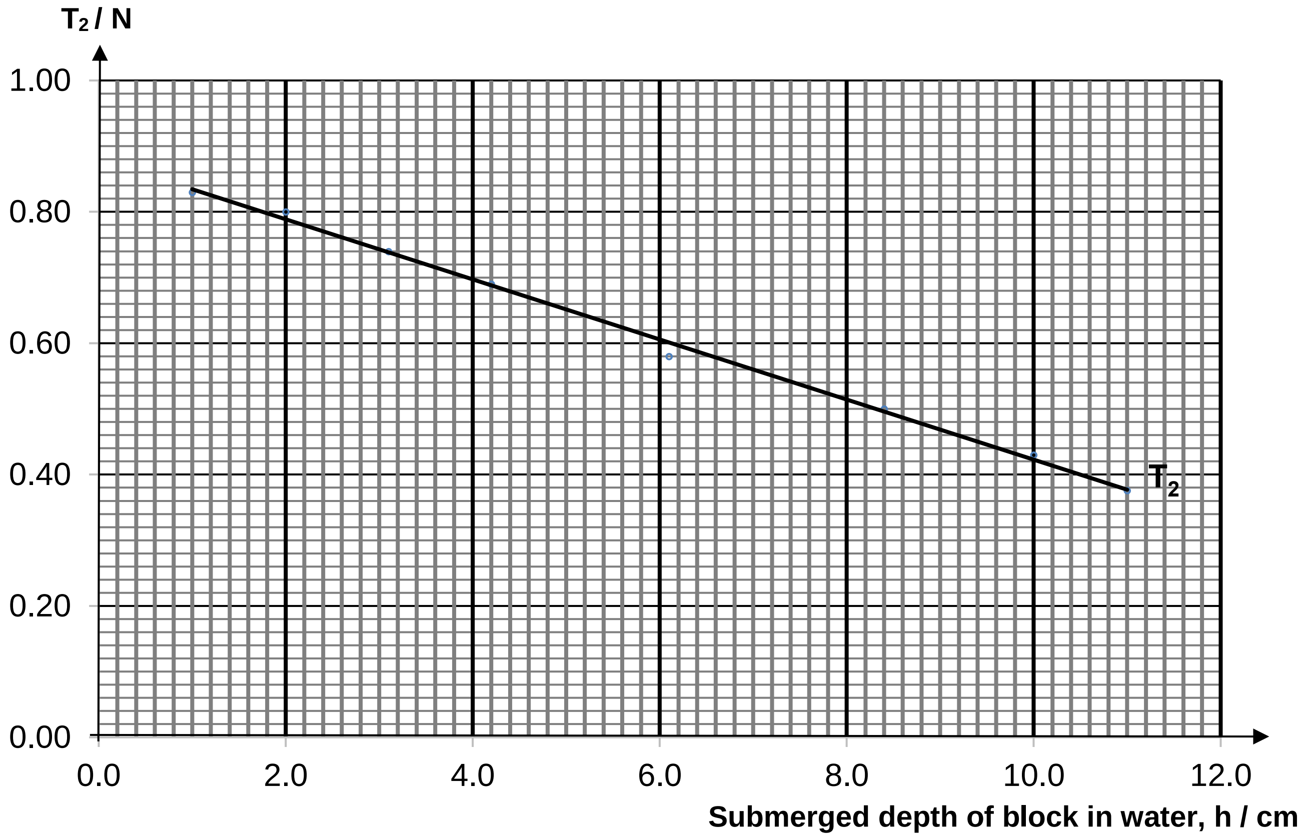


Fig. 5.2

(i) Use **(a)** and values from Fig. 5.2 to complete Fig. 5.3. Determine the values of U, the force that the water exerts on the block.

h / cm	**T_1 / N**	**T_2 / N**	**U / N**
2.0		0.79	
4.0			
6.0			
8.0			
10.0			

[3]

Fig. 5.3

(ii) **1.** Plot a graph of U against h in Fig. 5.4. [2]

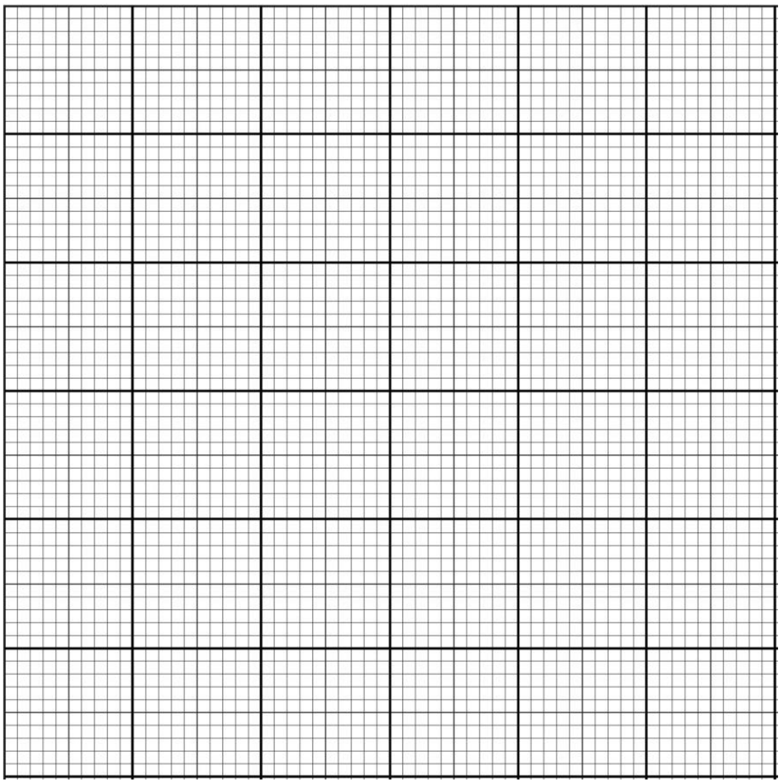


Fig. 5.4

2. The relationship between U and h is found to be

$$U = \rho g A h$$

where ρ is the density of water, g is the acceleration due to free fall and A is the cross sectional area of the block. The density of water is 1000 kg m^{-3}.

Use Fig. 5.4 to determine the value of A. Show your working clearly.

cross sectional area A = …………………… m^2 [2]

3. Lucas conducted a second experiment using salt solution. Given that the density of salt solution is 2.16 g cm^{-3}. State and explain how your graph in Fig. 5.4 would change.

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [1]

Section B

Answer **two** of the questions in this section.

6 **(a)** A ball bearing, A with mass 50 g, initially at rest, slides down a smooth slope, inclined at an angle of 37° to the horizontal as shown in Fig. 6.1. It travels 5.0 m along the slope before falling freely off the edge E.

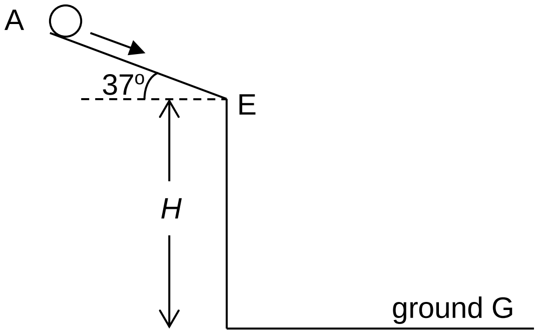


Fig. 6.1

(i) Show that the acceleration of the ball as it slides down the smooth slope from A to E is 5.9 m s^{-2}. [2]

(ii) Calculate the speed of the ball when it reaches the edge E of the slope.

speed of the ball = ……………………….. m s^{-1} [2]

(iii) In Fig. 6.1, sketch the path taken by the ball upon leaving the edge E of the slope. [1]

(iv) The time taken for the ball to reach the ground G after leaving the edge of the slope is 0.85 s. Show that the height *H* of the edge of the slope above the ground is 7.5 m. [2]

(v) Taking reference from edge E, sketch on Fig. 6.2 and Fig. 6.3 the variation with time of the horizontal displacement *x* and the vertical displacement *y* of the ball during its flight from E to G. Label the graphs P and Q respectively. (Indicate appropriate numerical values but no further calculation is required.)

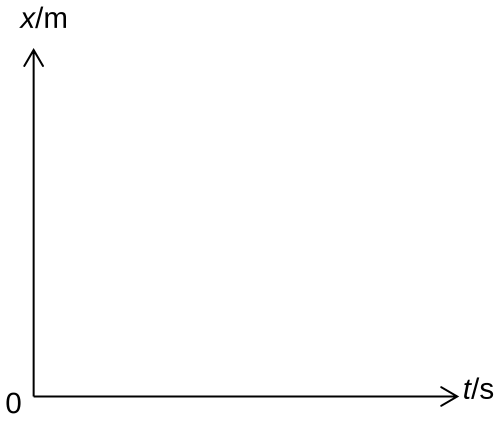


Fig. 6.2

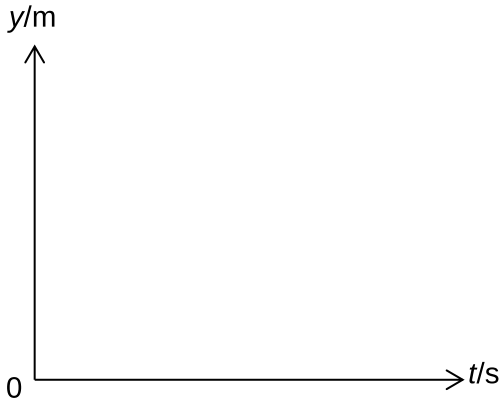


Fig. 6.3

[2]

(vi) Sketch on Fig. 6.2 the corresponding variation with time of the horizontal displacement of the ball during its flight from E to G, if air resistance is **not** negligible. Label the graph R. [1]

(b) Ball A in **(a)** and another ball B are supported by long strings, as shown in Fig. 6.4.

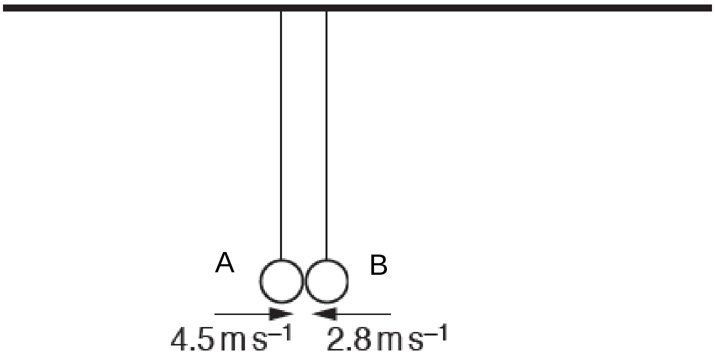


Fig. 6.4

The balls are each pulled back and released such that they moved towards each other. When the balls collide at the position shown in Fig. 6.4, the strings are vertical. The balls rebound in opposite directions.

Fig. 6.5 shows data for A and B during this collision.

ball	velocity just before collision / m s^{-1}	velocity just after collision / m s^{-1}
A	+ 4.5	- 1.8
B	- 2.8	+ 1.4

Fig. 6.5

The positive direction is taken to be horizontal and to the right.

(i) State the principle of conservation of linear momentum.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) Hence, determine the mass *M* of B.

M = …………………… g [3]

(iii) By making further calculation, determine if the collision is elastic.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iv) Use Newton's second and third laws of motion to explain why the magnitude of the change in momentum of each ball is the same.

....

....

....

....

....

.... [3]

7 (a) Distinguish between the electromotive force of a cell and the potential difference across a conductor.

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

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) A dry cell has an e.m.f. *E* and internal resistance *r* and is connected to an external resistor R as shown in Fig. 7.1. There is a current *I* in the circuit when the potential difference across the terminals of the cell is *V*.

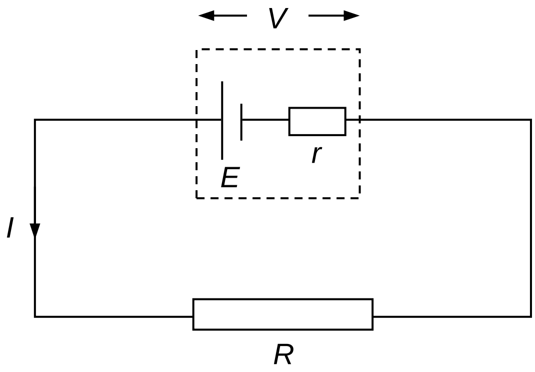


Fig.7.1

Derive an expression for V in terms of E, *I* and *r*. [2]

(c) The variation of *V* with *I* for the dry cell in **(b)** is shown in Fig. 7.2.

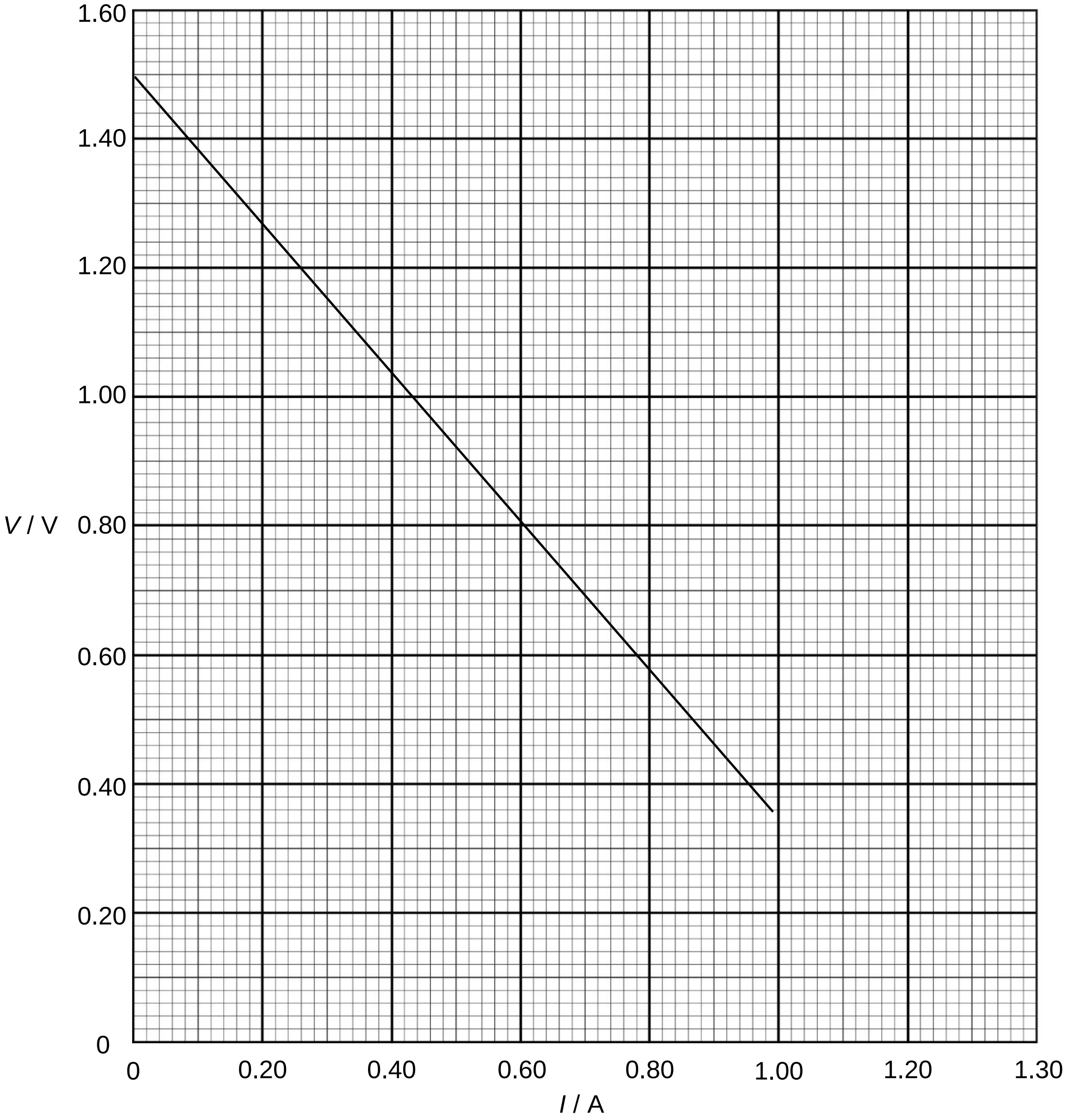


Fig. 7.2

(i) Complete Fig. 7.3 to show a circuit that could be used to obtain the data from which Fig. 7.2 can be plotted. [2]

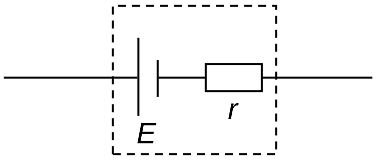


Fig.7.3

(ii) Use Fig. 7.2, explaining your calculations clearly, to determine the following:

1. the e.m.f. *E* of the dry cell,

E = ……………………………V [2]

2. the power dissipated in the external circuit when the current in the circuit is 0.4 A.

power = …………………W [2]

3. the internal resistance r of the cell.

r = …………………..Ω [2]

(iii) Fig. 7.4 shows the resistor of resistance *R* in Fig.7.2 replaced by an electrical device (load) and is connected in series with the dry cell. The current *I* in the circuit is 0.10 A.

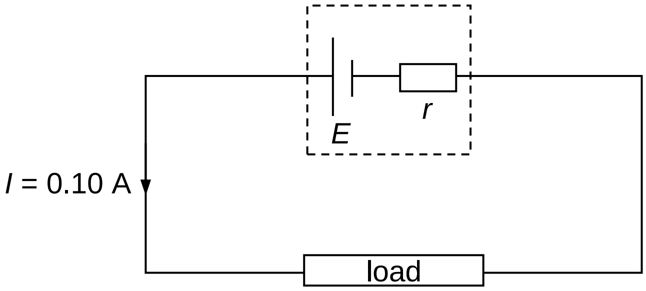


Fig.7.4

The power dissipated in the load is 0.14 W.

Calculate

1. the total power delivered by the dry cell,

power = …………………. W [1]

2. the resistance of the load.

resistance = ………………….Ω [1]

(d) Electric current in microchip circuits is carried through non-ohmic metals and semiconductors. Discuss qualitatively the effects of increasing temperature on the resistance of a semiconductor and filament lamp of the same dimensions.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(e) Fig. 7.5 shows a circuit of a fire alarm which is set to trigger at a temperature of 80 °C. The circuit consists of a specially made thermistor whose resistance is 100 Ω at room temperature and its resistance rises with the temperature of its surroundings.

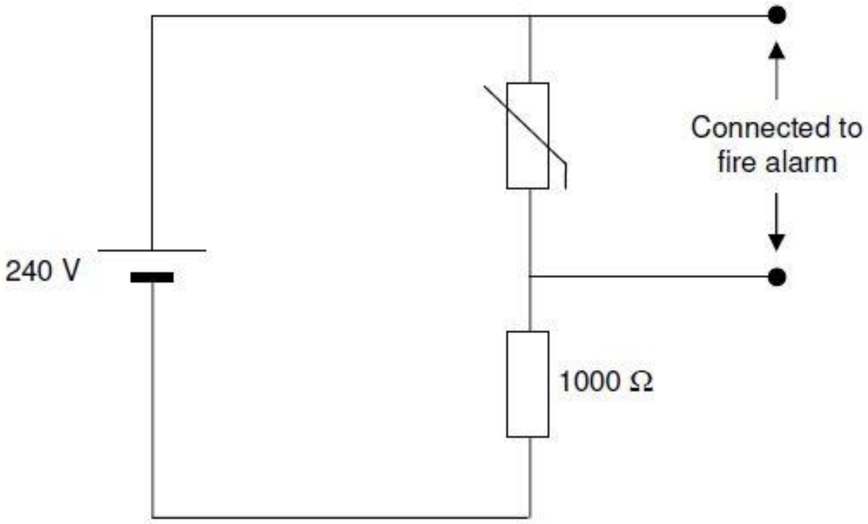


Fig. 7.5

(i) Given that the alarm connected across the thermistor requires a potential of 160 V to work, determine the resistance of the thermistor for the fire alarm to be triggered.

resistance = …………………….. Ω [2]

(ii) Explain whether the fire alarm will work properly if the 1000 resistor is replaced with a connecting wire.

……………………………………………………………………………………

…………………………………………………………………………………… [1]

8 **(a)** **(i)** State a wavelength within the visible light spectrum.

wavelength = ………………… nm [1]

(ii) Calculate the energy of a photon in electron volts for light of the wavelength stated in **(i)**.

energy = …………………… eV [3]

(b) Fig. 8.1 is a graph showing the maximum kinetic energies, in electron volts, of electrons emitted from a sodium surface when light of different frequencies from a hydrogen light source is irradiated on the sodium surface.

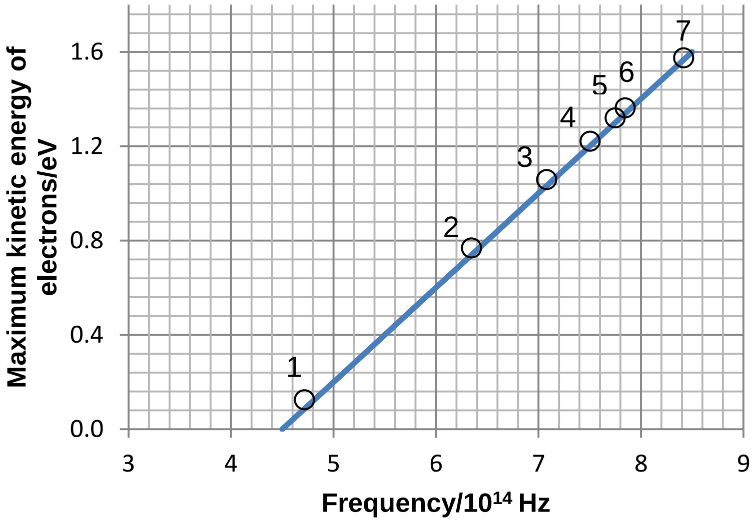


Fig. 8.1

(i) Explain what is meant by the term *threshold frequency of a metal*.

…………………………………………………………………………………………

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

(ii) Using Fig. 8.1 and answer to **(b)(i)**, state and explain the value of threshold frequency of sodium.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

(iii) Calculate the work function energy for sodium.

work function = …………………… J [2]

(iv) In a photoelectric experiment, the sodium surface is illuminated with a beam of monochromatic radiation, of frequency 6.0 x 10^{14} Hz and intensity 0.500 W m^{-2}, over an area of 4.50 x 10^{-5} m^2.

1. Use Fig. 8.1 to determine the stopping potential.

stopping potential = …………………. V [1]

2. Determine the number of photons incident on the sodium surface per unit time.

number of photons = …………………………….. s^{-1} [2]

3. By assuming 50% efficiency in the emission of photoelectrons, determine the maximum photoelectric current.

maximum photoelectric current = …………………. A [2]

(c) An electron beam, which fires individual electrons one after another, is directed at a wall made of a gold-coated silicon membrane. The wall has two 62 nm wide slits in it with a centre-to-centre separation of 272 nm.

The electrons were created using a tungsten filament and accelerated to a kinetic energy of 600 eV. After passing through the double slit, they were detected using a suitable screen placed 240 mm behind the slit. A resulting pattern formed after several hours is shown in Fig. 8.2. *d* is the separation between the centres of adjacent bright spots.

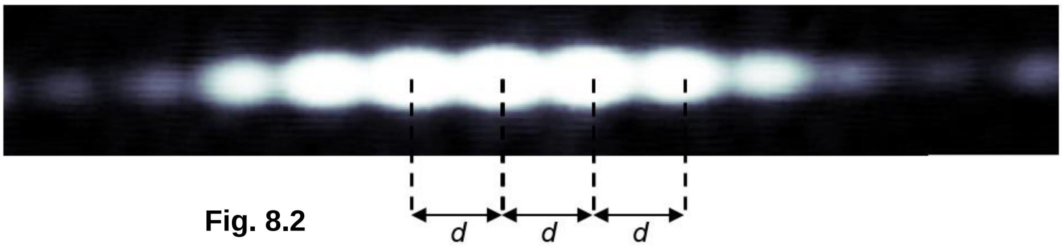


Fig. 8.2

(i) Suggest the significance of this experiment.

……………………………………………………………………………………………..

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

(ii) Show that the momentum of the electron when it is at the double slit wall is 1.32×10^{-23} N s. [2]

(iii) Determine the de Broglie wavelength of the electrons.

wavelength = ………………….. m [1]

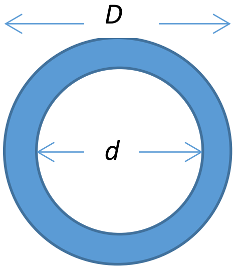
(iv) Hence, determine the separation *d*.

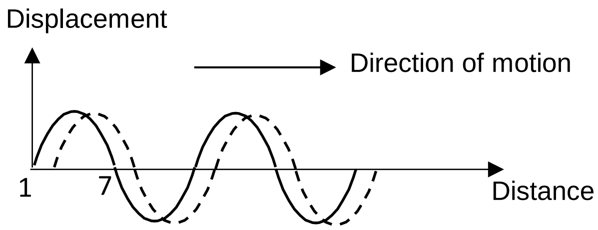
d = …………………… m [2]

End of Paper

Answer Key for PU2 PE2 H1 8866
Paper 1

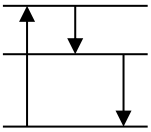
1	C	**2**	A	**3**	B	**4**	B	**5**	C
6	B	**7**	D	**8**	C	**9**	A	**10**	C
11	D	**12**	D	**13**	D	**14**	D	**15**	C
16	C	**17**	A	**18**	B	**19**	D	**20**	B
21	D	**22**	C	**23**	D	**24**	A	**25**	A
26	B	**27**	B	**28**	A	**29**	D	**30**	C

1	C	[P] = $\frac{kg\ m\ s^{-2}}{m^2}$ = kg m^{-1} s^{-2} Comparing the units in the equation: $m^3 s^{-1} = \frac{m^{\alpha}(kg\ m^{-1} s^{-2})}{kg\ m^{-1} s^{-1}\ (m)}$ Rearranging, $m^4 s^{-2} = m^{\alpha} s^{-2}$
2	A	Let *D* and *d* be external and internal diameters of the cylinder respectively. Let *t* be the thickness of the wall of the cylinder  The mean wall thickness is $t = \frac{1}{2}(D - d)$ = $\frac{1}{2}(95.0 - 87.0) = 4.0$ mm $\Delta t = \frac{1}{2}(\Delta D + \Delta d)$= 0.1 mm Hence the radius is 4.0 ± 0.1 mm.
3	B	
4	B	Area under a-t graph represents the change in velocity. Hence, the speed at point B will be greatest.
5	C	
6	B	For P and Q to collide, they must travel the same vertical displacement. Since $v_y = u_y + 2as$, u_y must be the same for P and Q.

		For Projectile P → $v_y = u_1\sin30° + 2as$ For Projectile Q → $v_y = u_2 + 2as$ Hence, $u_1\sin30° = u_2$
7	D	Applying Principle of Conservation of Momentum: (2.0 x 3.0) + (1.0 x 0) = (2.0 + 1.0) v V = 2.0 m s^{-1} KE lost = ½ $(2.0)(3.0)^2$ – ½ $(2.0+1.0)(2.0)^2$ = 3.0 J
8	C	FR = ma mg sinθ – F = ma F = mg sinθ – ma
9	A	Area under the F-t graph
10	C	Let the distance of mass 50g from pivot be x and on left side of the pivot Applying the Principle of moments 100 (10) + 50 x = 20 x 60 x = 4 (from the left side of the pivot)
11	D	
12	D	Work done on gas = 1 x 10^5 x 2 x 10^{-4} x 5.0 x 10^{-2} = 1.0 J
13	D	WD by force = gain in KE = ½ mv^2 - ½ mu^2 = ½ $(5)(12)^2$ - ½ $(5)(2)^2$ = 350 J
14	D	$efficiency = \frac{P_{out}}{P_{in}} \times 100\% = \frac{IV}{mgh/t} \times 100\% = \frac{200 \times 6000}{500 \times 9.81 \times 300} \times 100\% = 82\%$
15	C	Taking to the right to be +ve displacement,  At the next instant of time, particle 1 has –ve displacement (which means it is moving to the left) while particle 7 has +ve displacement (which means it is moving to the right)
16	C	$I = k\frac{A^2}{r^2}$

		$\frac{I'}{I}=\frac{A'^2}{A^2}\frac{r^2}{r'^2}$ $I'=5\frac{(2A)^2}{A^2}\frac{3^2}{4^2}=11.25\approx 11\,\mathrm{W}\,m^{-2}$
17	A	When the width of the slit is equal to the wavelength, maximum diffraction occurs and Fig. 17.1 is observed (the wavefronts are almost semicircular). When the width of the slit is larger than the wavelength, the wave passes through the slit and does not spread out much on the other side (as illustrated in Fig. 17.2). To reduce the effect of diffraction, the wavelength has to decrease. Since v=fλ, frequency of the vibration bar has to increase.
18	B	5 bright fringe separations are 15 mm long. Therefore, x = 3 mm $\lambda=\frac{xa}{D}=\frac{0.003\times 0.0009}{5.0}$ = 5.4x10^{-7} m
19	D	A is incorrect as a node is form at the surface of the metal sheet. B is incorrect as X and Y are out of phase. C is incorrect as sound waves are travelling along WXYZ. As sound waves are longitudinal waves, the air particles will be vibrating in the same direction as the travel of wave.
20	B	$R=\frac{\rho L}{A}$ Resistance of steel = $\frac{1\times 10^{-7}\times 1}{0.002^2}$ = 0.025 Ω Resistance of steel = $\frac{2.8\times 10^{-8}\times 1}{0.005^2-0.002^2}$ =1.333 x 10^{-3} Ω Effective resistance = $(\frac{1}{R_s}+\frac{1}{R_{Al}})^{-1}=1.27\ m\Omega$
21	D	R = $\frac{V}{I}=\frac{-6.0}{0}=\ \infty$ R = $\frac{V}{I}=\frac{6.0}{2}=\ 3.0\Omega$
22	C	Current *I* = 3.0 + (3.0 x 2.0)/6.0 = 4.0 A Total resistance of external circuit, *R* = 1.5 + (2.0 x 6.0)/(2.0 + 6.0) = 3.0 Ω. Efficiency output of emf source, η, is given by $\eta=\frac{IV}{IE}=0.90$, where *V* is the terminal p.d. Thus, *E*= *V*/0.90 = (4.0 x 3.0)/0.90 = 13.3 V Short cut: After working out I=4 A and total p.d. = 12 V, can eliminate choice B without further calculation.
23	D	$R'=(\frac{1}{R}+\frac{1}{2R})^{-1}=\frac{2R}{3}=8.0\Omega$ R = 12.0 Ω
24	A	Option A: $R_{eff}=R+2R+2R$=5R

		$I_{ammeter} = \frac{V_{PQ}}{5R} = 0.2\frac{V_{PQ}}{R}$ Option B: $R_{eff} = 2R + (\frac{1}{R} + \frac{1}{2R})^{-1}$= $\frac{8}{3}$R $I_{ammeter} = \frac{V_{PQ}}{\frac{8}{3}R} = 0.375\frac{V_{PQ}}{R}$ Option C: $R_{eff}\, on\ the\ upper\ branch = 2R + R$ = 3R $I_{ammeter} = \frac{V_{PQ}}{3R} = 0.333\frac{V_{PQ}}{R}$ Option D: $I_{ammeter} = \frac{V_{PQ}}{2R} = 0.5\frac{V_{PQ}}{R}$
25	A	F = n BIL sinθ = 0.2 x 3.0 x 0.04 x sin 0 x 50 = 1.2 N Apply FLHR to determine the direction of force. (From Fig. 25.2, current QS is flowing out of the page)
26	B	
27	B	When the frequency of light increases, each photon carries more energy. However, since the intensity remains constant, the total energy of the light wave per unit time is constant. Thus there must be fewer photons and hence fewer photoelectros produced. Thus the current must fall. Since the energy per photon is now higher, the photoelectrons emerge with a larger KE. Thus a larger stopping potential is needed to have zero photocurrent.
28	A	K_{max} = 0 eV occurs when λ = 250 nm. Therefore, the threshold wavelength is 250 nm. By photoelectric equation, $\frac{hc}{\lambda} = \Phi + K_{max}$ Hence, $\Phi = \frac{hc}{\lambda} - K_{max} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{250\times10^{-9}} - 0$ $\Phi = 7.956\times10^{-19}$ J = 4.97 eV
29	D	Option A - The most stable state of the atom is the ground state, i.e. when energy level is -13.60 eV. Option B - An electron can transit from the -0.53 eV level to 0 eV level by absorbing an electron of energy 0.53 eV. Option C - The incident photon of energy must have the exact amount of energy corresponding to the energy level difference.

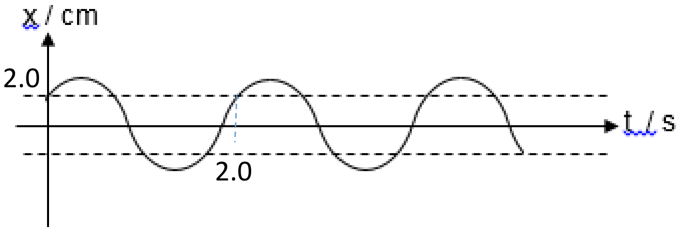
30	C	E_1 (photon absorbed) = $E_2 + E_3$ (photons emitted) $h\,c / \lambda_X = h\,c / \lambda_Y + h\,c / \lambda_Z$ $1 / \lambda_X = 1 / \lambda_Y + 1 / \lambda_Z$ $1 / \lambda_Z = 1 / \lambda_X - 1 / \lambda_Y$ $= (\lambda_Y - \lambda_X) / \lambda_X \lambda_Y$ 

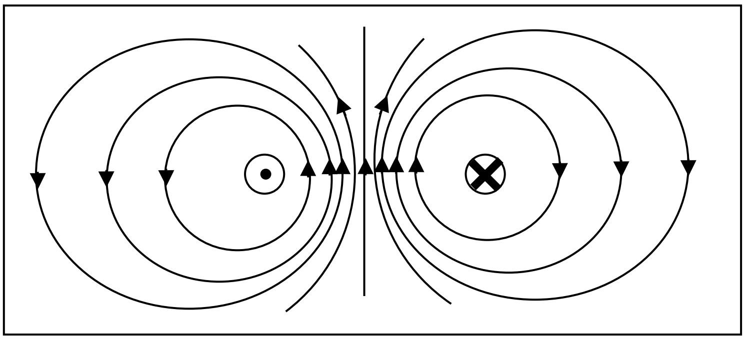
Paper 2 Answer Key

1	**(i)**	$\lambda = \frac{xd}{D} = \frac{(2.33 \times 10^{-3})(0.650 \times 10^{-3})}{2.80}$ = 5.41 x 10^{-7} m $\frac{\Delta\lambda}{\lambda} = \frac{\Delta x}{x} + \frac{\Delta d}{d} + \frac{\Delta D}{D}$	**C1**
		$\frac{\Delta\lambda}{\lambda} = \frac{0.01}{2.33} + \frac{0.001}{0.650} + \frac{0.01}{2.80}$	**C1**
		$\Delta\lambda$ = 0.0509 x 10^{-7} m = 0.05 x 10^{-7} m (1 SF)	**C1**
		Δλ = (5.41 ± 0.05) x 10^{-7} m (correct s.f and d.p.)	**A1**
	(ii)	By increasing *D*, the fringe separation *x* will also increase.	**B1**
		Hence, the fractional uncertainty due to *x* and *D* is reduced.	**B1**

2	**(a)**	The initial total momentum of the two trolleys is zero because the two trolleys have the same mass and have the same speed but travel in opposite directions. In equation form (let mass of each cart be M): M(10) + M(−10) = Mv_1 + Mv_2 0 = v_1+ v_2	**B1**
		This means that after the collision, the total momentum of the carts must be zero. Since the two trolleys have the same mass, the velocities of the two trolleys will be equal in magnitude but in opposite directions.	**B1**
	(b)	Since the mass, initial speeds, final speeds, of the two trolleys are the same, the two carts must have lost the same amount of kinetic energy. Appropriate comparison of masses. We can focus on just one trolley. Alternatively, award mark if total kinetic energy of both trolleys are added. Initial speed = 10 m s^{-1} Initial KE = ½ m $(10)^2$	**B1**
		Let final speed be v. Final KE = ½ m v^2 = 0.65 (½ m $(10)^2$) [M1 for correct comparison of KE] v^2 = 65 v = 8.06 = 8.1 m s^{-1}	**M1**

	(c)	Area under graph: Impulse = ½ (440)(0.001) + (440)(0.005) + ½ (440)(0.002) = 2.86 N s Or area of trapezium = ½ (0.005 + 0.008)(440) = 2.86 N s N s OR kg m s^{-1}	**M1** **A1** **B1**
	(d)	Impulse on trolley A = change in momentum = 2.86 Ns (can ecf from part (c)) Magnitude of change in velocity of trolley A = 10 – (–8.1) = 18.1 m s^{-1}. Mass = change in momentum / change in velocity = 2.86 / 18.1 = 0.158 kg	**C1** **A1**

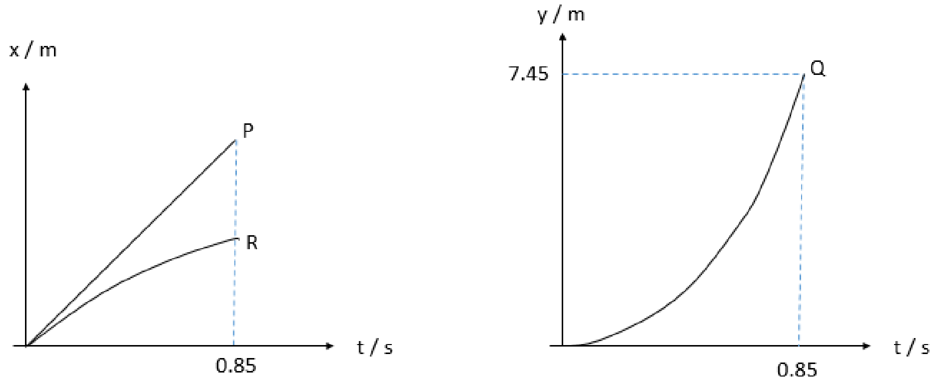
3	**(a)**	1.5 λ = 1.4 mm $\lambda = \dfrac{1.4\text{ x }10^{-3}}{1.5} = 9.33\text{ x }10^{-4}$ m Speed of the wave = f λ = (0.50)(9.33 x 10^{-4}) = 4.67 x 10^{-4} m s^{-1}	**C1** **A1**
	(b)	Point B	**A1**
	(c)	 1. Correct shape of graph and correct number of cycles i.e. 2 2. Starting point of graph must be between the positive y-values and equilibrium. 3. Amplitude and period labelled	**A1** **A1**

4	**(a)**		The tesla is defined by reference to the equation for the motor effect, namely $F = BIl$. 1 tesla is the field strength of a magnetic field where 1 newton of force is experienced by a metre long straight conductor carrying a current of 1 ampere, placed perpendicular to the magnetic field. All 3 underlined points. 2 underlined points (allow A1) 1 underlined point (no mark)	**A2**
	(b)			
			Students must show the closely spaced field lines in the region between the wires. Whereas for the "external" region the field lines must be spaced out further apart from each other. Vertical line must be shown at the midpoint between the two wires. Correct field lines direction	**A1** **A1**
	(c)		There is a magnetic force exerted on each wire, with magnitude F = BIL. Using Fleming Left hand rule, the direction of Fx is towards the left while Fy is towards the right. The forces acting in opposite direction will cause the 2 wires to repel. Accept: The magnetic field lines in the region between the two wires are highly concentrated. This creates a tendency for these field lines to redistribute itself towards the region of lower concentration. Hence the wires experience a force that pushes them away from each other.	**B1** **B1** **B1** **B1**
	(d)		$B = \mu_o I / (2 \pi r)$ $B = (4\pi \times 10^{-7}) (80) / (2 \pi (2.0))$ $B = 8.0 \times 10^{-6}$ T	**C1** **A1**
	(e)	**(i)**	By FLHR, direction is D to A.	**A1**
		(ii)	By Principle of Moments, $0.30(0.90)(0.08)(0.15)=5.0\times10^{-3}(9.81)(x)$ x = 0.0661 m = 6.61 cm	**C1** **A1**

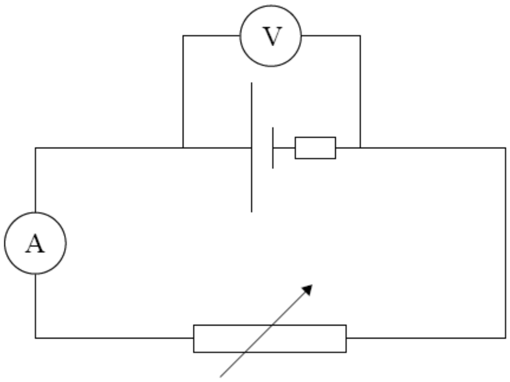
<table>
<tr><td>5</td><td>(a)</td><td colspan="3">2 upward forces, T_2 and force exerted by water
1 downward force which is the weight of the block
Sum of the upward forces must balance weight of the block s</td><td>A1</td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td colspan="2"><table>
<tr><th>h / cm</th><th>T_1 / N</th><th>T_2 / N</th><th>U / N</th></tr>
<tr><td>2.0</td><td>0.90</td><td>0.79</td><td>0.11</td></tr>
<tr><td>4.0</td><td>0.90</td><td>0.70</td><td>0.20</td></tr>
<tr><td>6.0</td><td>0.90</td><td>0.60</td><td>0.30</td></tr>
<tr><td>8.0</td><td>0.90</td><td>0.50</td><td>0.40</td></tr>
<tr><td>10.0</td><td>0.90</td><td>0.42</td><td>0.48</td></tr>
</table>
2 marks for reading T_2 accurately from the graph (2 correct T_2 – 1 mark)
1 mark for the correct value of U</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td>1.</td><td>Accurate plots (check at least 2 plots)
Axis labelled with units
Award ecf from b(i)</td><td>A1
A1</td></tr>
<tr><td></td><td></td><td></td><td>2.</td><td>Correct calculation of gradient

Gradient = $\rho gA = 1000 \times 9.81 \times A$
$A = 0.000460\ m^2$</td><td>M1

A1</td></tr>
<tr><td></td><td></td><td></td><td>3.</td><td>Since density of salt solution is higher than water, the gradient will be larger. Hence the slope of Fig. 5.4 will be steeper.</td><td>B1</td></tr>
</table>

6	**(a)**	**(i)**	A component of weight down the slope is causing the acceleration. $F_{net} = ma$ $mg \sin \theta = m\ 9.81 \sin 37° = ma$ $a = 5.9\ m\ s^{-2}$	 **M1** **C1**
		(ii)	$v^2 = u^2 + 2as$ $= 0 + 2\ (5.9) \times 5.0$ $v = 7.68\ m\ s^{-1}$ Alternatively, solve using conservation of energy.	 **C1** **A1**
		(iii)	Trajectory path from E to G	**A1**
		(iv)	s = ut + ½ at2 $= 7.68 \sin 37° (0.85) + ½ (9.81) (0.85)^2$ $= 7.45$ m	 **C1** **A1**
		(v)	 Correct linear P Correct curve for Q with vertical displacement labelled in Q at t=0.85s and at t=0s, gradient (i.e. vertical velocity) = 0	**A1** **A1**
		(vi)	Correct trend of R	**A1**
	(b)	**(i)**	The principle of conservation of momentum states that in the absence of external forces, total momentum of system before the collision is equal to the total momentum of system after the collision.	**B1** **B1**
		(ii)	4.5 × 50 – 2.8 × M (= ...) (...) = –1.8 × 50 + 1.4 × M M = 75 g	**C1** **C1** **A1**
		(iii)	total initial kinetic energy = $0.5\ (0.075)\ (-1.8)^2 + 0.5\ (0.050)\ (4.5)^2 = 0.52$ J total final kinetic energy = $0.5\ (0.075)(1.4)^2 + 0.5\ (0.050)\ (-2.8)^2 = 0.27$ J total initial kinetic energy/KE not equal to the total final kinetic energy/KE, so not elastic or is inelastic Accept alterative: relative speed of approach is not equal to relative speed of separation	 **M1** **B1**
		(iv)	force on X is equal and opposite to force on Y (Newton III)	**M1**

			force equals/is proportional to rate of change of momentum (Newton II) time of collision same for both balls hence change in momentum is the same	**M1** **A1**

7	**(a)**	Electromotive force of the cell is defined as the amount of chemical energy that is converted into electrical energy when a unit charge flows through the circuit while potential difference across a conductor is the amount of electrical energy converted to other forms of energy when a unit charge flows through it.			**B1** **B1**
	(b)	By conservation of energy, energy supplied by cell is dissipated as heat in r and R, i.e. $E\,I = I^2\,r + V\,I$ Hence $E = I\,r + V$ (or $V = E - I\,r$)			**M1** **A1**
	(c)	**(i)**			
		correct position of variable resistor correct positions of ammeter and voltmeter			**A1** **A1**
		(ii)	**1.**	$E = V$ when $I = 0$ from graph $E = 1.5$ V	**M1** **A1**
			2.	P = IV = 0.4 x 1.03 = 0.412 W	**C1** **A1**
			3.	r is the slope of the graph. from graph $E = 1.5$ V (sensible choice of triangle, at least half the line as hypothenuse) $r = 0.7 / 0.6 = 1.2\ (\pm 0.1)\ \Omega$	**M1** **A1**
		(iii)	**1.**	P = IE = 0.10 x1.5 = 0.15 W Alternative P = $I^2 r + 0.14 = 0.10^2\ (1.2) + 0.14 = 0.152$ W	**A1**
			2.	$0.14 = I^2\,R$ $R = 14\ \Omega$	**A1**
	(d)	For filament lamp, mobile charge carriers are the free electrons. Increase in temperature results in atomic vibrations increases, hence leading to an increase in resistance with temperature.			**B1**

			For semiconductors, with increase in temperature, atomic vibrations increase but mobile charge carriers increase as well. Effect of increase in mobile charge carriers on lowering resistance is greater than effect of greater atomic vibrations on increasing resistance.	**B1** **B1**
	(e)	**(i)**	When the fire alarm is working, Current flow in the circuit = $\frac{240-160}{1000} = 0.080\,A$ Resistance of thermistor when fire alarm working = $\frac{V}{I} = \frac{160}{0.080} = 2000\Omega$ *Note: The thermistor used in the question is that of a positive temperature coefficient where its resistance rises with temperature.* *The conventional thermistor has a negative temperature coefficient where its resistance drops with temperature.*	**C1** **A1**
		(ii)	If the 1000 W resistor is replaced by a connecting wire, the p.d. across the alarm will always be 240 V. It will not work properly as the alarm will always be triggered.	**B1**

8	**(a)**	**(i)**	Wavelength is between 390 to 750 nm		**B1**
		(ii)	E = hc/λ = 5.1 × 10^{-19} to 2.6 × 10^{-19} J E = 1.7 to 3.2 eV		**M1** **C1** **A1**
	(b)	**(i)**	Threshold frequency of the metal is the <u>minimum frequency</u> of light with which photoelectrons will be emitted when it is irradiated onto the metal surface.		**B1**
		(ii)	The graphs cuts the x-axis at 4.5×10^{14} Hz, <u>below which</u> no photoelectrons were detected hence the threshold frequency of sodium is 4.5 × 10^{14} Hz		**A1** **B1**
		(iii)	ϕ = E =hf E = 2.98 × 10^{-19} J		**M1** **A1**
		(iv)	**1.**	$eV_s = KE_{max}$ = 0.6 eV (from Fig. 8.1) V_s = 0.6 V	**A1**
			2.	Int = $\frac{P}{A} = \frac{E}{tA} = \frac{N_{photons}\times hf}{tA}$ $\frac{N_{photons}}{t} = \frac{Int \times A}{hf} = \frac{0.500 \times 4.5 \times 10^{-5}}{6.63 \times 10^{-34} \times 6 \times 10^{14}}$ = 5.66 x 10^{13} s^{-1}	**C1** **A1**
			3.	Efficiency = 50% $\frac{N_{photoelectrons}}{t} = 50\% \times 5.66 \times 10^{13} = 2.828 \times 10^{13}$ I = $\frac{N_{photoelectrons}\times e}{t} = 2.828 \times 10^{13} \times 1.6 \times 10^{-19}$ $= 4.52 \times 10^{-6}A$	**C1** **A1**

	(c)	**(i)**	Electrons have a wave-like nature.	**B1**
		(ii)	Kinetic energy of electron at wall, E_k = 600 eV = 9.6 x 10^{-17} J Momentum of electron at wall, p $p^2 = 2mE_k$ $p = \sqrt{2(9.11\times10^{-31})(9.6\times10^{-17})}$ $= 1.32\times10^{-23}$ N s	**C1** **C1**
		(iii)	de Broglie wavelength λ of electron at wall $= \frac{h}{p}$ $= \frac{6.63\times10^{-34}}{1.32\times10^{-23}}$ $= 5.01\times10^{-11}$ m	 **A1**
		(iv)	$d = \frac{\lambda D}{a}$ $= \frac{(5.01\times10^{-11})(0.240)}{272\times10^{-9}}$ $= 4.42\times10^{-5}$ m	 **C1** **A1**