MERIDIAN JUNIOR COLLEGE
JC2 Preliminary Examinations
Higher 1

H1 Physics 8866/02

Paper 2 Structured Questions **20 September 2016**

2 hours

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

Class	Reg No

Candidate Name: ______________________________

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 2B pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

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

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	
Paper 1	**/ 30**
Section A	
1	**/ 10**
2	**/ 12**
3	**/ 8**
4	**/ 10**
Section B	
5	**/ 20**
6	**/ 20**
7	**/20**
Deductions	
Total	**/ 110**

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-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
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

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

Section A

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

1 **(a)** Fig. 1.1 shows a light gate, which is an electronic sensor used to measure the speed of an object. The light gate consists of an infrared beam which travels between its two arms. The light gate is triggered when the beam is blocked by the object, and the time duration of the obstruction is recorded using a data logger (not shown).

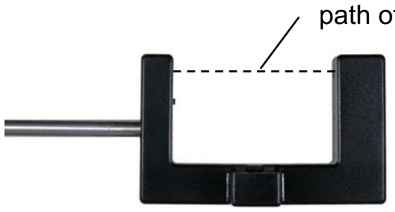

Fig. 1.1

A weighted card is released and falls vertically through the light gate, as shown in Fig. 1.2.

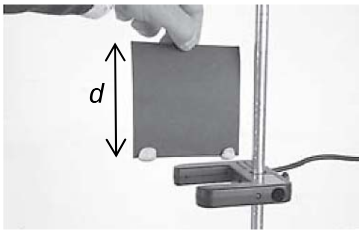

Fig. 1.2

The card has a length d = (0.200 ± 0.002) m, and the time taken for the card to travel through the light gate was t = (0.06428 ± 0.00001) s.

(i) Calculate the average speed of the card. Express it with its associated uncertainty.

speed = (.................... ±……………) m s^{-1} [3]

(ii) Suggest two reasons why, with a single light gate, we can only measure the average speed of the falling card, but not its instantaneous velocity.

Reason 1: ....

....

Reason 2: ....

.... [2]

(iii) Suggest a source of random error that limits how precisely the speed can be measured.

....

.... [1]

(b) The light gate can be used with a "picket fence" (a clear plastic card with dark opaque strips printed on it). This allows readings of speed to be taken in quick succession. A picket fence is dropped from a height above the light gate, and falls freely through the light gate, as shown in Fig. 1.3. The experiment can be used to determine the acceleration of the picket fence in free fall.

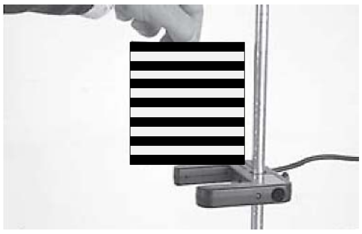

Fig. 1.3

The light gate is first triggered when the beam is blocked by the bottom-most strip of the picket fence. The best-fit line for the experimental data is shown on the speed-time graph in Fig. 1.4.

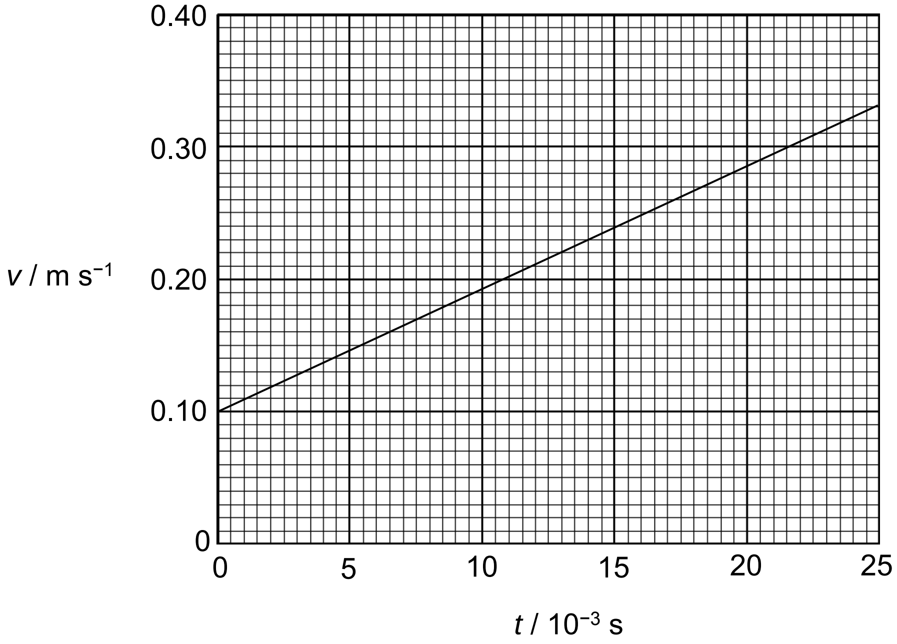

Fig. 1.4

(i) Determine the acceleration of the picket fence.

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

(ii) State the characteristic of the graph which indicates a systematic error in the experiment. Explain your answer.

....

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....

....

.... [2]

2 A roller coaster's carriage, of mass 300 kg, slides down a smooth slope and executes a smooth loop of diameter *d*. It experiences friction after the loop, denoted as zone A, as shown in Fig. 2.1 below.

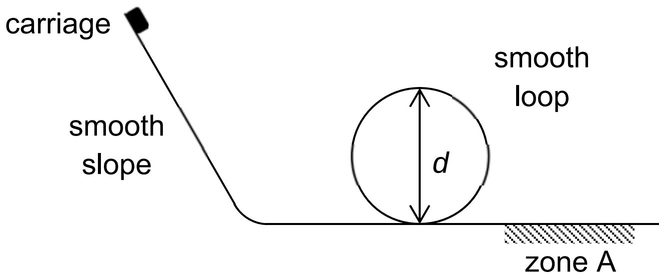

Fig. 2.1

The potential energy and kinetic energies are plotted against time in the following graph provided in Fig 2.2.

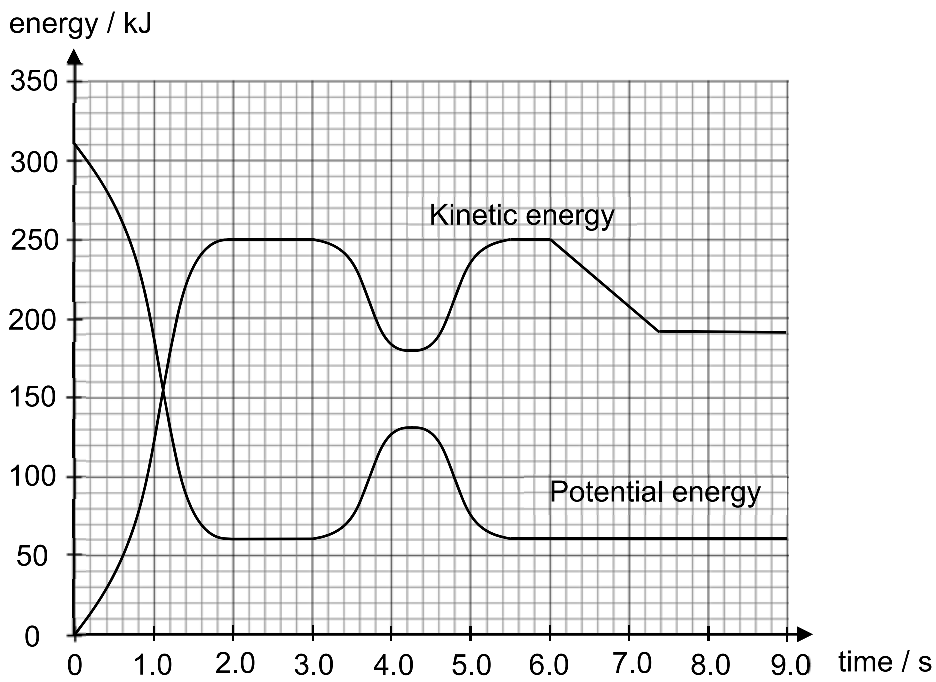

Fig. 2.2

(a) On Fig. 2.2, sketch the variation of total mechanical energy with time, from $t = 0$ s to $t = 9.0$ s. [2]

(b) Between $t = 3.0$ s and $t = 5.4$ s, the carriage executes the loop. Using the graph, calculate the diameter *d* of the loop.

d = ... m [2]

(c) **(i)** State the start and end times at which the carriage is within zone A. Explain your answer with reference to Fig. 2.2.

time start: .... s

time end: .... s

....

....

....

.... [3]

(ii) Calculate the rate at which zone A dissipated kinetic energy with respect to time.

rate of kinetic energy dissipation = ... kW [2]

(iii) Calculate the velocity of the carriage when it entered zone A.

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

(iv) Hence, calculate the force of friction when the carriage first entered zone A.

force = ... N [2]

3 Five identical electrical devices of resistance 10 Ω and three switches, S_A, S_B and S_C, are arranged in a network as shown in Fig. 3.1. S_A is open while S_B and S_C are closed.

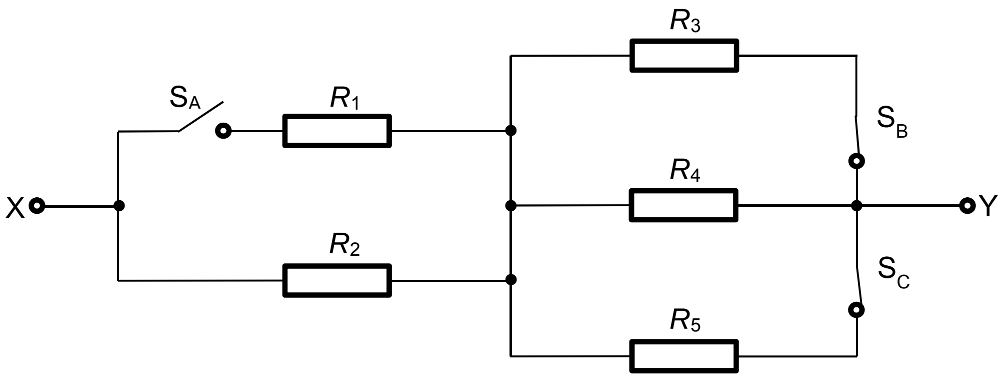

Fig. 3.1

(a) Determine the value of R_{XY}, the resistance between terminals X and Y.

R_{XY} = ... Ω [2]

(b) The network is now connected to a cell of e.m.f. 3.0 V with an internal resistance of 0.40 Ω as shown in Fig. 3.2.

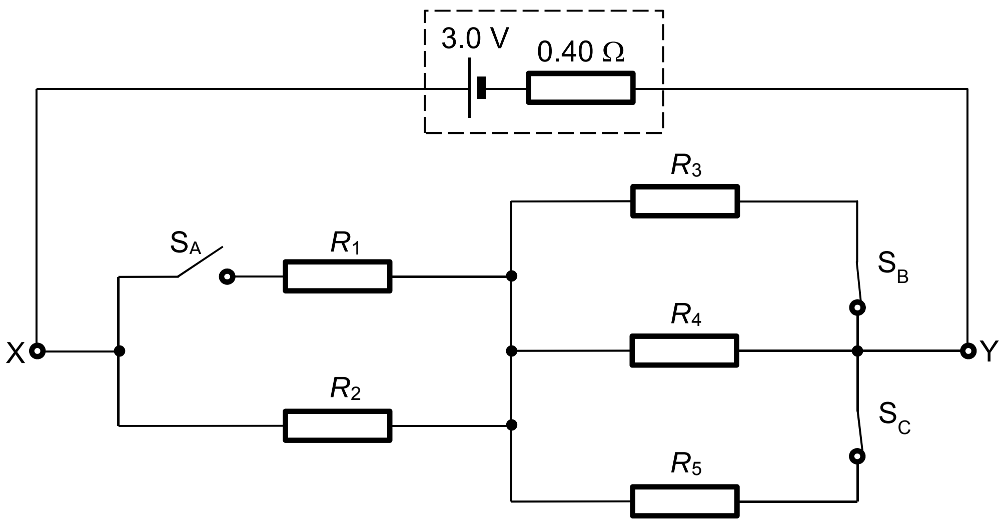

Fig. 3.2

(i) Determine the current supplied by the cell.

current = ... A [2]

(ii) Calculate the power dissipated in R_3.

power = ... W [2]

(c) Ideal diodes have infinite resistance when they are in reverse bias and zero resistance when they are in forward bias. The switches in Fig. 3.2 can be replaced with ideal diodes to obtain the same circuit.

Complete Fig. 3.3 below with the diodes in suitable orientations. [2]

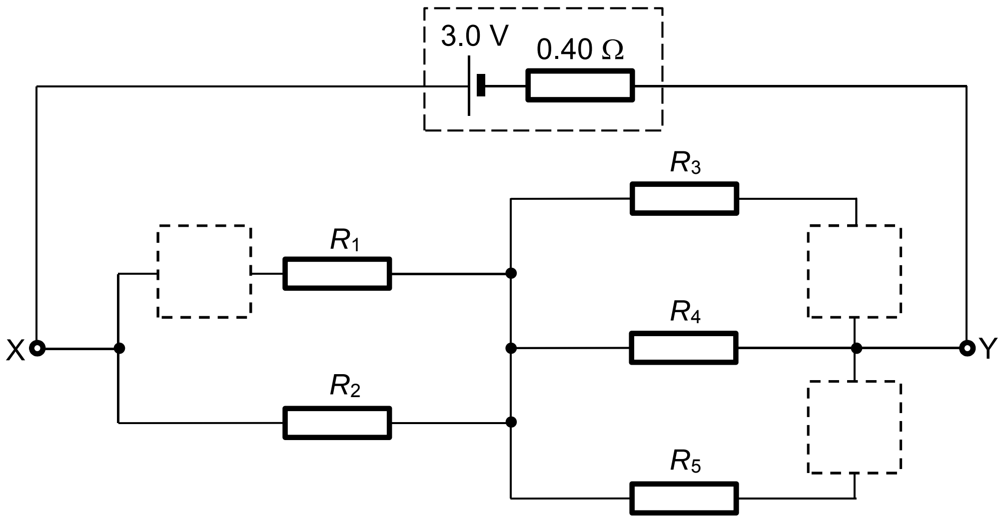

Fig. 3.3

4 **(a)** Distinguish between a line emission spectrum and a line absorption spectrum in terms of their appearance.

....

....

.... [2]

(b) Explain how a line emission spectrum is obtained.

....

....

....

....

....

.... [3]

(c) Explain how a line spectrum can be used to identify the elements in a sample of gas.

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....

....[2]

(d) Some of the energy levels of a particular atom X are shown in Fig. 4.1.

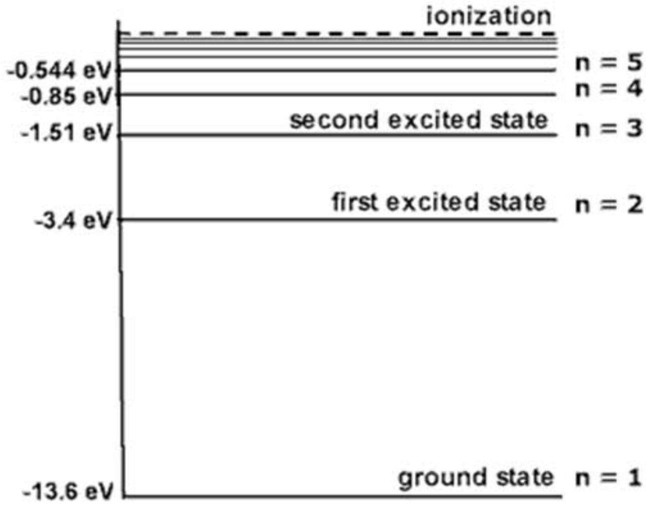

Fig. 4.1

(i) State the ionisation energy of atom X.

.... [1]

(ii) Cool vapour of X at low pressure is bombarded with electrons of kinetic energy 2.00×10^{-18} J. With appropriate calculations, state and explain the transition(s) you would expect to observe.

....

....

....

....

.... [2]

Section B

Answer any **two** questions in the spaces provided.

5 **(a)** An object S of weight 40.0 N is supported by two ropes A and B, as shown in Fig. 5.1.

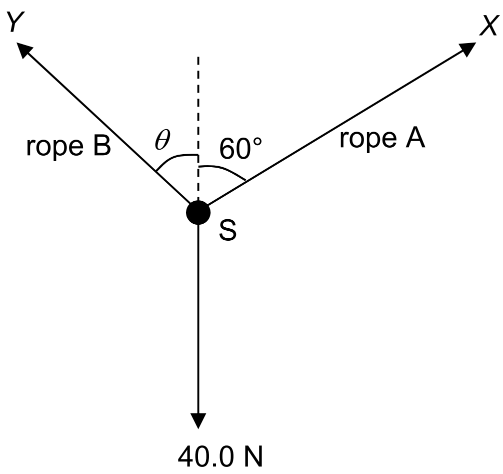

Fig. 5.1

Rope A is at 60° to the vertical and exerts force X on S. Rope B is at an angle θ to the vertical and exerts force Y on S.

The magnitude of force X is varied from 0 to 100 N. Rope A is always kept at 60° to the vertical. The force Y is varied in magnitude and direction to keep S in equilibrium.

(i) Determine the magnitude and direction of force Y for the magnitude of force X equal to

1. zero,

magnitude of Y = ... N

angle θ = ... ° [1]

2. 100 N.

magnitude of Y = ... N

angle θ = ... ° [3]

(ii) By reference to Fig. 5.1, explain why rope B cannot be parallel to the weight of S no matter how large the magnitude of *X*.

....

....

....

.... [2]

(b) Two identical carts, A and B, moved at 10.0 m s^{-1} toward each other. The two carts collided in an inelastic collision where 20% of the kinetic energy was dissipated.

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

....

....

....

.... [2]

(ii) Show that the final speed of cart A is about 8.9 m s^{-1}. [2]

During the collision, the magnitude of the force between the carts varied with time, as shown in Fig. 5.2.

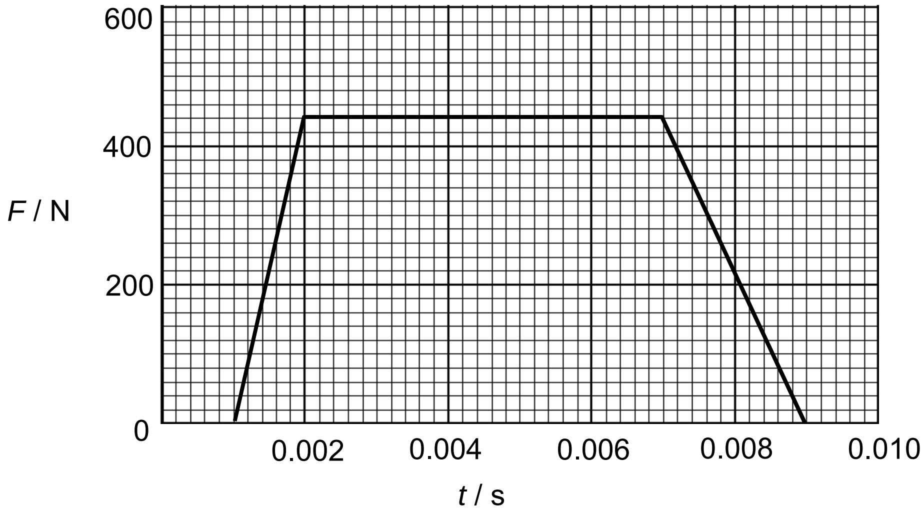

Fig. 5.2

(iii) Calculate the impulse cart B exerts on cart A during the collision. Give the unit with your answer.

impulse = ... unit: ……………. [3]

(iv) Hence calculate the mass of each cart.

mass = ... kg [2]

(v) Fig. 5.3 shows the velocity-time graph for Cart A. Sketch the velocity-time graph for Cart B. (No detailed calculations are necessary.)

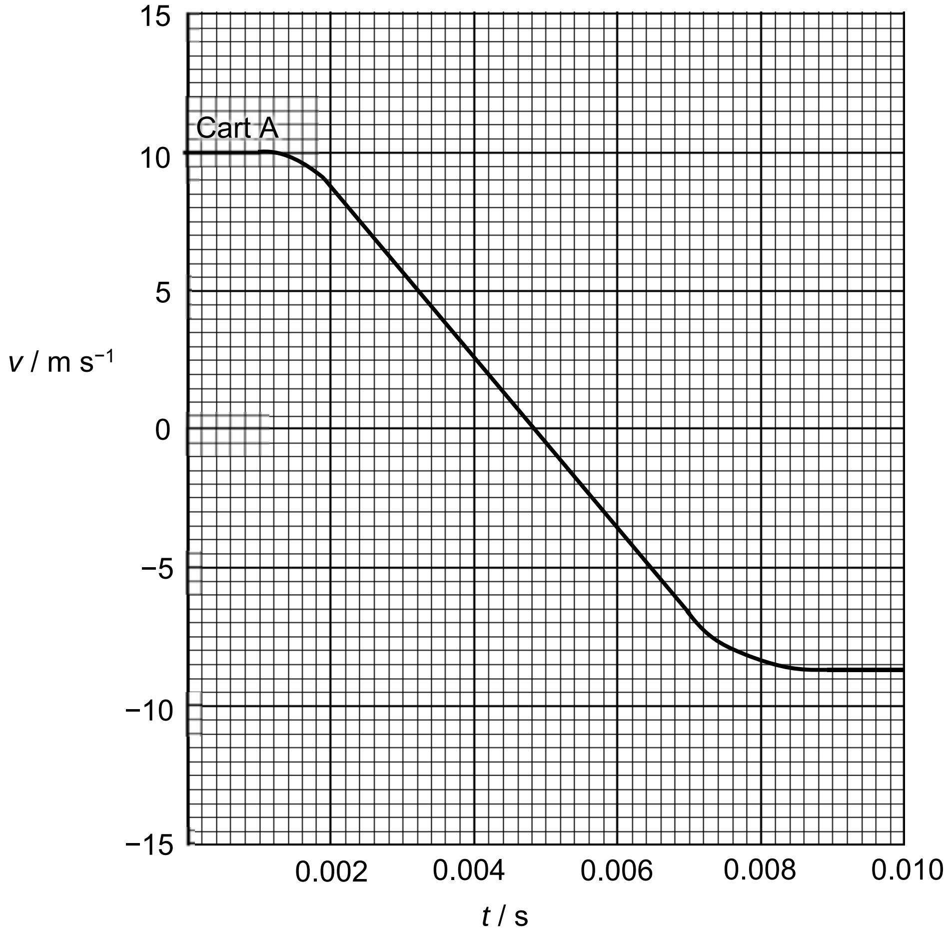

Fig. 5.3

[3]

(vi) Explain how your graph in **(v)** shows an application of Newton's third law.

....

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....

.... [2]

6 **(a)** **(i)** State how a polarised transverse wave differs from an unpolarised transverse wave.

....

....

....

.... [2]

(ii) Suggest how it can be verified that a laser light is plane-polarised.

....

.... [1]

(b) Fig. 6.1 shows the variation with distance of the displacement of the points along a string when a wave propagates along the string.

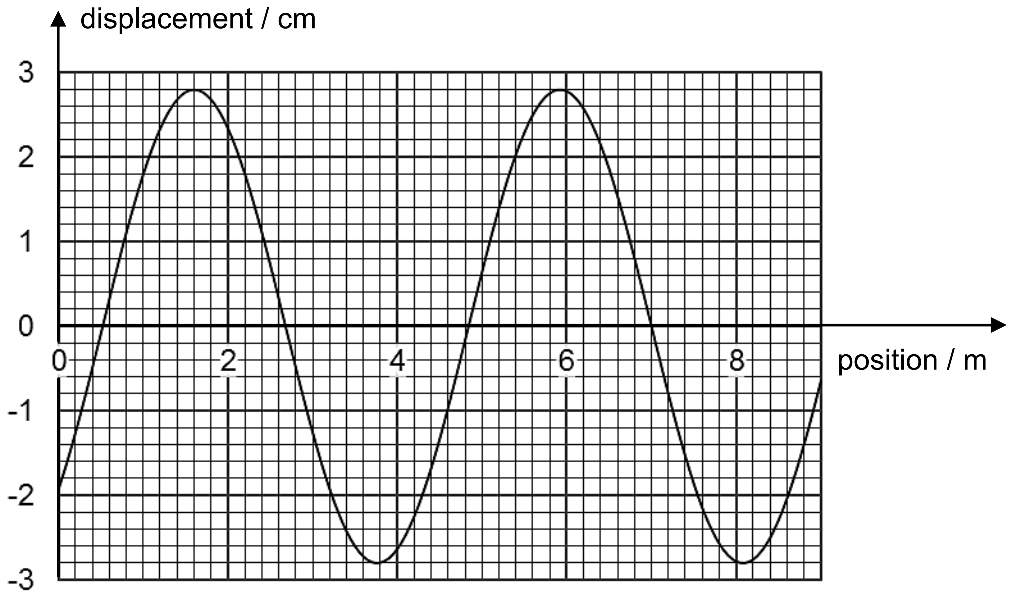

Fig. 6.1

(i) By taking readings from the graph, determine

1. the amplitude of the wave,

amplitude = ... cm [1]

2. the wavelength of the wave

wavelength = ... m [2]

(ii) State and explain the additional information required to determine the speed of the wave along this string.

....

....

....

.... [2]

(c) **(i)** Define the principle of superposition.

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....

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.... [1]

Fig. 6.2 shows a double slit arrangement to demonstrate observable interference of light on the screen.

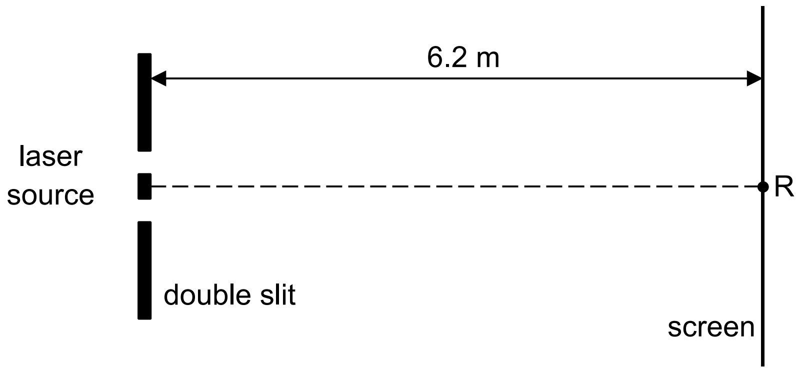

Fig 6.2

(ii) Suggest why a laser source is used.

....

.... [1]

(iii) The separation between the two slits is 0.80 mm. The fringe separation observed on the screen is 5.0 mm. Determine the wavelength of the laser light used.

wavelength = ... m [2]

(iv) On Fig. 6.3, sketch the variation with distance of the intensity of the fringes formed on the screen. (show at least 3 bright fringes) [2]

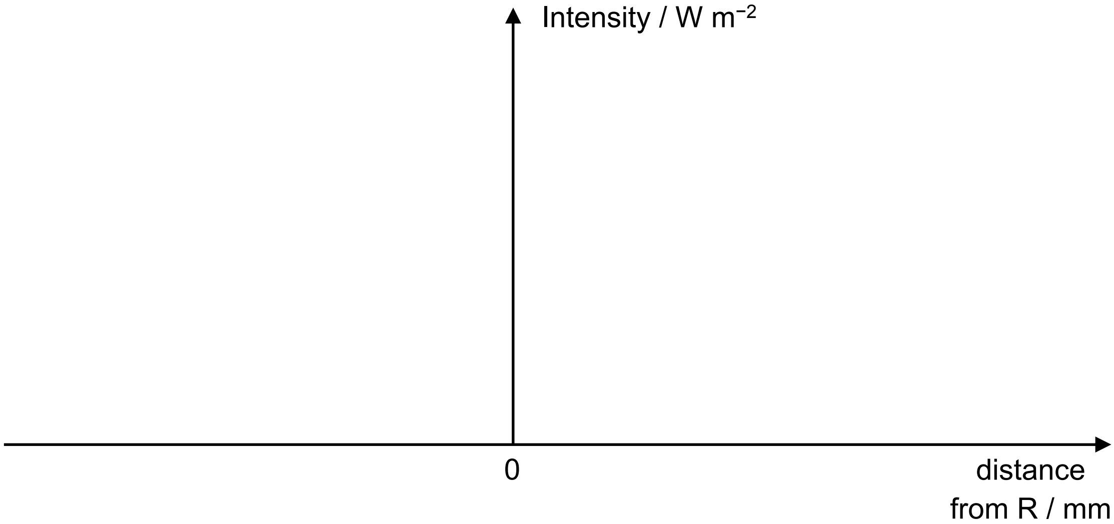

Fig 6.3

The screen is now tilted at an angle as shown in Fig. 6.4.

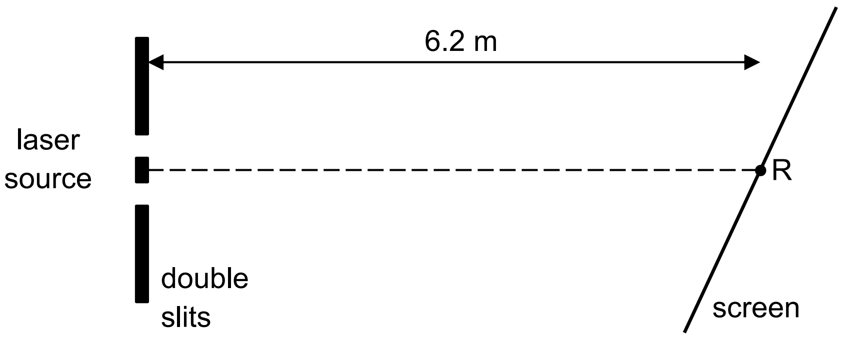

Fig 6.4

(v) Compare the intensities of bright fringes that are formed above and below point R on the screen. Explain your answer.

....

....

....

.... [2]

(vi) Compare the fringe separation of the bright fringes that are formed above and below point R on the screen. Explain your answer.

....

....

....

.... [2]

(d) A standing sound wave is set up within a pipe with both ends open. Two nodes are observed within the pipe. The pipe is 1.5 m long. The speed of sound is 330 m s^{-1}.

Sketch the profile of the standing wave formed in the pipe on Fig. 6.5 and calculate the frequency of the sound.

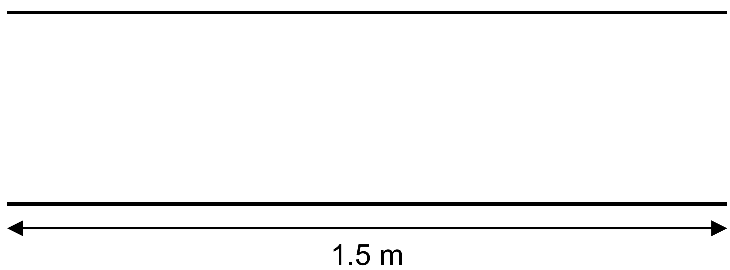

Fig. 6.5

frequency = ... Hz [2]

7 **(a)** **(i)** Define *resistance* of an electrical device.

....

.... [1]

(ii) Define the ohm.

....

.... [1]

(b) A heating element consists of a straight wire of length 4.5 m and has a cross sectional area of 6.8×10^{-8} m^2. Its resistivity is 1.1×10^{-6} Ω m. Show that the resistance of the heating element is 73 Ω. [1]

(c) A heater consists of three such heating elements (R_1, R_2 and R_3) that are connected to a 240 V supply as shown in Fig. 7.1.

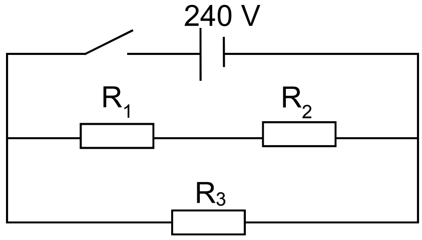

Fig. 7.1

(i) Calculate the number of electrons passing through R_3 when the switch is closed for 10 minutes.

number of electrons =.. [2]

(ii) Calculate the power output of R_3.

power output = ... W [2]

(iii) Draw a new circuit to show how the three heating elements can be connected to the 240 V power supply so as to maximise power output. Explain your answer.

....

....

.... [2]

(iv) Each 4.5 m wire is wound as a coil as shown in Fig. 7.2.

Fig. 7.2

Each turn of the coil may be considered to act as a current carrying long straight wire. State and explain whether the turns of the wire will attract or repel one another.

....

....

....

.... [2]

(d) **(i)** Fig. 7.3 shows the path of a proton within a region of uniform electric field between two horizontal plates. Draw the electric field lines between the two plates. [1]

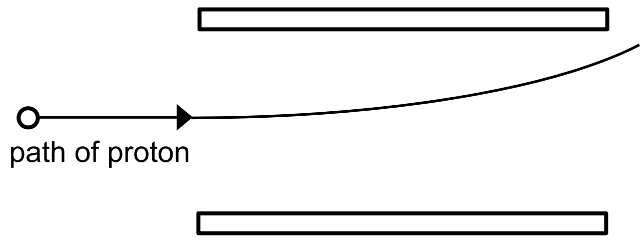

Fig. 7.3

(ii) The proton enters the electric field horizontally at a speed of 2.8×10^{5} m s^{-1} and emerges from the field after 2.4×10^{-13} s. It experiences a constant electric force of 6.7×10^{-10} N within the electric field.

Calculate the speed of the proton as it emerges from the field.

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

(e) **(i)** In another experiment, a charged particle enters into a region of uniform magnetic field at point X. Fig. 7.4 shows the path XYZ of the charged particle within the field.

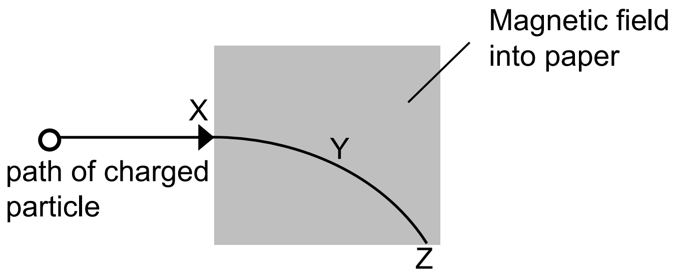

Fig. 7.4

1. State whether the charged particle is positively or negatively charged.

.... [1]

2. Draw a labelled arrow on Fig. 7.4 indicating the direction of the magnetic force F_B acting on the particle at position Y of the path. [1]

(ii) The charged particle emerges from the magnetic field without a change in speed. Using energy considerations, explain why there is no change in speed when the particle is in the field.

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.... [2]

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