MERIDIAN JUNIOR COLLEGE
Preliminary Examination
Higher 1

H1 Physics

8866/2

Paper 2

23 September 2014

2 hours

Candidate Name ______________________________

Class	Reg Number

READ THESE INSTRUCTIONS FIRST

This booklet contains Sections A and B of the Preliminary Examination Paper 2.

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

<u>Section A</u>
Answer **all** questions.

<u>Section B</u>
Answer any **two** questions.

You are advised to spend about one hour on each section. Write your answers on this question booklet in the blanks provided.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question. Marks will be deducted if units are not stated where necessary or if answers are not quoted to the appropriate number of significant figures.

All working for numerical answers must be shown. You are reminded of the need for good English and clear presentation of your answers.

Examiner's Use	
Section A	
Q1	**/ 6**
Q2	**/ 12**
Q3	**/ 10**
Q4	**/ 12**
Section B	
Circle the questions you have attempted	
Q5	**/20**
Q6	**/20**
Q7	**/20**
Deductions	
Total	**/80**

DATA AND FORMULAE

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 this section.

1 A small wooden block is projected up a frictionless ramp with an initial speed of 4.0 m s^{-1} as shown in Fig. 1 below. The ramp is inclined at 20° and the block was projected from a point 6.0 m from the bottom of the ramp.

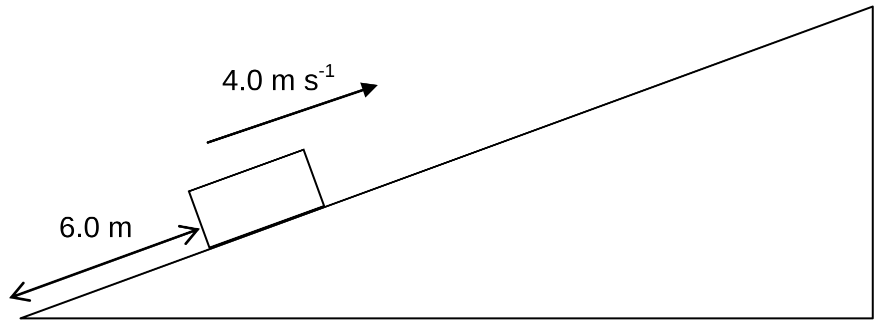


Fig. 1

(a) Calculate the distance moved by the block before it comes to instantaneous rest.

distance moved = ... m [2]

(b) Determine the time taken for the block to reach the bottom of the ramp from the time it was projected.

time = ... s [2]

(c) Sketch the displacement time graph of the entire motion from the time the block was projected to the time it reaches the bottom of the ramp.

[2]

2 Five identical resistors along with a NTC thermistor, a filament lamp and a voltmeter are connected to a e.m.f. source of 15.0 V as shown below in Fig. 2.1. The e.m.f source has negligible internal resistance.

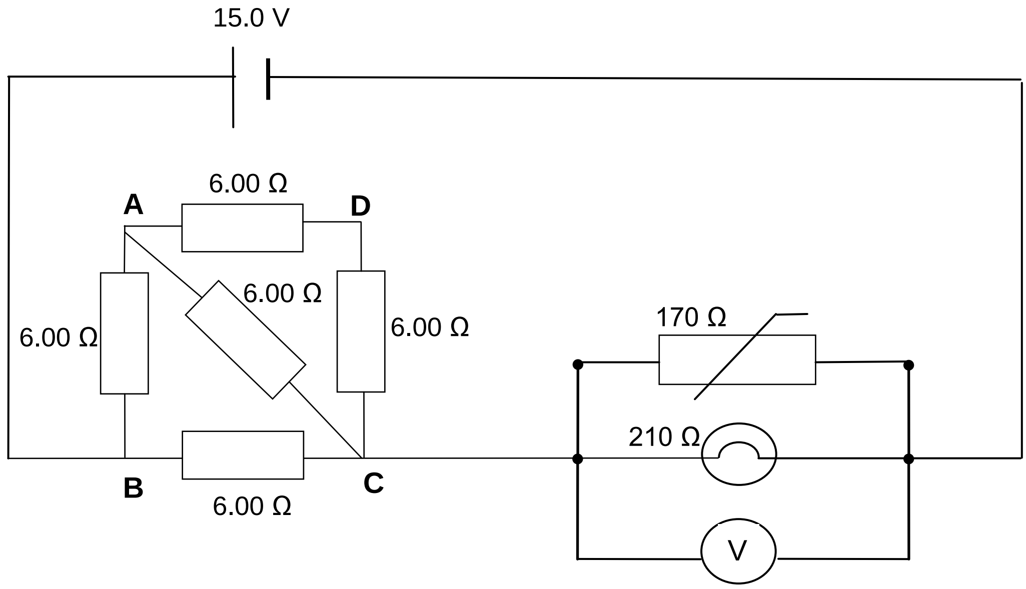


Fig. 2.1

(a) **(i)** Determine the effective resistance of the network of resistors between points **B** and **C**.

effective resistance = ... Ω [3]

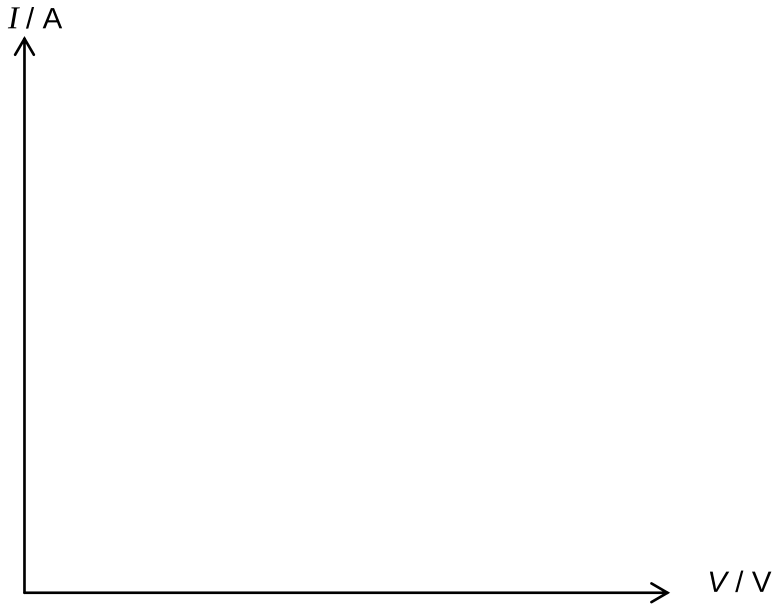
(ii) Hence, determine the voltmeter reading.

voltmeter reading = ... V [2]

(iii) Determine the power dissipated in the filament lamp

power = ...W [1]

(b) **(i)** On the axes below, sketch and label the *I*-*V* characteristics of the thermistor and the filament lamp. Explain how the resistance of each of the devices can be obtained from their respective graphs.



....

.... [3]

(ii) Explain the *I*-*V* characteristic of the thermistor and how it changes with increasing temperature.

....

....

....

....

....

....

.... [3]

3 **(a)** A long vertical rigid conductor passes through a sheet of cardboard that is held horizontal. A small compass is placed at the point **P** and the needle points in the direction shown in Fig. 3.1(a) and Fig. 3.1(b).

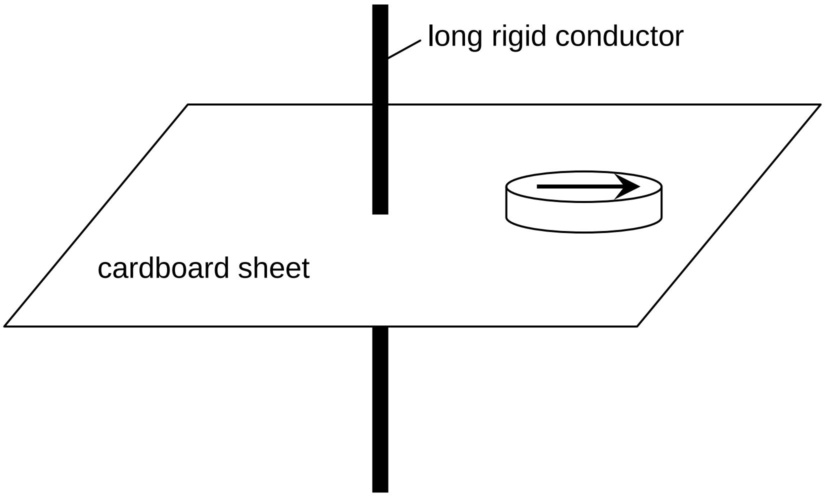


Fig. 3.1(a) Side view

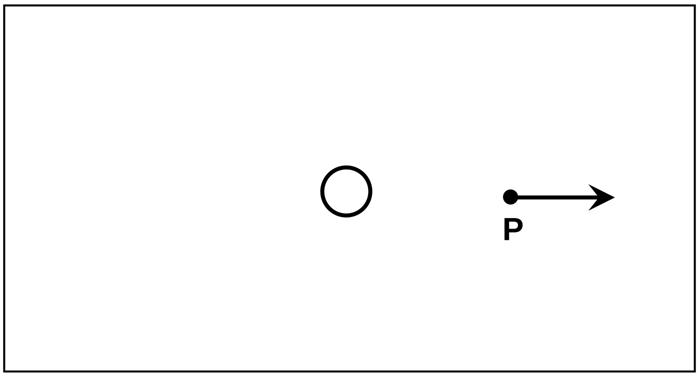


Fig. 3.1(b) Top view

A current is then passed through the conductor and the compass needle now points in a direction that makes an angle of 30° to its original direction as shown in Fig. 3.2.

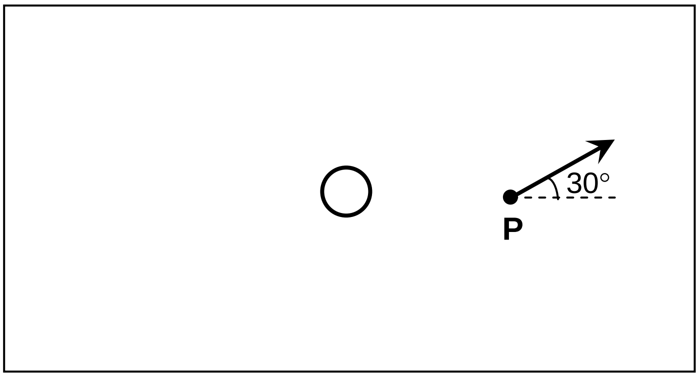


Fig. 3.2 Top view

(i) With reference to Fig. 3.2, state the direction of the current in the conductor. Explain your answer.

....

....

....

.... [3]

(ii) The compass is 2.0 cm from the wire and the current I in the wire is 4.0 A. Calculate the magnetic flux density before the current is turned on.

The magnetic flux density *B* at a distance *d* from a wire is given by $B = \frac{\mu_o I}{2\pi d}$

where permeability of free space, $\mu_o = 4\pi \times 10^{-7}$ H m^{-1}.

magnetic flux density = ... T [2]

(b) The long rigid conductor is now placed horizontally between the poles of a magnet and the current flowing through it is increased until the wire just lift off the ground as shown in Fig. 3.3. The mass of the conductor is 0.42 kg and its length is 5.0 m. The magnitude of the magnetic field strength is 0.30 T and the width of the magnet is 0.80 m.

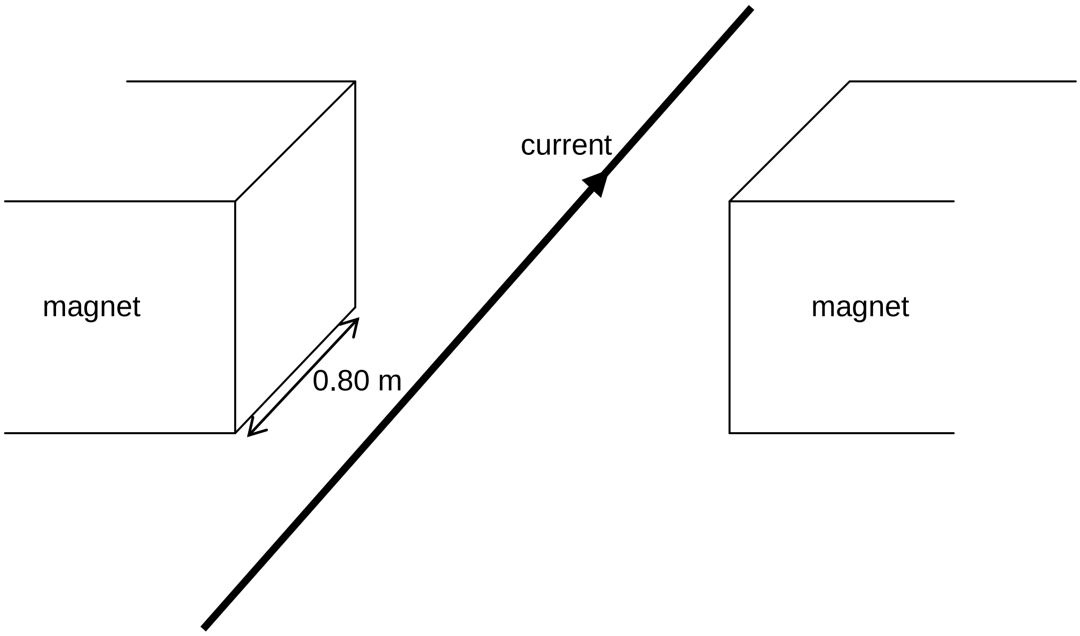


Fig. 3.3

(i) On Fig. 3.3, label the letter 'N' the north pole of the magnet. Explain your choice.

....

....

....

....

.... [2]

(ii) Determine the current in the wire.

current = …………………. A [1]

(iii) Fig. 3.4 shows two points **X** and **Y** that are at equal distances from the current carrying wire in **(b)**.

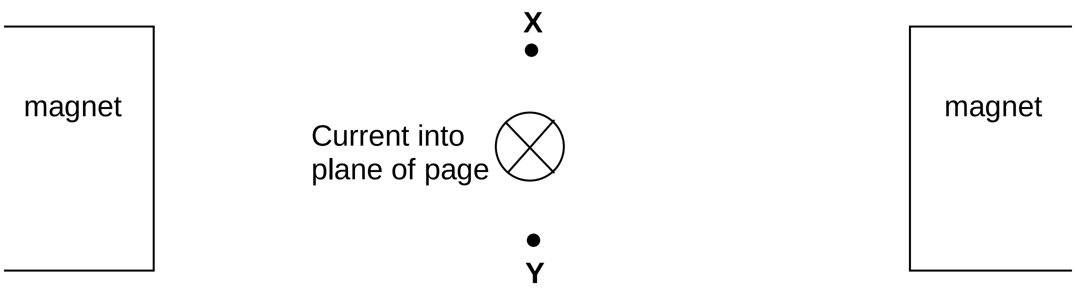


Fig. 3.4

State and explain which point (**X** or **Y**) has a greater magnetic flux density.

....

....

....

.... [2]

4 Some experimental data points for the variation with length l of the tensile force F on a bungee jump cord are plotted in Fig. 4.1.

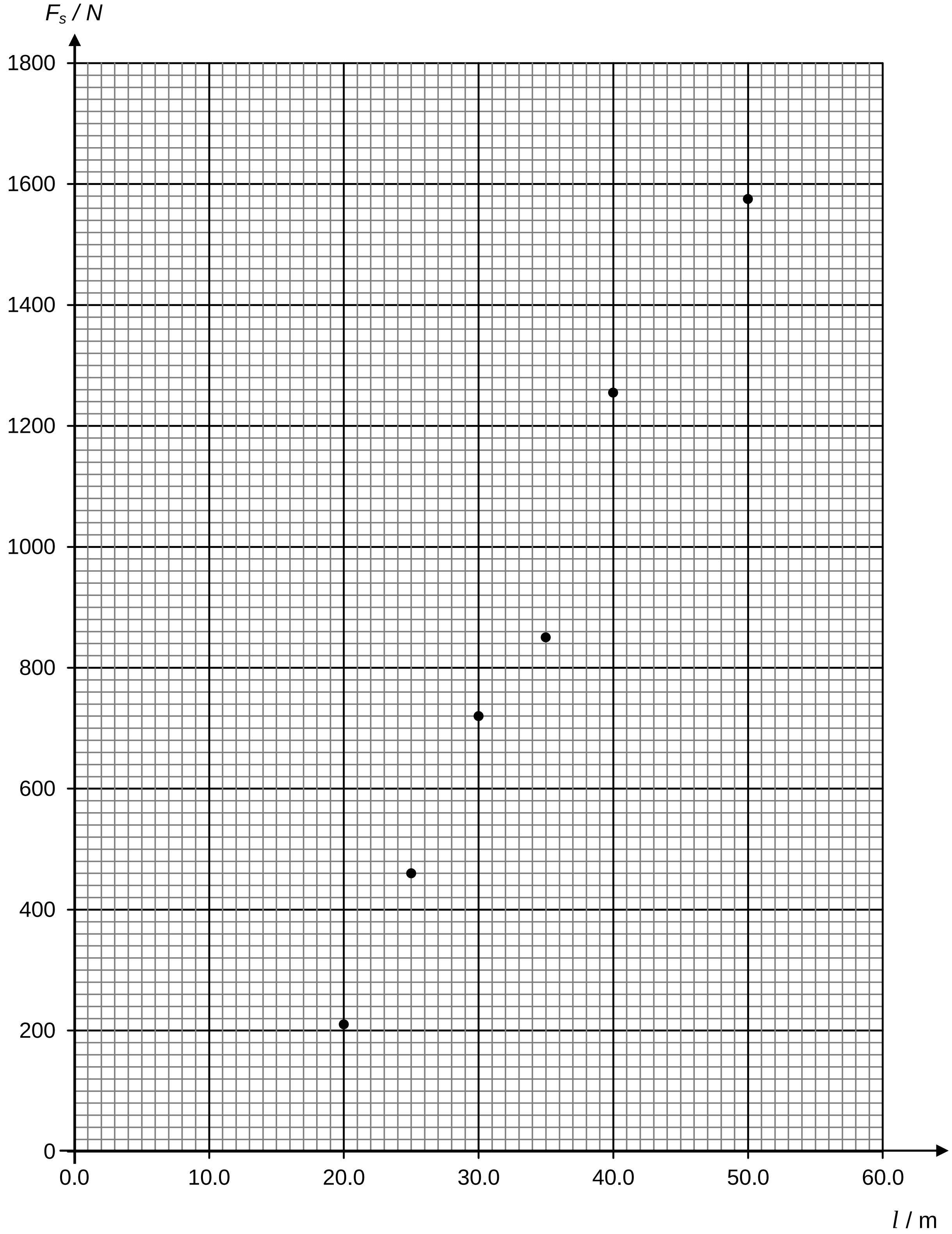


Fig. 4.1

(a) **(i)** On Fig. 4.1, draw the line of best fit for all the data points. [1]

(ii) Determine the unstretched length of the cord.

length = …………………… m [1]

(iii) Calculate the spring constant of the cord.

spring constant = …………………… N m^{-1} [2]

(b) Instead of purchasing cords of various spring constants, a bungee jump operator connects multiple identical cords in parallel to form cables of different effective spring constants for jumpers of different masses.

For one particular cable, 3 identical cords are connected in parallel.

(i) Calculate the effective spring constant of the cable.

effective spring constant = …………………… N m^{-1} [1]

(ii) Draw a second line on Fig. 4.1 to represent the variation with length *l* of the tensile force *F* of the cable. Label your graph as **(ii)**. [1]

(iii) For a jumper of mass 130 kg, determine the distance from the bungee jump platform to the lowest point of his motion.

displacement = ……………………. m [3]

(iv) Draw a suitable horizontal line on Fig. 4.1 to determine the length of the cable when the kinetic energy of the jumper is maximum. Label the point as *L*. [1]

(v) Describe the energy transformations from the point of maximum kinetic energy to the lowest point of motion. Ignore all resistive forces.

....

....

....

....

.... [2]

Section B

Answer **two** questions in this section.

5 **(a)** The Young Modulus E of a material is given by the equation

$$E = \frac{FL}{Ae}$$

where F = force exerted on the material,
L = original length of the material,
A = cross-sectional area of the material,
e = extension of the material.

In performing an experiment to determine the Young Modulus of steel, Alex made the following measurements of a cylindrical steel wire:

diameter of wire = (1.05 ± 0.04) mm
length of wire = (2.28 ± 0.01) m

Alex measured the extension of the wire as the force was varied. He then plotted a graph of the force against the extension. The slope of the graph, which gives the value of $\left(\frac{F}{e}\right)$, was found to be $(93 \pm 5) \times 10^3$ N m^{-1}.

(i) Express E, together with its associated uncertainty, to an appropriate number of significant figures.

E = ... N m^{-2} [3]

(ii) State and explain which quantity contributes most to the uncertainty of E.

....

.... [2]

(b) The diagram in Fig. 5.1 shows two similar masses *M* suspended in equilibrium by inextensible strings.

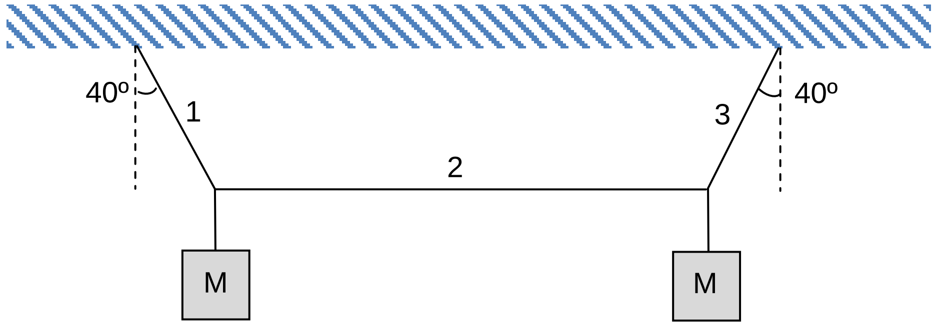


Fig. 5.1

(i) Given that the tension in string 2 is 45 N, determine the mass of *M*.

M = ... kg [3]

(ii) Explain with appropriate calculations whether strings with a breaking strength 65 N could be used for the set up in Fig. 5.1.

....

.... [2]

(c) A tennis ball of mass 57.0 g is released from rest and it collides with a rebounded rubber ball of mass 780 g. The collision between the rubber ball and the tennis ball is assumed to be a *head-on elastic* collision. The speeds of both balls are 6.50 m s^{-1} and 5.20 m s^{-1} when they collide as shown in Fig. 5.2. After the collision, the rubber ball and the tennis ball move with velocities v_r and v_t respectively as shown in Fig. 5.3.

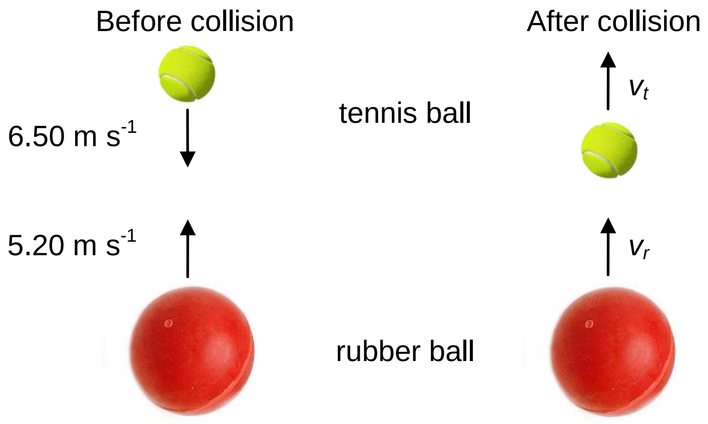


Fig. 5.2 **Fig. 5.3**

(i) Explain what is meant by a *head-on elastic* collision.

....

....

....

.... [2]

(ii) Taking upwards as positive,

1. write an equation in terms of v_r and v_t to represent the conservation of momentum in this collision;

[1]

2. write an equation, in terms of v_r and v_t, relating the relative speeds of approach and separation;

[1]

3. hence, or otherwise, find the values of v_r and v_t.

v_r = ... m s^{-1}

v_t = ... m s^{-1} [2]

(iii) Fig. 5.4 shows the variation with time *t* of the force *F* experienced by the tennis ball during the collision. The duration of the collision is 40 ms.

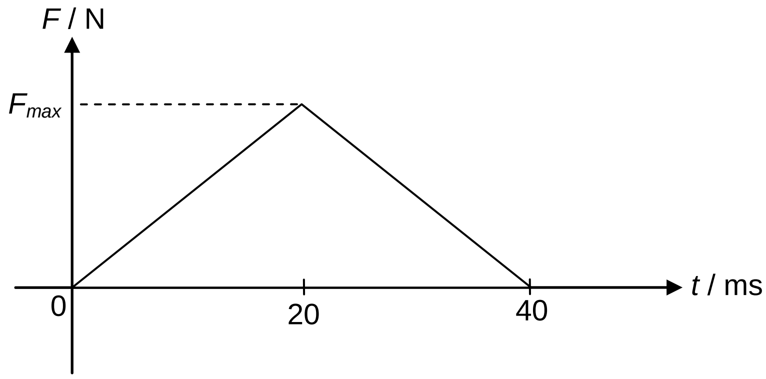


Fig. 5.4

Using your results from **(c)(ii)**, calculate the change in momentum of the tennis ball.

change in momentum = ... N s [2]

(iv) Hence, determine the maximum force, F_{max}, experienced by the tennis ball.

F_{max} = ... N [2]

6 **(a)** **(i)** Explain what is meant by

1. *diffraction*;

....

....

.... [1]

2. *interference*; and

....

....

.... [1]

3. *coherence*.

....

....

.... [1]

(ii) State two conditions for observable interference of two waves.

....

....

....

.... [2]

(b) To help guide large ships berth properly into docks, an engineer proposed using interference of electromagnetic (EM) waves. The proposal suggests installing two EM wave emitters P and Q positioned 95 m apart at the edges of the dock gates. The two emitters can be taken to be point sources and they emit EM waves of frequency f_1 in phase.

The ship can be guided by searching for the strong signal radiated along the lines of constructive interference, also known as anti-nodal lines. For safety, it is important for the ship to ensure that it is sailing along the centre-line of the gates, as such the ship needs to "lock on" to the central anti-nodal line.

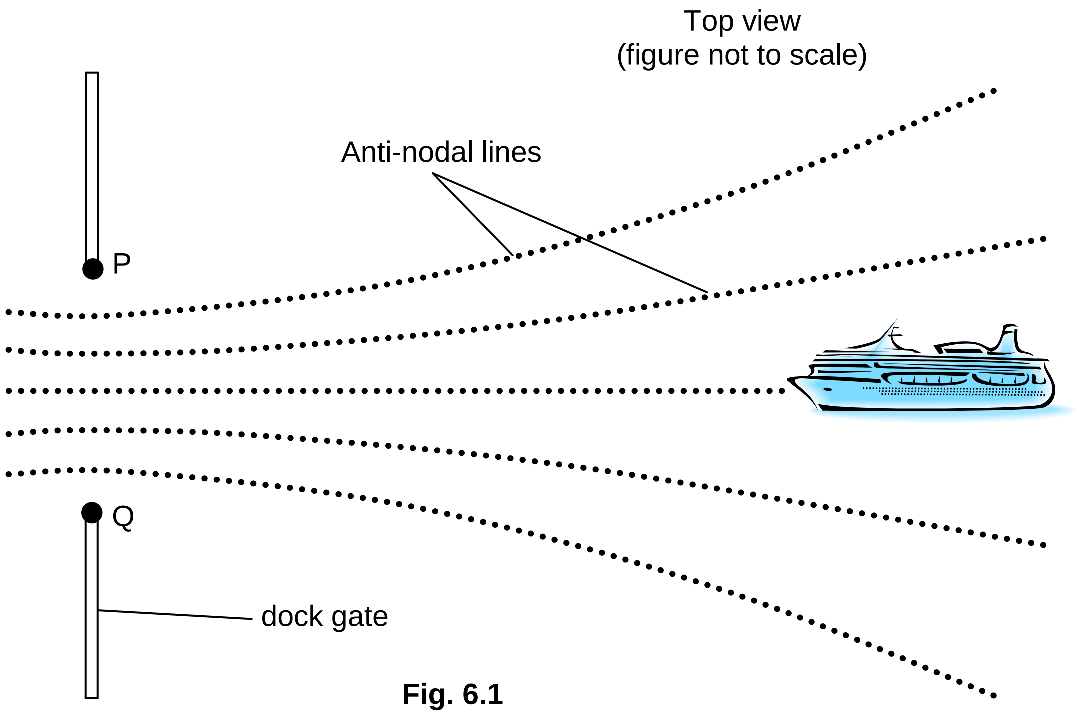


Fig. 6.1

(i) Explain why the centre-line will always be an anti-nodal line regardless of the frequency of the EM waves used.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) State and explain which type of EM waves is suitable for such a system.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(iii) Assuming that the ship is sailing along the centre-line, state and explain how the intensity of the resultant signal varies as it approaches the dock gates.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………… [2]

(c) One particular large cargo ship strays off the centre-line as shown in Fig. 6.2.

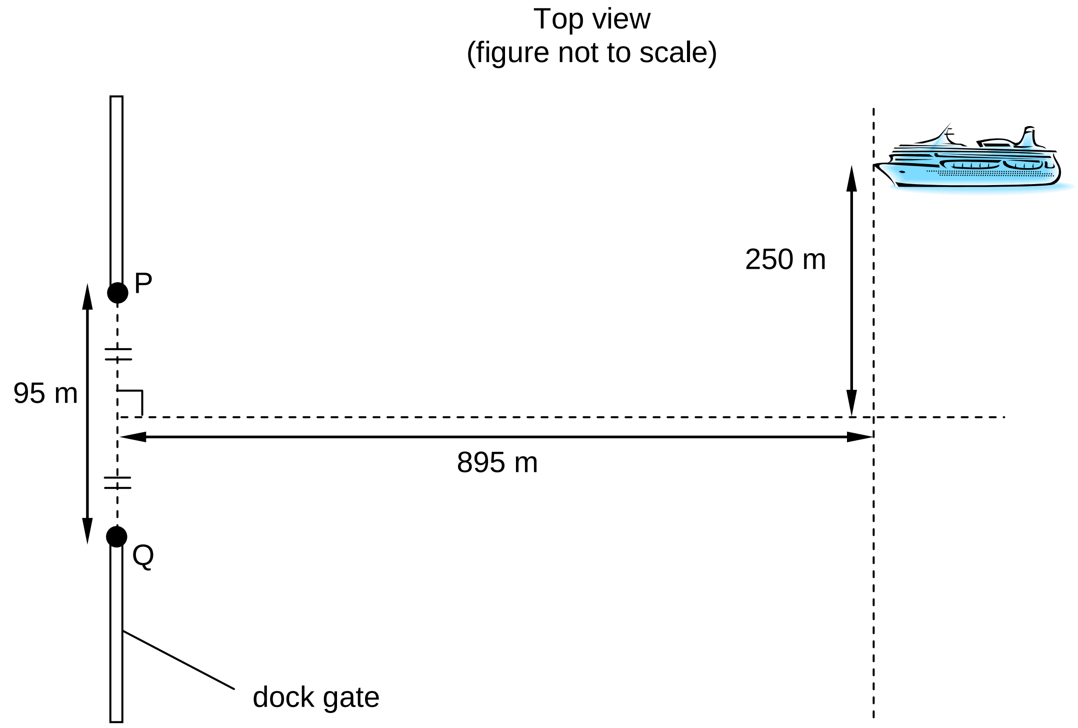


Fig. 6.2

Explain quantitatively whether the ship is on an anti-nodal line, given that f_1 is 23.5 MHz.

………………………………………………………………………………………………

……………………………………………………………………………………… [3]

(d) As an additional precaution to ensure that the ship "locks on" to the central anti-nodal line, the emitters can simultaneously emit another EM wave of a different frequency f_2.

(i) Explain how this precaution helps to prevent the ship from "locking on" to the wrong anti-nodal line.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(ii) Discuss why this additional precaution may still not be fool proof.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

……………………………………………………………………………………… [1]

(e) In another guiding system proposed by another engineer, light guides are lined at the edge of the dock gates to help guide the ship's captain. The minimum power of light that can be detected by the human eye of area 0.53 cm^2 is about 2.4×10^{-11} W.

(i) Show that the minimum intensity of light that is detectable by the human eye is 4.5×10^{-7} W m^{-2}. [1]

(ii) If a ship is 15 km away from the dock gates, determine the required power of one light guide such that it is observable by the ship's captain. Assume that the light guide is a point source and that there are no energy losses.

power = ……………………… W [2]

(f) Suggest one advantage and one disadvantage of the wave-interference system over the light guide system in guiding ships to berth safely.

Advantage:

……………………………………………………………………………………………………

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

Disadvantage:

……………………………………………………………………………………………………

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

7 (a) Two beams of monochromatic light have similar intensities. The light in one beam has wavelength of 400 nm and the light in the other beam has wavelength 700 nm.

The two beams are incident separately on three different metal surfaces. The work function of each of these surfaces is shown in Fig. 7.1.

Metal	work function / eV
magnesium	3.68
potassium	2.26
caesium	1.88

Fig. 7.1

(i) Explain what is meant by the *work function* of the surface.

....

....

.... [2]

(ii) Using appropriate calculation, explain which combination/s, if any, of monochromatic light and metal surface would give rise to photo-electric emission.

....

....

.... [4]

(iii) A student argued that the intensities of the two beams of light must be the same to compare the maximum kinetic energy of the emitted electrons. Explain the validity of his claim.

....

....

....

.... [2]

(b) A parallel beam of electrons, all travelling at the same speed, is incident normally on a carbon film. The scattering of the electrons by the film is observed on a fluorescent screen, as shown in Fig. 7.2.

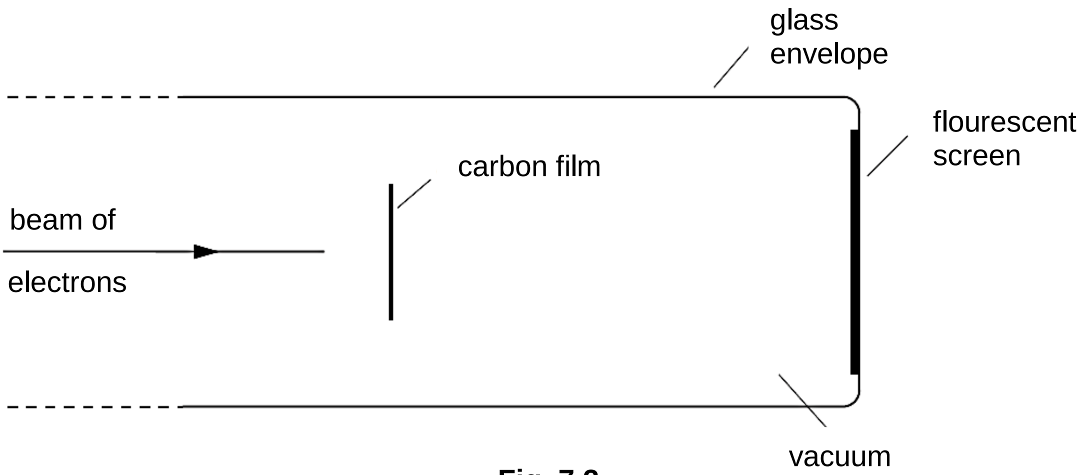


Fig. 7.2

(i) By considering the particulate nature of electrons, predict what would be seen on the screen.

....

.... [1]

(ii) However in this experiment, the particulate nature of the electrons was not observed. Describe briefly the pattern that is actually observed on the screen. You may draw a sketch if you wish.

....

.... [1]

(iii) The electrons are travelling at a constant speed of 8.5×10^6 m s^{-1}. Determine the de Broglie wavelength of the electrons.

wavelength of electrons = …………………………. m [2]

(c) In a fluorescent lamp, electrons move at high speed through mercury vapour in a glass tube. When the electrons collide with mercury atoms, some of the atoms are put into excited states.

(i) The electrical power input to the lamp is 25 W, and 52% of the energy supplied is released as photons of wavelength 255 nm.

1. Calculate the energy of a photon of wavelength 255 nm.

energy of photon = …………………………. J [1]

2. Calculate the number of photons of this wavelength emitted per second.

number of photons emitted per second = …………………………. s^{-1} [3]

(ii) A simplified energy level diagram for a mercury atom is shown in Fig. 7.3. During the de-excitation of atoms, photons of wavelength 255 nm are emitted.

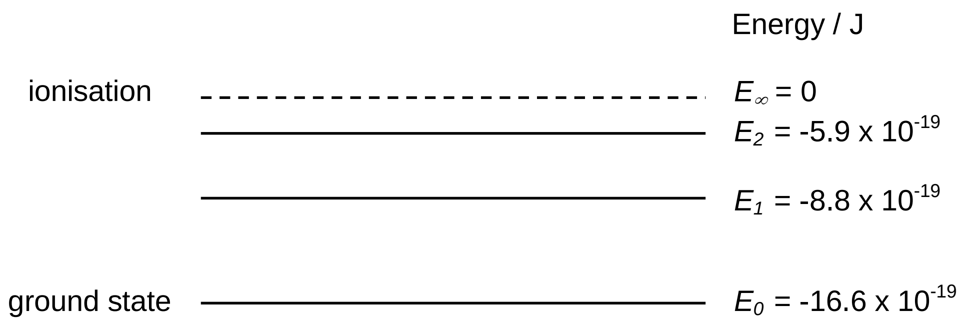


Fig 7.3

Draw an arrow on Fig. 7.3 to show the transition that resulted in the emission of photon of wavelength 255 nm. [1]

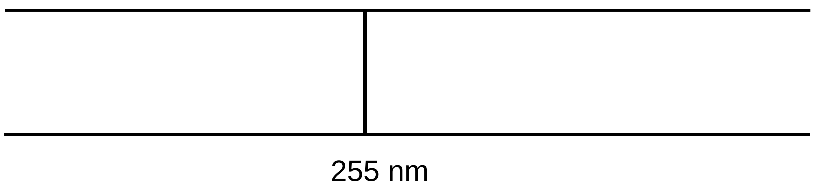
(iii) These photons strike a special coating on the inner surface of the glass tube, making it emit various wavelengths of light. Suggest why photons of wavelength 255 nm cannot themselves be used to provide illumination.

…..

…..

.... [1]

(iv) Sketch and label the remaining mercury emission line spectrum (assuming that emission only occur at most two levels above the ground state and emission line corresponds to wavelength 255 nm has been indicated).



[2]

End of Paper