OCR
RECOGNISING ACHIEVEMENT

ADVANCED SUBSIDIARY GCE

PHYSICS A

G482

Electrons, Waves and Photons

Candidates answer on the question paper.

OCR Supplied Materials:
- Data, Formulae and Relationships Booklet

Other Materials Required:
- Electronic calculator

Monday 6 June 2011
Afternoon

Duration: 1 hour 45 minutes

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Answer **all** the questions.
- Do **not** write in the bar codes.

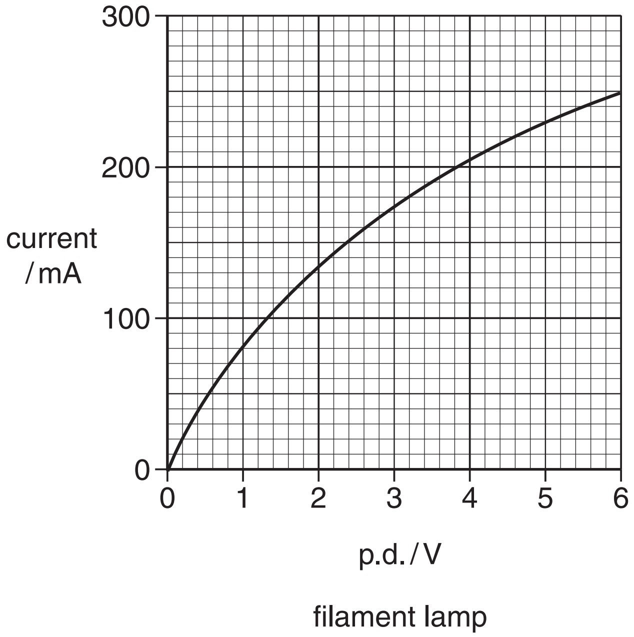
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.
  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

Turn over

Answer **all** the questions.

1 Two 6.0V torches produce similar light intensities. The light source of one is a single filament lamp and of the other is a combination of four light-emitting diodes (LEDs). Fig. 1.1 shows the I-V characteristics of the filament lamp and **one** LED.



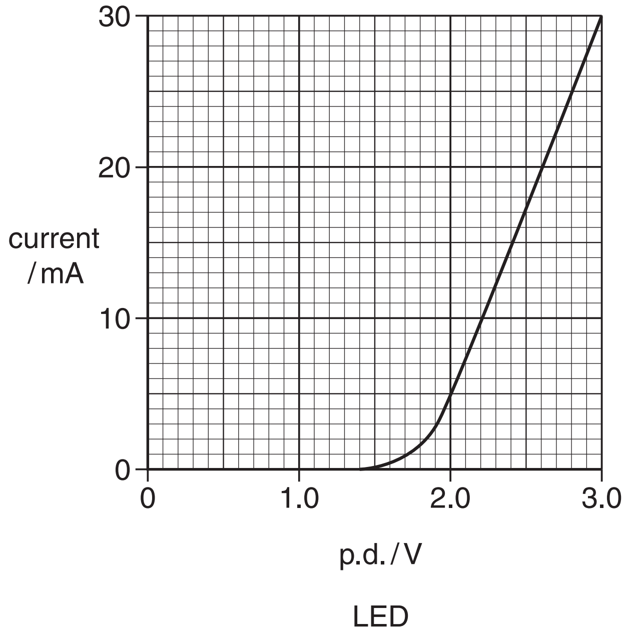


Fig. 1.1

(a) **(i)** Describe how the resistance of the filament lamp at 6.0V can be determined from its I-V characteristic.

....

.... **[2]**

(ii) State how the I-V characteristics show that the filament lamp and the LED do not obey Ohm's law.

....

.... **[1]**

(b) When at normal brightness the current in the filament lamp is 0.25A at a p.d. of 6.0V.

(i) Calculate the charge Q passing through the filament each second.

Q = ... C **[1]**

(ii) Calculate the energy drawn from the battery each second.

energy = ... J **[1]**

(iii) The battery is able to keep the lamp lit for 4 hours. Estimate the energy stored in the battery.

energy stored = ... J **[2]**

(c) The LEDs in the LED torch are connected in pairs across the 6.0 V battery and switch so that the potential difference across each of the four LEDs is 3.0 V.

(i) Define the term *potential difference*.

....

.... **[2]**

(ii) Use Fig. 1.1 to determine the current through each LED.

current = ... mA **[1]**

(iii) Show that the power drawn from the battery in the LED torch is 0.36 W.

[2]

(iv) Sketch a circuit diagram showing how the battery, the four LEDs and the switch are connected in the torch.

[3]

(d) Suggest one advantage of using LEDs rather than a filament lamp in a torch.

....

.... **[1]**

[Total: 16]

2 This question is about possible heating circuits used to demist the rear window of a car. The heater is made of 8 thin strips of a metal conductor fused onto the glass surface. Fig. 2.1 shows the 8 strips connected in parallel to the car battery of e.m.f. E and internal resistance r.

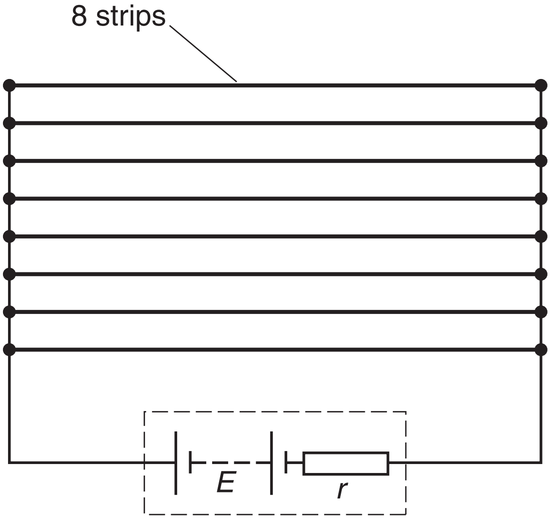


Fig. 2.1

(a) The potential difference across each strip is 12 V when a current of 2.0 A passes through it.

(i) Calculate the resistance r_p of one strip of the heater.

r_p = ... Ω **[1]**

(ii) Calculate the total resistance R_p of the heater.

R_p = ... Ω **[3]**

(iii) Show that the power P dissipated by the heater is about 200 W.

[2]

(b) Each strip is 0.90 m long, 2.4×10^{-4} m thick and 2.0×10^{-3} m wide.

Calculate the resistivity ρ of the metal of the strip. Give the unit with your answer.

ρ = ...unit .... **[4]**

(c) An alternative way of making the heater is to connect eight metal strips in **series.** The heater is to dissipate the same power as the parallel combination of **(a)** when the p.d. across it is 12 V.

(i) Explain why the total resistance of the series heater must equal R_p calculated in **(a)(ii)**.

....

.... **[1]**

(ii) Calculate the resistance r_s of one strip of this series heater.

r_s = ... Ω **[1]**

(iii) Suggest, with a reason, whether you would choose the series or parallel circuit arrangement of the strips for a demister heater.

....

.... **[1]**

(d) Fig. 2.2 is a graph showing how the potential difference across the terminals of the battery varies with the current drawn from it.

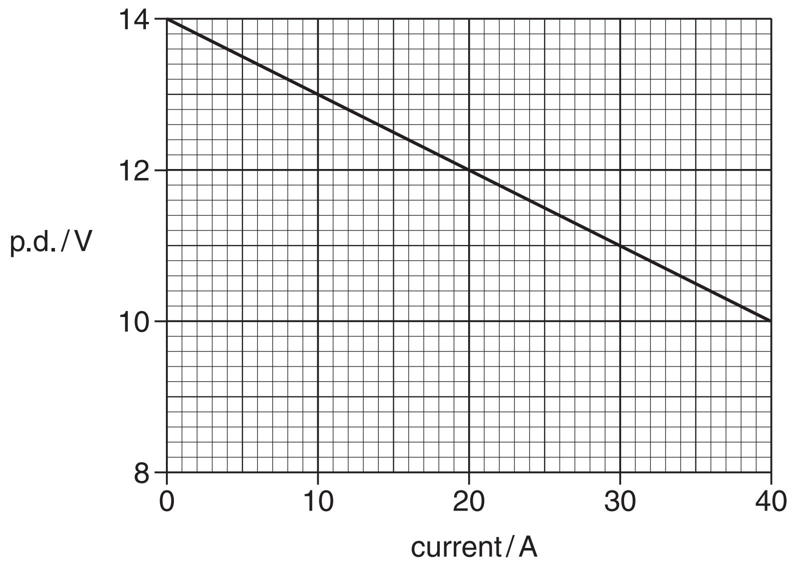


Fig. 2.2

(i) From the graph find the e.m.f. E of the battery.

E = ... V **[1]**

(ii) Use data from the graph to calculate the internal resistance r of the battery.

r = ... Ω **[3]**

[Total: 17]

3 This question is about the use of a light-dependent resistor (LDR) as a light sensor in a potential divider circuit. Fig. 3.1 shows how the resistance of a particular LDR varies with light intensity.

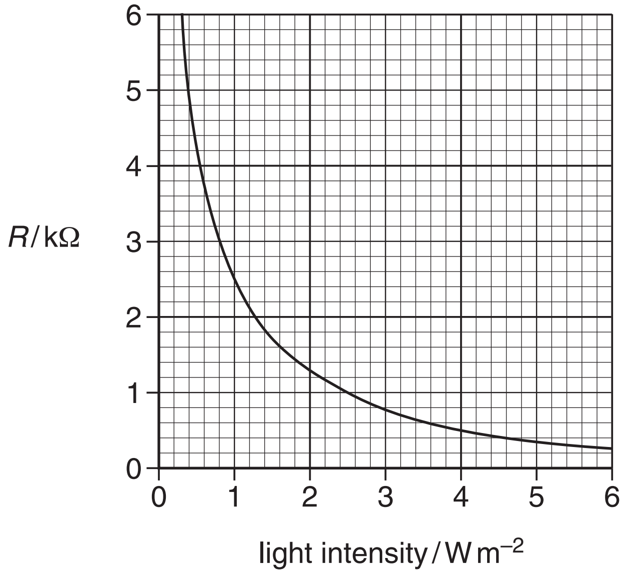


Fig. 3.1

(a) Explain the term *intensity*.

....

.... **[1]**

(b) The intensity of daylight is about 10 W m^{-2} and at night time is about 0.1 W m^{-2}. Describe how the resistance of the LDR changes during the day compared with how it changes at night.

....

....

.... **[2]**

(c) Fig. 3.2 shows a light-sensing potential divider circuit where the LDR is connected in parallel to the input of an electronic circuit that operates a 230 V mains lamp.

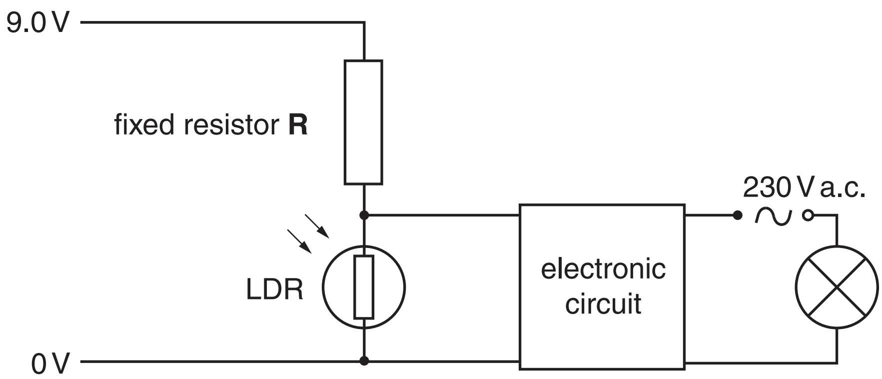


Fig. 3.2

The electronic circuit draws a negligible current. The potential difference across the LDR must be at least 5.0V to activate the circuit and switch on the lamp. The lamp is switched on when the light intensity falls to $1.0\,W\,m^{-2}$.

(i) Use Fig. 3.1 to determine the resistance of the LDR at a light intensity of $1.0\,W\,m^{-2}$.

resistance = ... kΩ **[1]**

(ii) Calculate the current in the LDR in Fig. 3.2 for the p.d. across it to be 5.0V.

current = ... A **[2]**

(iii) Show that the resistance of the fixed resistor **R** in Fig. 3.2 is 2.0kΩ.

[1]

(d) The lamp switches off when the light intensity reaches $2.5\,W\,m^{-2}$. Calculate the p.d. across the LDR when this happens.

potential difference = ... V **[3]**

(e) Explain why the LDR must be shielded or be at some distance from the lamp when it switches on.

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....

....

.... **[2]**

[Total: 12]

4 A photoelectric cell is an electronic device that can detect photons.

(a) Fig. 4.1 shows a cross-section through a simple photocell.

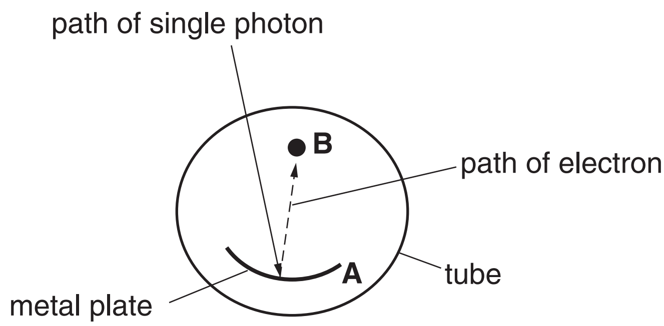

Fig. 4.1

A metal plate **A** is coated with potassium in an evacuated transparent tube. A photon entering the tube is absorbed by the plate, causing one electron to be released from the surface towards the collector rod **B**.

(i) State the name of this process.

.... **[1]**

(ii) Potassium has a work function of 3.5×10^{-19} J.

1 Define the term *work function*.

....

.... **[1]**

2 Calculate the threshold frequency of potassium.

threshold frequency = ... Hz **[2]**

(iii) The photon incident on plate **A** has a wavelength of 4.2×10^{-7} m. Show that its energy is about 5×10^{-19} J.

[2]

(iv) Calculate the maximum kinetic energy of the electron emitted from the potassium surface of plate **A**.

maximum kinetic energy = ... J **[2]**

(b) An electron is released with zero speed from plate **A**. It is accelerated from plate **A** through a potential difference of 12 V to the metal rod **B** in Fig. 4.1.

(i) **1** State the increase in kinetic energy of the electron in electronvolts (eV).

increase in k.e. = ... eV **[1]**

2 Show that this increase is about 2×10^{-18} J.

[1]

(ii) Calculate the speed of the electron as it hits rod **B**.

speed = ... $\mathrm{m\,s^{-1}}$ **[3]**

(c) The photocell is connected to a 12 V d.c. supply through a very sensitive ammeter. Light of wavelength 4.2×10^{-7} m shines on plate **A**. The plate absorbs 1.2×10^{-6} J of light energy every second. One per cent of the absorbed photons cause electrons to be emitted from the plate. Estimate the current in the circuit.

current = ... A **[3]**

[Total: 16]

5 In Fig. 5.1 the solid line on the graph represents the displacement y against position x of a **progressive** transverse wave on a stretched wire at time t = 0. The dotted line shows the displacement at a later time t = 0.75 ms, where the wave has moved to the right.

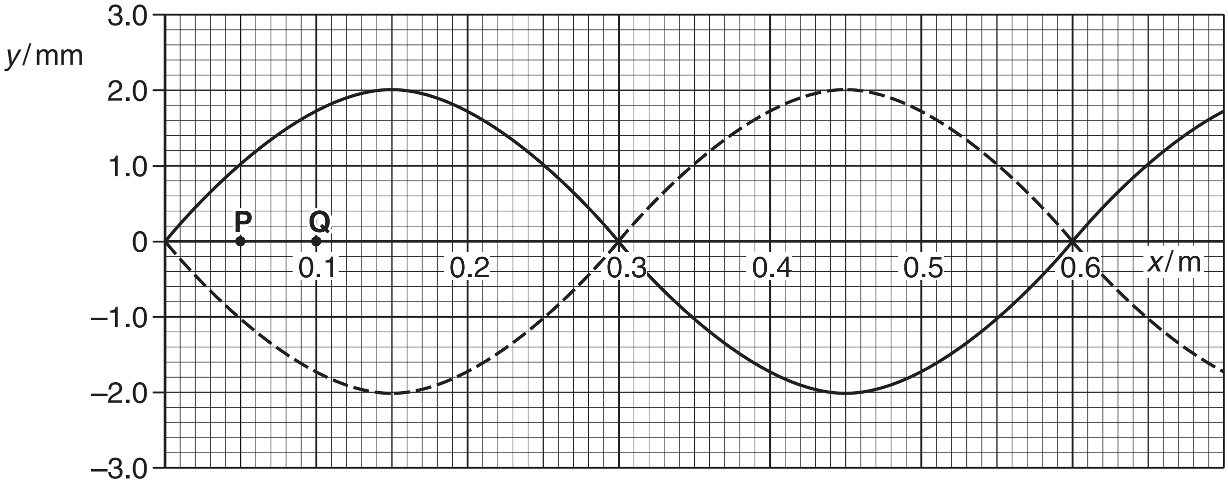

Fig. 5.1

(a) **(i)** Determine the wavelength of the wave.

wavelength = ... m **[1]**

(ii) **1** Explain how Fig. 5.1 shows that the period of the wave is 1.5 ms.

....

.... **[1]**

2 Calculate the speed of the wave along the wire.

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

(b) Consider the oscillations of the wire at positions **P** (x = 0.05 m) and **Q** (x = 0.10 m). See Fig. 5.1. For the **progressive** wave on the wire state the difference, if any, in **amplitude** of the oscillations of the wave at **P** and **Q**.

difference = ... mm **[1]**

(c) (i) Describe the diference between the *displacement* and the *amplitude* of a wave.

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.... **[2]**

(ii) Describe how a *stationary* wave is different from a *progressive* wave.

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.... **[2]**

Question 5 is continued on page 12

(d) Fig. 5.2 shows the wire of Fig. 5.1 under tension fixed at points $x = 0$ and 0.60 m. The frequency of the mechanical oscillator close to one end is varied so that a **stationary** wave is set up on the wire.

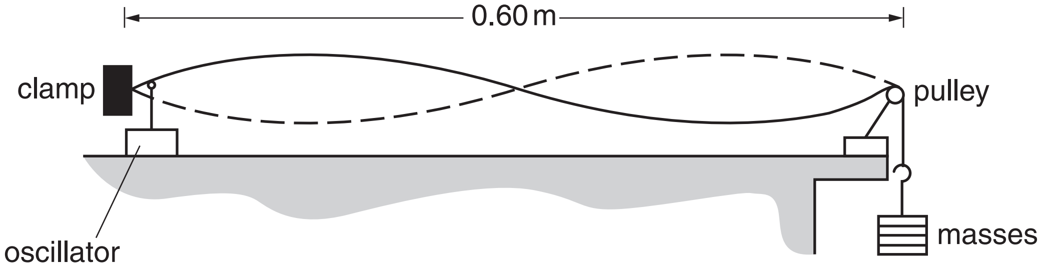

Fig. 5.2

(i) By considering the motion of progressive waves on the wire, explain how the stationary wave is produced.

In your answer you should make clear how the stationary wave arises.

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.... **[3]**

(ii) In Fig. 5.3 the solid line on the graph represents the displacement y against position x of the **stationary** wave on the stretched wire at time $t = 0$. The dotted line shows the displacement at a later time $t = 0.75\,\text{ms}$.

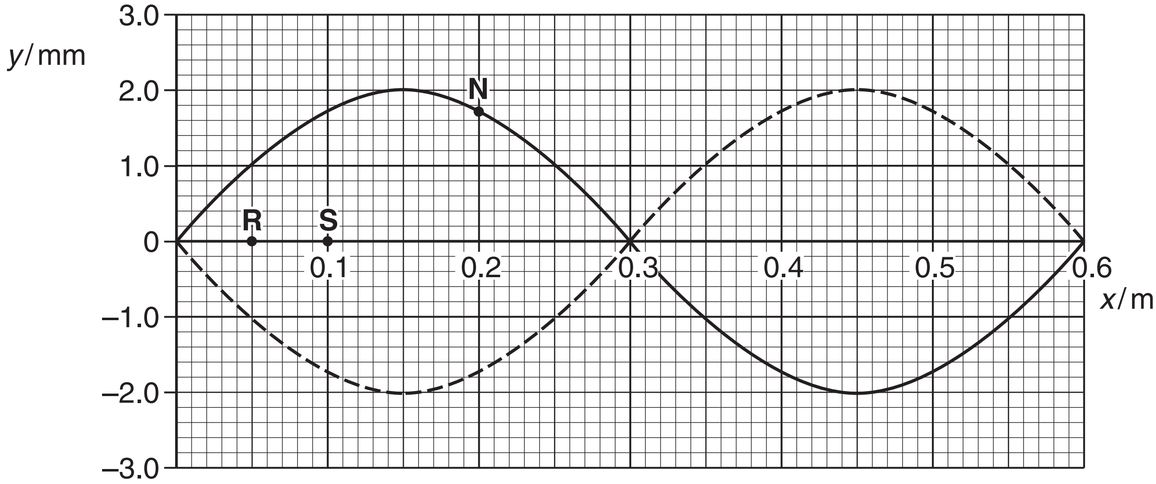

Fig. 5.3

For the **stationary** wave on the wire

1 state the difference, if any, in **amplitude** of the oscillations at **R** and **S**

difference = ... mm **[1]**

2 mark with an **X** the position of one antinode **[1]**

3 mark with a **Y** on the dotted line on Fig. 5.3 where the point **N** on the wave is at $t = 0.75\,\text{ms}$. **[1]**

[Total: 15]

6 This question is about measuring the wavelength of the yellow light from a sodium lamp.

(a) A beam of light from a sodium lamp passes through a pair of narrow slits $\mathbf{S_1}$ and $\mathbf{S_2}$ producing a pattern on a screen. See Fig. 6.1. The pattern on the screen consists of regularly spaced bright and dark lines, called fringes. See Fig. 6.2.

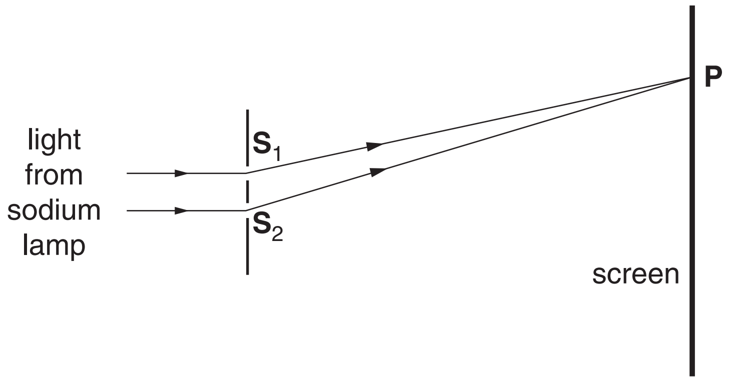

Fig. 6.1

(i) State and explain the conditions necessary for the light from the two slits $\mathbf{S_1}$ and $\mathbf{S_2}$ to produce a visible pattern on the screen.

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.... **[3]**

(ii) Using the ideas of wave superposition, explain the existence of the bright and the dark fringes. In your answer state the condition for a bright fringe to appear on the screen at **P** in Fig. 6.1 and the condition for a dark fringe to appear at **P**.

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.... **[4]**

(b) Fig. 6.2 shows the central part of the fringe pattern on the screen at 1.5 m from the slits $\mathbf{S}_1$ and $\mathbf{S}_2$ which are 0.60 mm apart.

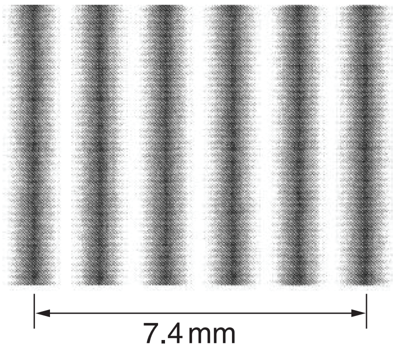

Fig. 6.2

Calculate

(i) the fringe separation, that is, the separation x between adjacent dark lines

x = ... m **[1]**

(ii) the wavelength λ of the yellow light.

λ = ... m **[3]**

(c) One of the two slits is covered up. Describe and explain how the pattern of light on the screen is different from that of Fig. 6.2.

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.... **[3]**

[Total: 14]

7 **(a)** Describe a *plane polarised wave*.

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.... **[2]**

(b) Light reflected from the surface of water is partially plane polarised in the horizontal direction. The reflected light is totally plane polarised when the angle of reflection is about 53°.

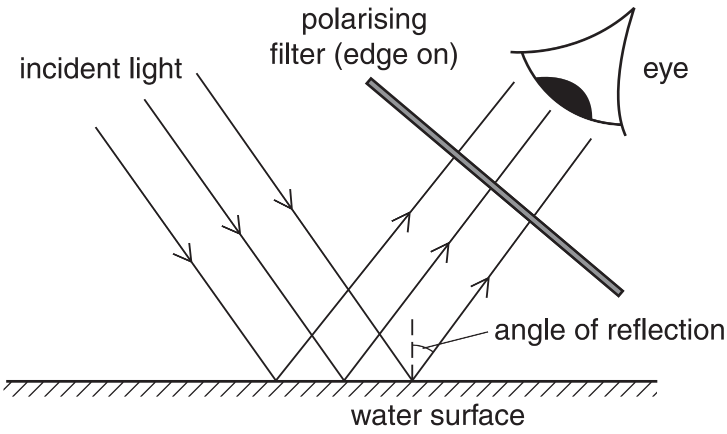

Fig. 7.1

Describe, referring to Fig. 7.1, the experiment that you would perform using a polarising filter (a sheet of Polaroid) to determine whether this statement is correct. Describe what you expect to observe.

In your answer you should make clear how you would use any apparatus to make observations or take suitable measurements.

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.... **[4]**

(c) State Malus' law for the intensity I of a beam of plane polarised light transmitted through a polarising sheet with its transmission axis at an angle θ to the plane of polarisation. Explain the meaning of any other symbols that you use.
Use Malus' law to explain the observations in the experiment of part **(b)**.

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.... **[4]**

[Total: 10]

END OF QUESTION PAPER

ADDITIONAL PAGE

If additional space if required, you should use the lined pages below. The question number(s) must be clearly shown.

ADDITIONAL PAGE

ADDITIONAL PAGE