Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Monday 16 October 2023

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WPH12/01**

Physics

International Advanced Subsidiary/Advanced Level
UNIT 2: Waves and Electricity

You must have:
Scientific calculator, ruler, protractor

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*
- **Show all your working out** in calculations and **include units** where appropriate.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- In the question marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.
- The list of data, formulae and relationships is printed at the end of this booklet.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

SECTION A

Answer ALL questions.

For questions 1–10, in Section A, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The formula for a diffraction grating in the list of equations is $n\lambda = d\sin\theta$.

Which of the following quantities does not have units?

☒ **A** n

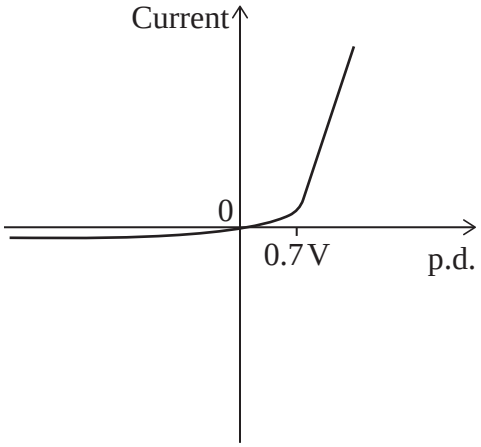
☒ **B** λ

☒ **C** d

☒ **D** θ

(Total for Question 1 = 1 mark)

2 The current-potential difference (p.d.) graph for a diode is shown.



Which of the following statements is correct for this diode?

☒ **A** This diode does not conduct in the reverse direction.

☒ **B** The resistance of this diode in the reverse direction is infinite.

☒ **C** The resistance of this diode decreases when the p.d. is above 0.7 V.

☒ **D** This diode does not conduct when the p.d. is below 0.7 V.

(Total for Question 2 = 1 mark)

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3 Which of the following would increase the detail in an ultrasound scan?

- ☒ **A** increasing the duration of the pulses
- ☒ **B** increasing the frequency of the ultrasound
- ☒ **C** increasing the intensity of the ultrasound
- ☒ **D** increasing the wavelength of the ultrasound

(Total for Question 3 = 1 mark)

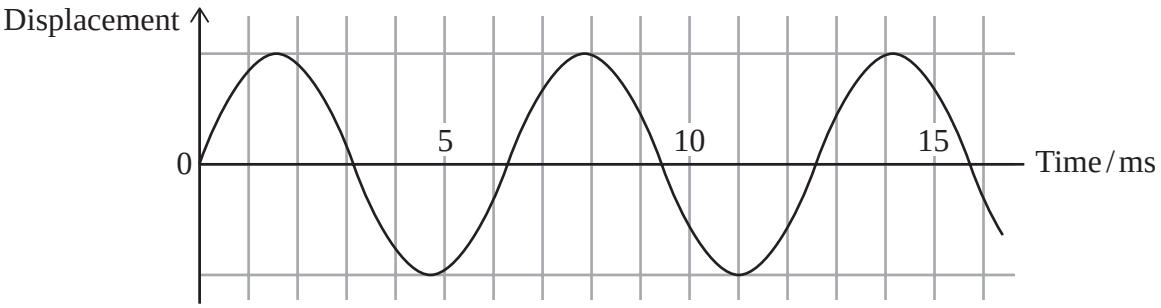
4 In a current-carrying copper wire, the drift velocity of the electrons is very small.

Which of the following best explains this?

- ☒ **A** The charge on an electron is very small.
- ☒ **B** The cross-sectional area of the wire is very small.
- ☒ **C** The current in the wire is very large.
- ☒ **D** The number of electrons per unit volume for copper is very large.

(Total for Question 4 = 1 mark)

5 The graph shows how displacement varies with time for a particular point as a wave passes.



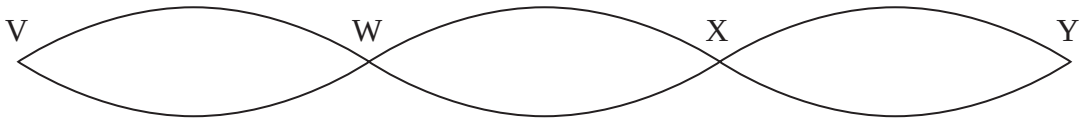
Which of the following statements is **not** correct?

- ☒ **A** The time period can be determined directly from the graph.
- ☒ **B** The wavelength can be determined directly from the graph.
- ☒ **C** The wave could be longitudinal.
- ☒ **D** The wave could be transverse.

(Total for Question 5 = 1 mark)

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Questions 6 and 7 refer to the standing wave pattern on a string as shown.



6 The length of the string VY is 0.6 m.

Which of the following is the wavelength of the standing wave?

- ☒ **A** 0.2 m
- ☒ **B** 0.4 m
- ☒ **C** 0.6 m
- ☒ **D** 0.9 m

(Total for Question 6 = 1 mark)

7 Which of the following sections of the string would be in phase with each other?

- ☒ **A** VW and WX
- ☒ **B** WX and XY
- ☒ **C** VW and XY
- ☒ **D** No sections are in phase.

(Total for Question 7 = 1 mark)

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8 A string is placed under tension T. A wave travels along the string.

A second string has the same mass but twice the length. A wave travels along this string with the same velocity as the wave in the first string.

Which of the following is the tension in the second string?

☒ **A** $4T$

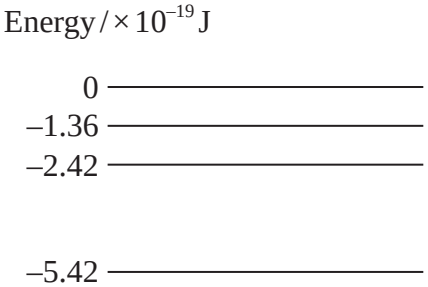
☒ **B** $2T$

☒ **C** $\frac{T}{2}$

☒ **D** $\frac{T}{4}$

(Total for Question 8 = 1 mark)

9 The diagram shows some of the energy levels for a hydrogen atom.



Which of the following expressions is equal to the lowest frequency of light possible from a transition between these energy levels?

☒ **A** $\frac{5.42 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **B** $\frac{1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **C** $\frac{2.42 \times 10^{-19} + 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

☒ **D** $\frac{2.42 \times 10^{-19} - 1.36 \times 10^{-19}}{6.63 \times 10^{-34}}$

(Total for Question 9 = 1 mark)

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10 Two photographs, X and Y, were taken of the same car windscreen. Photograph Y was taken through a polarising filter.



Photograph X



Photograph Y

(Source: © Etan J. Tal)

Which row of the table is correct?

		Light transmitted through windscreen	Light reflected from windscreen
☒	**A**	plane polarised	plane polarised
☒	**B**	plane polarised	unpolarised
☒	**C**	unpolarised	plane polarised
☒	**D**	unpolarised	unpolarised

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

11 Some animals use a pulse-echo technique to collect information about their surroundings.

Describe how this technique provides information about the surroundings.

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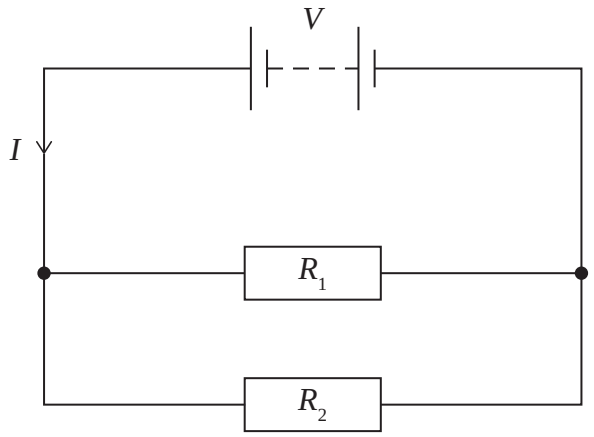
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(Total for Question 11 = 3 marks)

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12 Two resistors are connected in a circuit, as shown.



An expression for the combined resistance of the two resistors is $\frac{R_1R_2}{R_1 + R_2}$

Derive this expression.

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(Total for Question 12 = 3 marks)

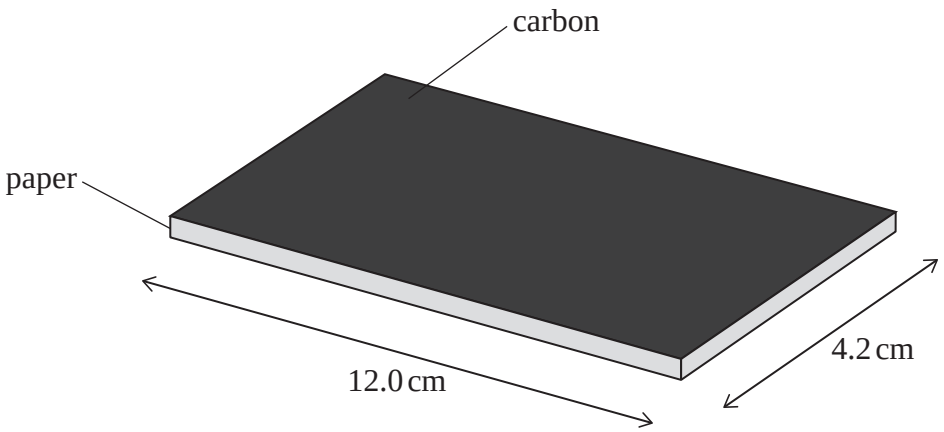
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13 'Resistivity paper' is paper covered with a thin layer of carbon.

The distance between the ends of a piece of resistivity paper is 12.0 cm. The resistivity paper is 4.2 cm wide as shown.



The resistance between the ends of the resistivity paper is 8.8 Ω.

(a) Calculate the thickness of the layer of carbon.

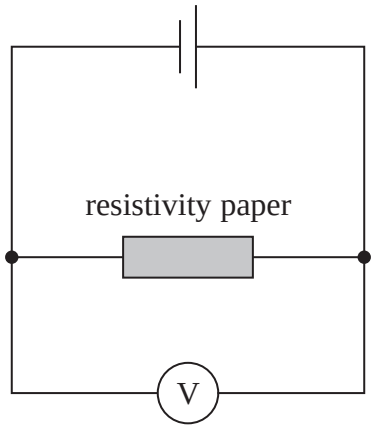
resistivity of carbon = 3.7×10^{-5} Ω m

(3)

Thickness of layer of carbon = ...

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(b) A student connected the ends of the resistivity paper to a cell of e.m.f. 1.5 V and a voltmeter, as shown.



(i) The reading on the voltmeter was 1.4 V.

Calculate the internal resistance of the cell.

(3)

Internal resistance = ...

(ii) The connection to the right-hand terminal of the voltmeter was moved to a distance of 3.0 cm from the left-hand side of the resistivity paper.

Determine the reading on the voltmeter.

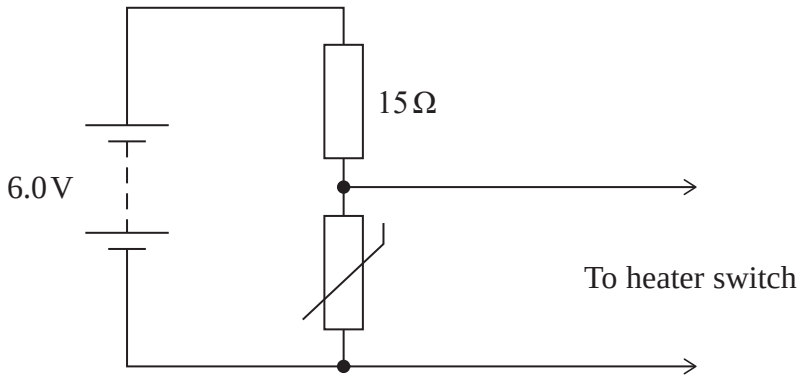
(1)

Reading on voltmeter = ...

(Total for Question 13 = 7 marks)

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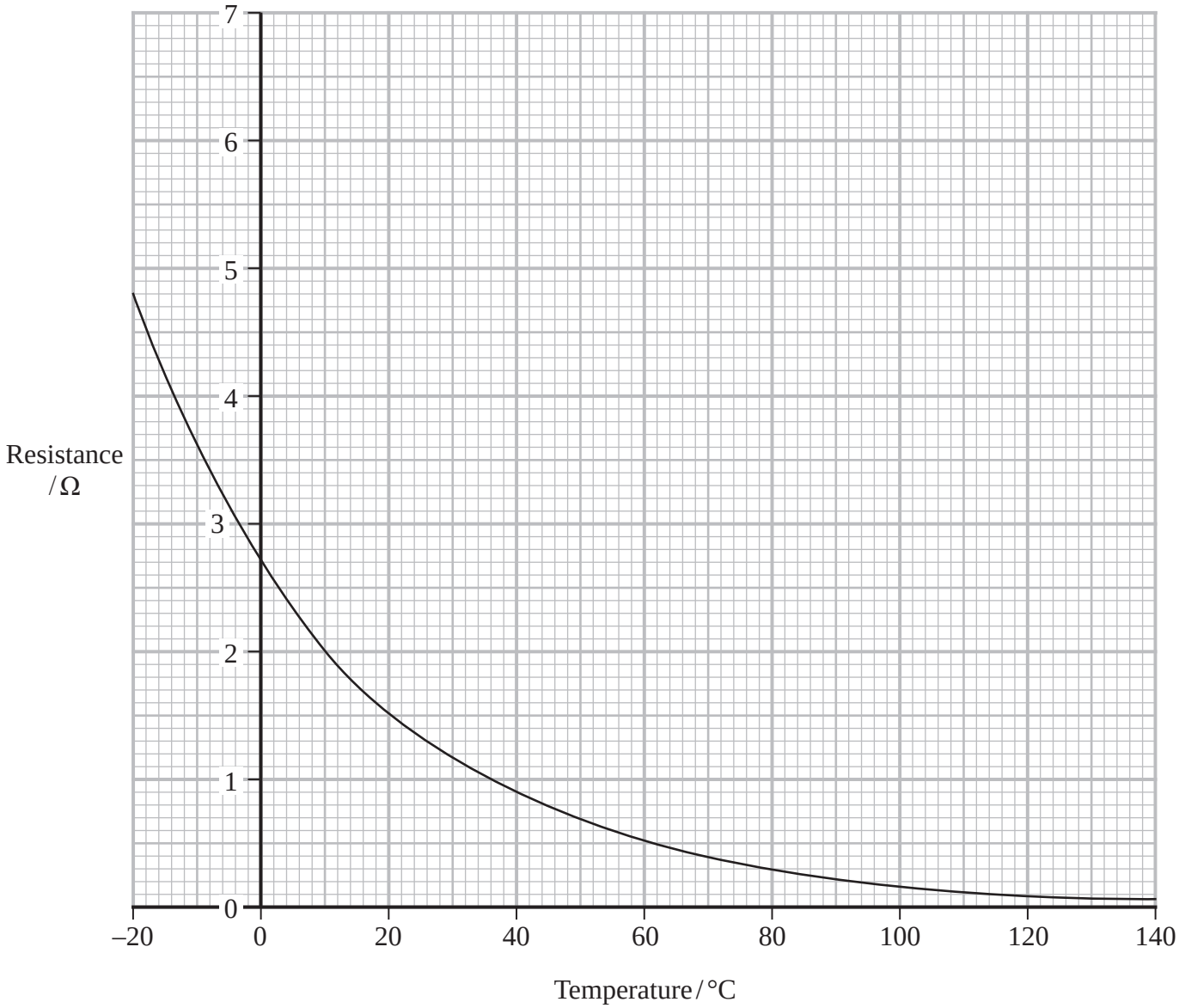
14 A temperature-sensing circuit consists of a fixed resistor and a thermistor, as shown.



The circuit supplies a potential difference (p.d.) to operate the heater switch.

The heater switches on when the p.d. across the thermistor is greater than 0.7 V.

The resistance of the thermistor varies with temperature as shown on the graph.



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(a) Deduce whether this circuit would switch on the heater when the temperature falls below 10 °C.

You should include a calculation of the p.d. across the thermistor when the temperature is 10 °C.

(6)

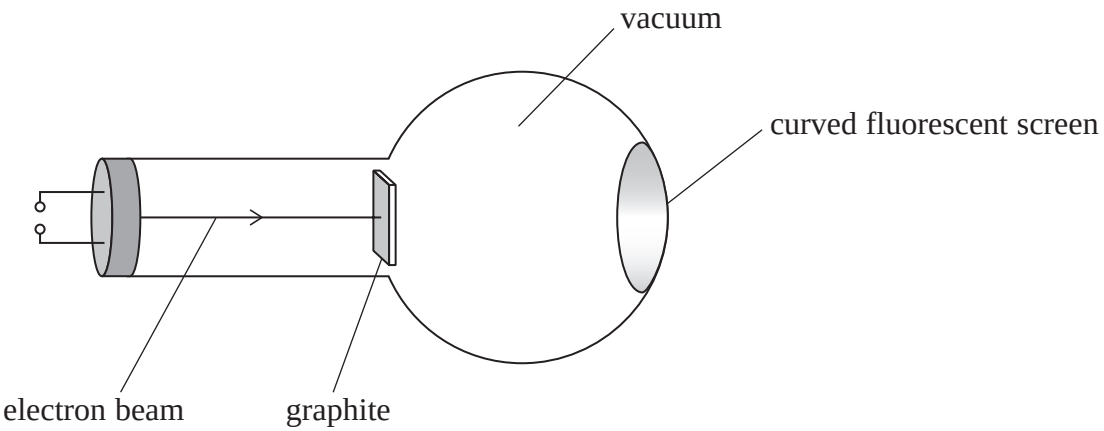
(b) Explain why the resistance of the thermistor changes with temperature.

(2)

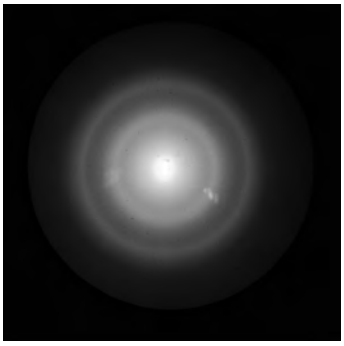
(Total for Question 14 = 8 marks)

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15 A teacher demonstrated the behaviour of electrons travelling through graphite.
An electron beam was directed through a thin piece of graphite towards a fluorescent screen, as shown.



The electrons produced a pattern on the fluorescent screen as shown below.



(Source: © ANDREW LAMBERT PHOTOGRAPHY/SCIENCE PHOTO LIBRARY)

(a) This demonstration can be used to make conclusions about the behaviour of the electrons and the structure of the graphite.

State these conclusions.

(4)

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(b) The electrons were accelerated through a potential difference (p.d.) of 2400 V before interacting with the graphite.

(i) Show that the work done on each electron is about 4×10^{-16} J.

(2)

(ii) Calculate the maximum velocity of the electrons.

(2)

Maximum velocity = ...

(iii) The accelerating p.d. was then increased.

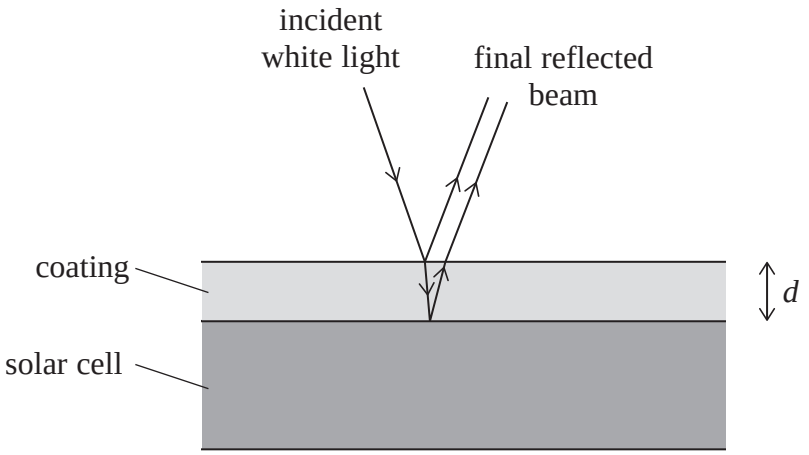
Explain how the pattern on the screen would change.

(3)

(Total for Question 15 = 11 marks)

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16 A solar cell has a thin coating of thickness *d* to reduce the reflection of light. White light incident on the coating is reflected from the top and bottom surfaces of the coating. This produces a final reflected beam, as shown.



(a) Explain why some wavelengths of the incident white light will be missing from the final reflected beam.

(3)

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(b) White light is incident perpendicular to the surface of the coating.

Calculate the wavelength that would be missing from the final reflected beam.
Assume the refractive index is 2.3 for all visible wavelengths.

$d = 6.5 \times 10^{-8}$ m

(4)

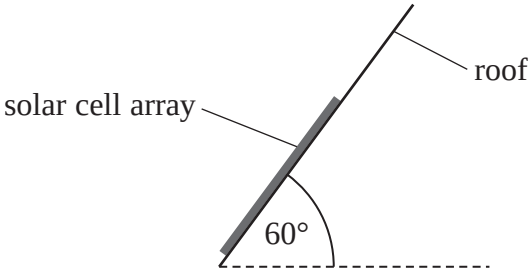
Wavelength = ...

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(c) A solar cell array is placed on the roof of a house as shown.



The area of the solar cell array is $8.7\,m^2$. The roof of the house slopes at an angle of 60° to the horizontal as shown below.



When the intensity of radiation from the Sun perpendicular to the surface of the Earth is $1.1\,kW\,m^{-2}$, the output of the solar cell array is $5.4 \times 10^6\,J$ per hour.

Calculate the efficiency of the solar cell array.

(4)

Efficiency = ...

(Total for Question 16 = 11 marks)

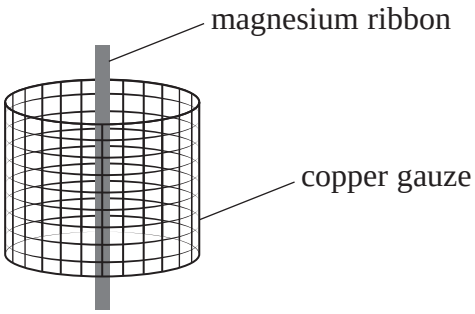
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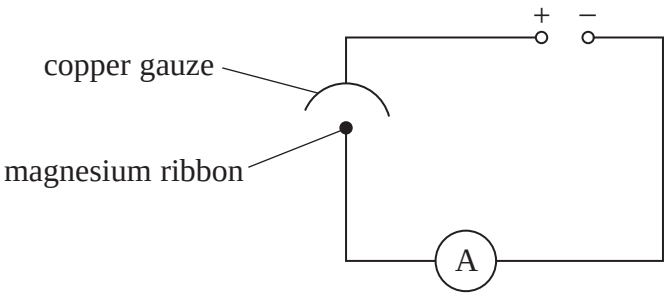
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17 Some students investigated the photoelectric effect.

They used a piece of magnesium ribbon placed inside a cylinder of copper gauze as shown. There was an air gap between the copper gauze and the magnesium ribbon.



The copper gauze was connected to the positive terminal of a power supply. The magnesium ribbon and a sensitive ammeter were connected to the negative terminal of the power supply, as shown.



The students made the following observations:

- when light from an ultraviolet lamp was incident on the gauze and ribbon, a current was detected by the ammeter.
- when the polarity of the power supply was reversed, the current decreased to zero.

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*(a) Explain these observations.

(6)

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(b) The students reconnected the circuit so that a current was detected when ultraviolet light was incident on the gauze and ribbon.

(i) The students replaced their original lamp with an ultraviolet lamp with a much greater intensity.

Explain the effect this had on their experiment.

(3)

(ii) The ultraviolet lamp was replaced by a laser which emitted red light of wavelength 633 nm.

Deduce whether the photoelectric effect will occur.

work function of magnesium = 3.7 eV

(4)

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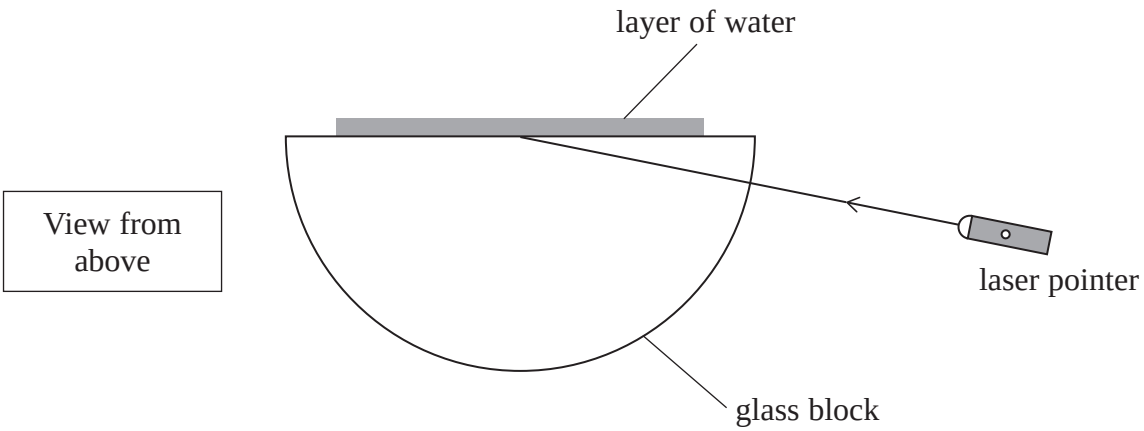
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18 A ray of light from a laser pointer is directed into a semi-circular glass block, as shown. There is a layer of water along the vertical flat side of the glass block.



(a) Explain why the ray of light does not change direction when entering the glass block.

Your answer should refer to wavefronts.

(4)

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(b) Show that the critical angle between glass and water is about 60°.

refractive index of glass = 1.51
refractive index of water = 1.33

(3)

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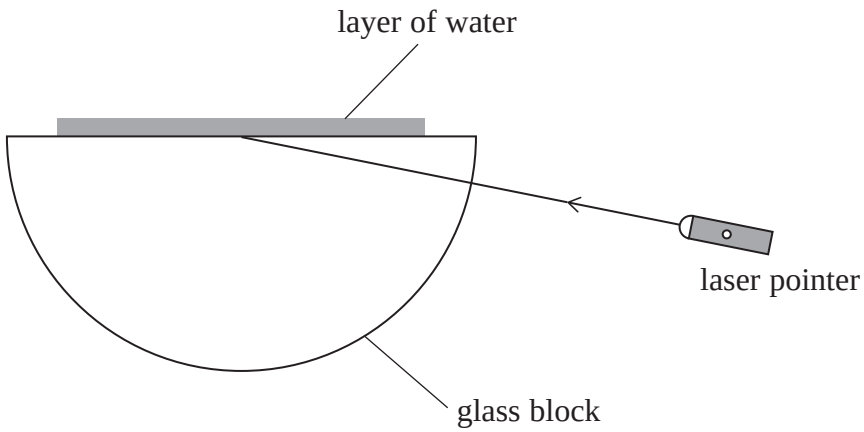
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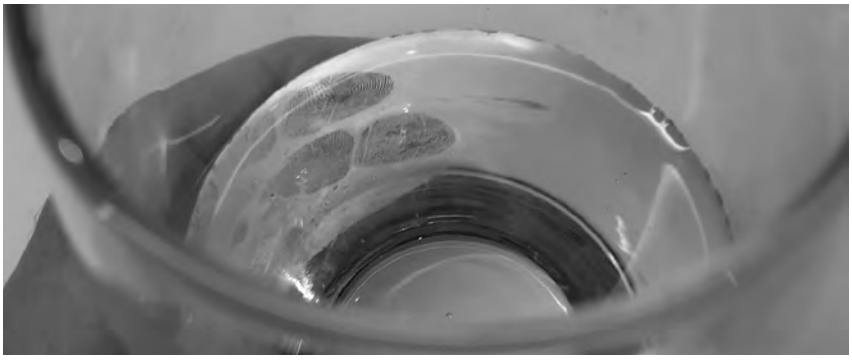
(c) Complete the diagram to show the path of the ray of light after meeting the boundary between the glass and water.

(3)

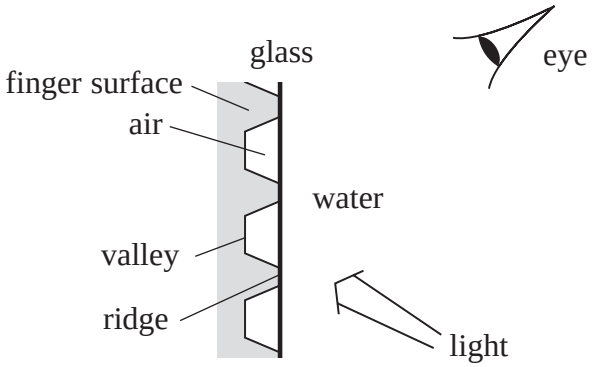


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(d) The photograph shows a hand holding a glass beaker containing water.



Fingerprints are a series of ridges and valleys on the surface of fingers. The valleys trap air when the finger presses against the glass as shown in the diagram below.



Light in the water is incident upon the boundary between the glass and the air.

The critical angle between glass and air is about 40°. Skin has a similar value of refractive index to glass.

Explain why the fingerprints are seen as light and dark regions.

(4)

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(Total for Question 18 = 14 marks)

TOTAL FOR SECTION B = 70 MARKS
TOTAL FOR PAPER = 80 MARKS

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List of data, formulae and relationships

Acceleration of free fall	$g = 9.81$ m s^{-2}	(close to Earth's surface)
Electron charge	$e = -1.60 \times 10^{-19}$ C	
Electron mass	$m_e = 9.11 \times 10^{-31}$ kg	
Electronvolt	$1\,\text{eV} = 1.60 \times 10^{-19}$ J	
Gravitational field strength	$g = 9.81$ N kg^{-1}	(close to Earth's surface)
Planck constant	$h = 6.63 \times 10^{-34}$ J s	
Speed of light in a vacuum	$c = 3.00 \times 10^{8}$ m s^{-1}	

Unit 1

Mechanics

Kinematic equations of motion

$$s = \frac{(u + v)t}{2}$$

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

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

Forces

$$\Sigma F = ma$$

$$g = \frac{F}{m}$$

$$W = mg$$

Momentum

$$p = mv$$

Moment of force

$$\text{moment} = Fx$$

Work and energy

$$\Delta W = F\Delta s$$

$$E_k = \frac{1}{2}mv^2$$

$$\Delta E_{grav} = mg\Delta h$$

Power

$$P = \frac{E}{t}$$

$$P = \frac{W}{t}$$

Efficiency

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}}$$

$$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}}$$

Materials

Density $\rho = \frac{m}{V}$

Stokes' law $F = 6\pi\eta r v$

Hooke's law $\Delta F = k\Delta x$

Elastic strain energy $\Delta E_{el} = \frac{1}{2} F \Delta x$

Young modulus $E = \frac{\sigma}{\varepsilon}$ where

Stress $\sigma = \frac{F}{A}$

Strain $\varepsilon = \frac{\Delta x}{x}$

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Unit 2

Waves

Wave speed	$v = f\lambda$
Speed of a transverse wave on a string	$v = \sqrt{\frac{T}{\mu}}$
Intensity of radiation	$I = \frac{P}{A}$
Refractive index	$n_1 \sin\theta_1 = n_2 \sin\theta_2$
	$n = \frac{c}{v}$
Critical angle	$\sin C = \frac{1}{n}$
Diffraction grating	$n\lambda = d\sin\theta$

Electricity

Potential difference	$V = \frac{W}{Q}$
Resistance	$R = \frac{V}{I}$
Electrical power, energy	$P = VI$
	$P = I^2R$
	$P = \frac{V^2}{R}$
	$W = VIt$
Resistivity	$R = \frac{\rho l}{A}$
Current	$I = \frac{\Delta Q}{\Delta t}$
	$I = nqvA$
Resistors in series	$R = R_1 + R_2 + R_3$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

Particle nature of light

Photon model	$E = hf$
Einstein's photoelectric equation	$hf = \phi + \frac{1}{2}mv^2_{max}$
de Broglie wavelength	$\lambda = \frac{h}{p}$

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