Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 15 May 2024

Morning (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

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 ▶

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 ☒.

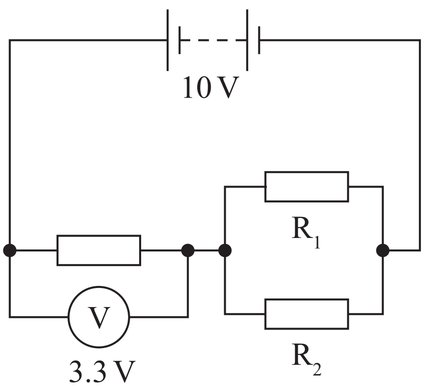
1 The temperature of a thermistor and the temperature of a metal wire are increased.

Which row of the table gives the changes in resistance of the thermistor and the metal wire as the temperature is increased?

	Resistance of thermistor	Resistance of metal wire
☐ **A**	decreases	decreases
☐ **B**	decreases	increases
☐ **C**	increases	decreases
☐ **D**	increases	increases

(Total for Question 1 = 1 mark)

2 The battery in the circuit shown has a negligible internal resistance.
Resistor R_1 and resistor R_2 are identical.



Which of the following expressions gives the potential difference across resistor R_1 in volts?

☐ **A** $\frac{1}{2} \times 3.3$

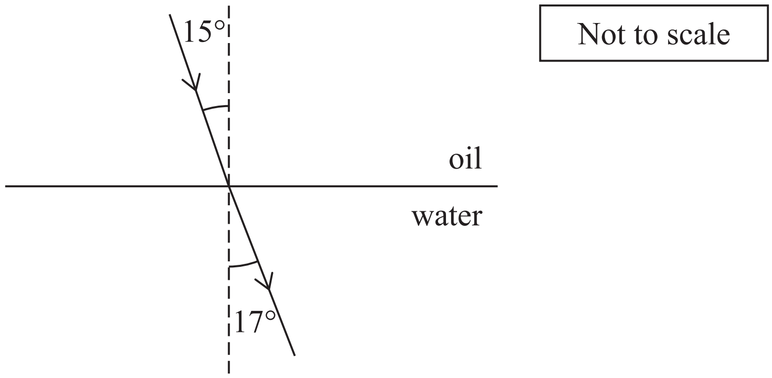
☐ **B** 3.3

☐ **C** $\frac{1}{2} \times (10 - 3.3)$

☐ **D** $10 - 3.3$

(Total for Question 2 = 1 mark)

3 The diagram shows a ray of light incident at a boundary between oil and water.
The refractive index of water is 1.33



Which of the following expressions gives the refractive index of the oil?

☒ **A** $\dfrac{\sin 17°}{1.33 \sin 15°}$

☒ **B** $\dfrac{1.33 \sin 17°}{\sin 15°}$

☒ **C** $\dfrac{\sin 15°}{1.33 \sin 17°}$

☒ **D** $\dfrac{1.33 \sin 15°}{\sin 17°}$

(Total for Question 3 = 1 mark)

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4 Which of the following is evidence that electrons can behave like waves?

☒ **A** Electrons are attracted towards positively charged objects.

☒ **B** Electrons can absorb photons and move between energy levels in an atom.

☒ **C** Electrons can be diffracted when passing through a thin sheet of graphite.

☒ **D** Electrons can be released by photons in the photoelectric effect.

(Total for Question 4 = 1 mark)

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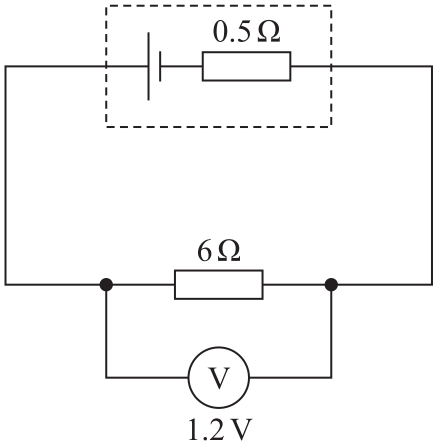
5 The circuit shown includes a cell with internal resistance 0.5 Ω.



Which of the following expressions gives the e.m.f., in V, of the cell?

☒ **A** $1.2 - \frac{1.2 \times 0.5}{6}$

☒ **B** 1.2

☒ **C** $1.2 + \frac{1.2 \times 0.5}{6}$

☒ **D** $1.2 + \frac{6 \times 0.5}{1.2}$

(Total for Question 5 = 1 mark)

6 Which of the following describes threshold frequency?

☒ **A** The frequency of light that causes photoelectrons to have maximum kinetic energy.

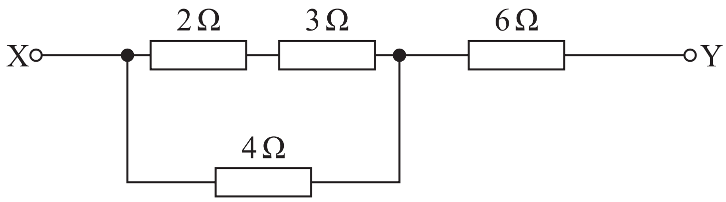
☒ **B** The frequency of light emitted when excited electrons fall to the ground state.

☒ **C** The minimum frequency of light that can cause an electron to leave a surface.

☒ **D** The maximum frequency of light which excites an electron in the ground state.

(Total for Question 6 = 1 mark)

7 The diagram shows part of an electrical circuit.



Which of the following expressions gives the total resistance, in ohms, between X and Y?

☒ **A** $\dfrac{1}{\dfrac{1}{2+3}+\dfrac{1}{4}+6}$

☒ **B** $\dfrac{1}{2+3}+\dfrac{1}{4}+6$

☒ **C** $\dfrac{1}{\dfrac{1}{2}+\dfrac{1}{3}+\dfrac{1}{4}}+6$

☒ **D** $\dfrac{1}{\dfrac{1}{2+3}+\dfrac{1}{4}}+6$

(Total for Question 7 = 1 mark)

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8 There is tension T in a string of length l. When the string is displaced and then released, waves move on the string with speed v.

A string of length $2l$ has the same diameter and is made from the same material. The tension in this string is $2T$.

Which of the following expressions gives the speed of waves on the string of length $2l$?

☒ **A** $\dfrac{v}{\sqrt{2}}$

☒ **B** $\dfrac{v}{2}$

☒ **C** $\sqrt{2}v$

☒ **D** $2v$

(Total for Question 8 = 1 mark)

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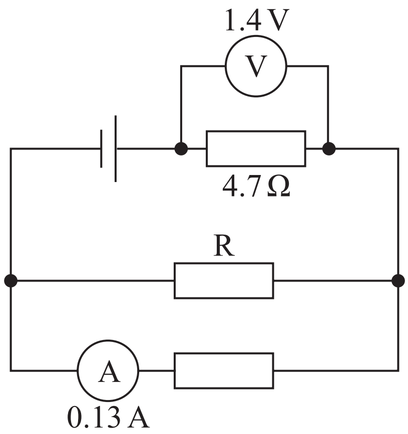
9 A student connects the circuit shown. The resistors all have different resistances.



Which of the following expressions gives the current, in amps, in resistor R?

☒ **A** $\frac{1.4}{4.7} - 0.13$

☒ **B** $\frac{1.4}{4.7} + 0.13$

☒ **C** $\frac{4.7}{1.4} - 0.13$

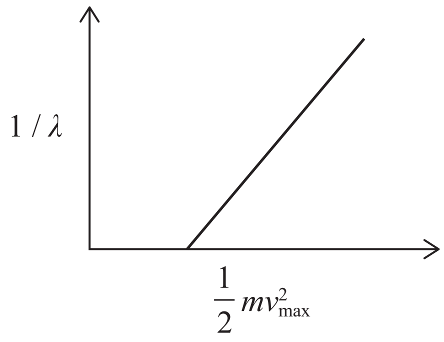
☒ **D** $\frac{4.7}{1.4} + 0.13$

(Total for Question 9 = 1 mark)

10 Light of wavelength λ travelling at speed c is incident on a metal surface.

Photoelectrons are emitted from the surface with a maximum kinetic energy $\frac{1}{2}mv_{max}^2$.

The graph shows the relationship between $1/\lambda$ and $\frac{1}{2}mv_{max}^2$.



Which of the following shows how the gradient of the graph can be used to determine the Planck constant *h*?

☒ **A** $h = \frac{1}{\text{gradient}}$

☒ **B** $h = \frac{1}{\text{c} \times \text{gradient}}$

☒ **C** $h = \frac{\text{c}}{\text{gradient}}$

☒ **D** $h = \text{gradient}$

(Total for Question 10 = 1 mark)

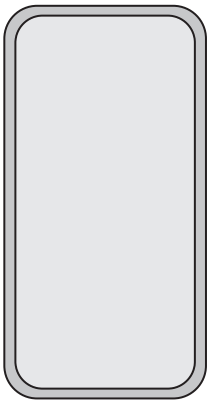
TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 A student wearing polarising sunglasses observes a mobile phone screen.

The student rotates the mobile phone through 90°, as shown. The screen then appears completely black.



mobile phone

mobile phone rotated through 90°

Explain why the screen appears completely black when the student rotates the mobile phone through 90°.

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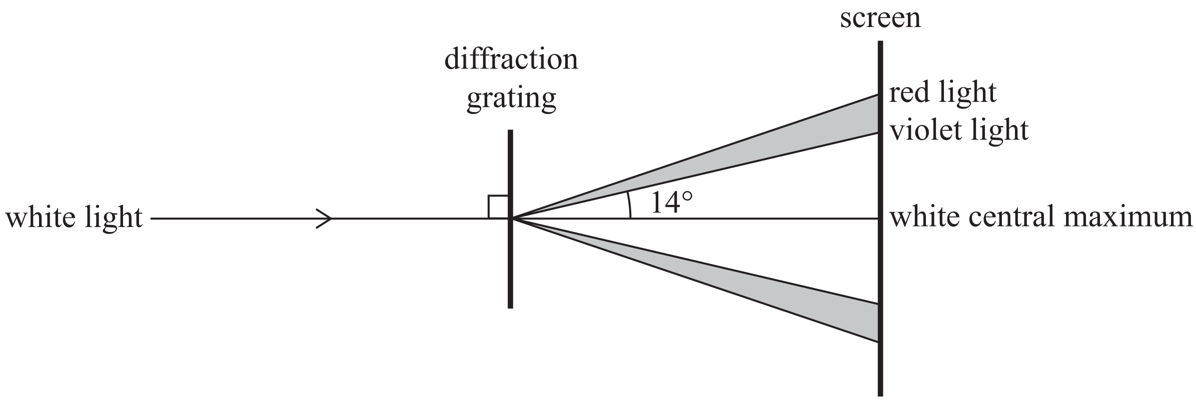
(Total for Question 11 = 3 marks)

12 A student directs a beam of white light through a diffraction grating and onto a screen. A white central maximum forms on the screen with a visible spectrum of light on either side, as shown.



(a) In the visible spectrum formed on the screen, violet light is closest to the central maximum and red light is furthest away.

Explain why the violet light is closest to the central maximum.

(2)

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(b) The diffraction grating has a line spacing of 1.62×10^{-6} m.

Calculate the wavelength of the violet light.

(2)

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Wavelength of the violet light = ...

(Total for Question 12 = 4 marks)

13 A fishing boat uses a pulse-echo technique to determine the depth of fish under the water surface.

The boat has a transducer which emits pulses of sound into the water and detects returning pulses of sound.

(a) The transducer emits a pulse of sound and detects an echo from a fish after a time of 37 ms.

speed of sound in water = $1500\,\mathrm{m\,s^{-1}}$

Calculate the distance between the transducer and the fish.

(3)

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Distance = ...

(b) After each pulse is emitted by the transducer, there is a fixed time *T* before the next pulse is emitted.

Explain how *T* affects the maximum distance at which a fish can be detected.

(2)

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(c) The transducer can emit pulses of sound waves of different frequency.

Explain how the frequency should be adjusted to improve the accuracy when detecting the location of a fish.

(2)

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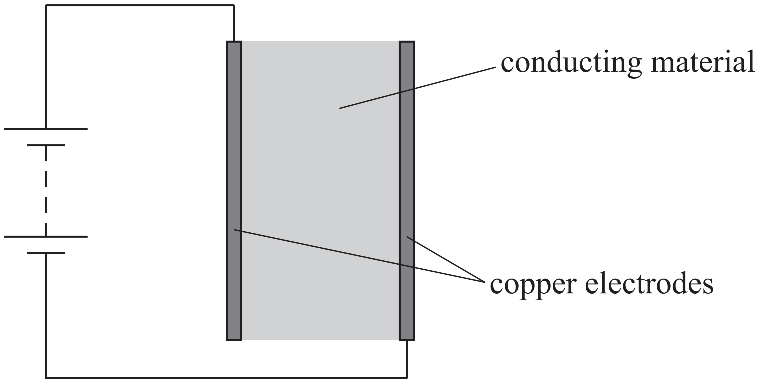
(Total for Question 13 = 7 marks)

14 An electrical heating system consists of heating panels.

Each panel is made from a thin sheet of conducting material attached to two copper electrodes. The electrodes are connected to a power supply, as shown.



(a) A student uses a sample of the conducting material to determine its resistivity.

(i) State what is meant by resistivity of a material.

(1)

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(ii) Describe how the student could determine a value for the resistivity of the conducting material.

You do **not** need to draw a circuit diagram.

(4)

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(b) Copper has a low resistivity compared with the resistivity of the conducting material.

Explain how the low resistivity of copper affects the drift velocity of electrons in the copper electrodes.

(2)

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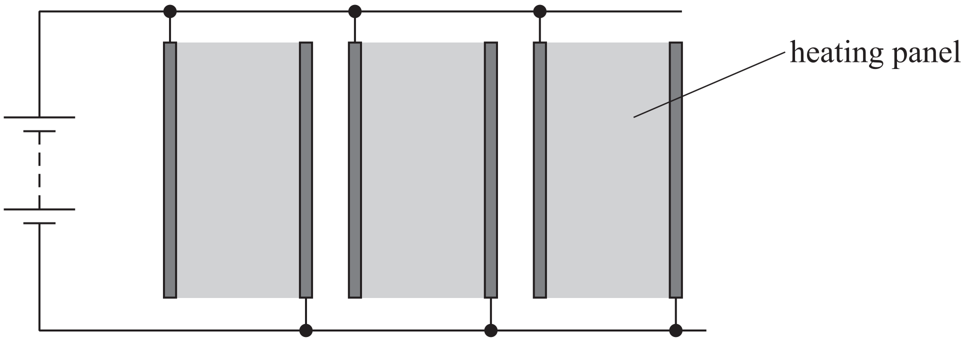
(c) The power output of the heating system can be changed by connecting more panels in parallel with the power supply, as shown.



Explain how adding panels in parallel changes the power output of the system.

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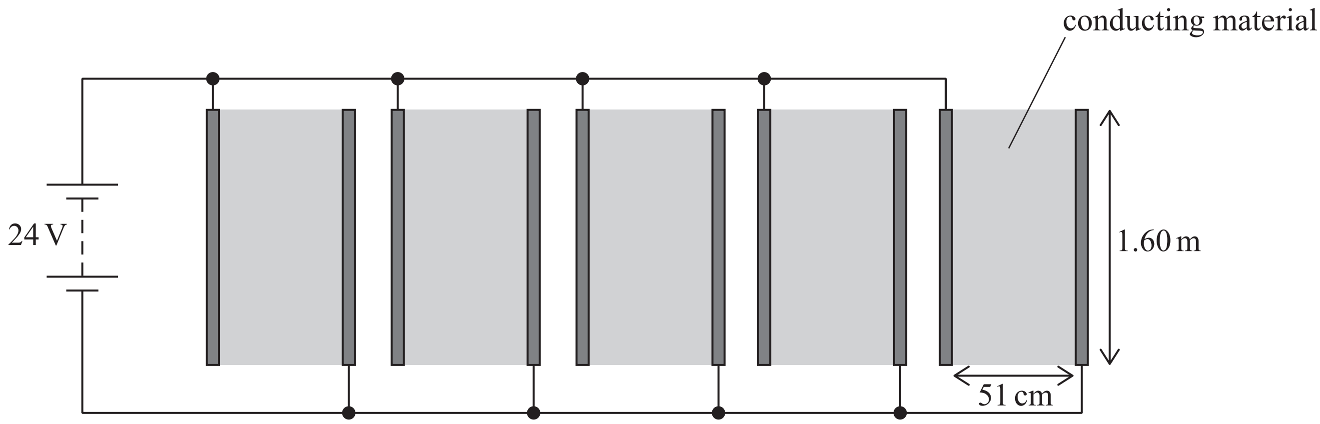
(d) A student designs a heating system using five heating panels, as shown.



To be safe, the maximum power of the student's heating system should be less than 350 W.

Deduce whether the student's heating system is safe.

resistivity of conducting material = $6.4 \times 10^{-3}\,\Omega\,m$
thickness of conducting material = 0.48 mm

(5)

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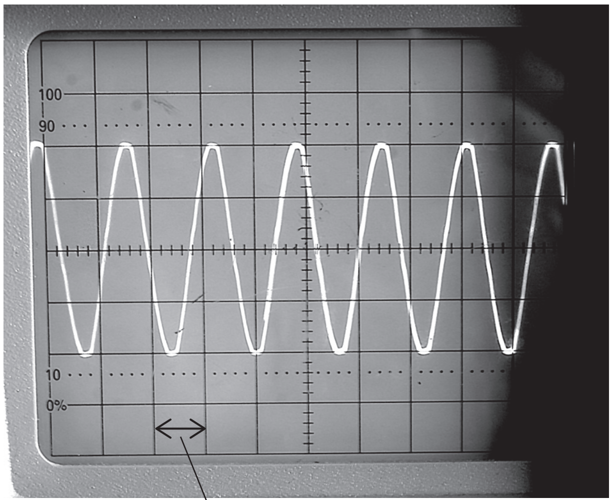
(Total for Question 14 = 14 marks)

15 The photograph shows a musical instrument called panpipes.

(Source: © barisonal/Getty Images)

The instrument is made using pipes of different lengths. Blowing air across the top of one of the pipes produces a sound.

(a) A student connected a microphone to an oscilloscope. She then placed the microphone near to one of the pipes. The photograph below shows the oscilloscope screen when the pipe was producing a sound.



Calculate an accurate value for the frequency of the sound wave.

1 division = 1.5 ms

(3)

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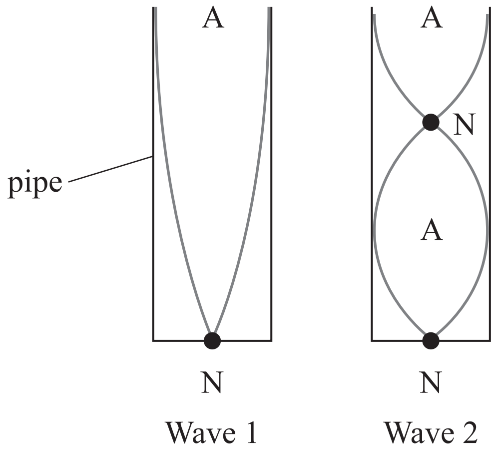
Frequency = ...

(b) Each pipe is open at the top and closed at the bottom. When air is blown across the open end, a stationary wave is formed in the pipe.

The student was able to produce two sounds from the same pipe. The diagram shows the nodes N and antinodes A in the stationary waves that caused each sound.



Explain how the frequency of wave 1 compares with the frequency of wave 2.

(3)

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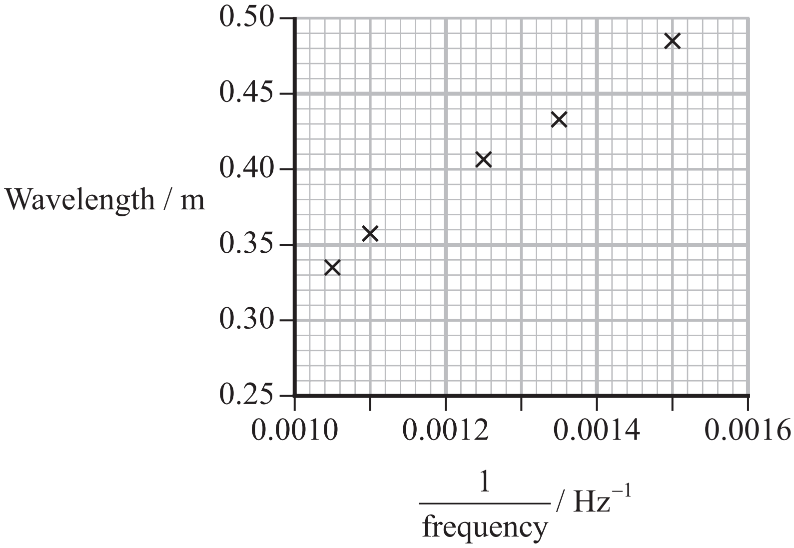
(c) The student determined the frequency and wavelength of sound waves produced in different pipes and plotted the graph shown.



Determine a value for the speed of sound.

(2)

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Speed of sound = ...

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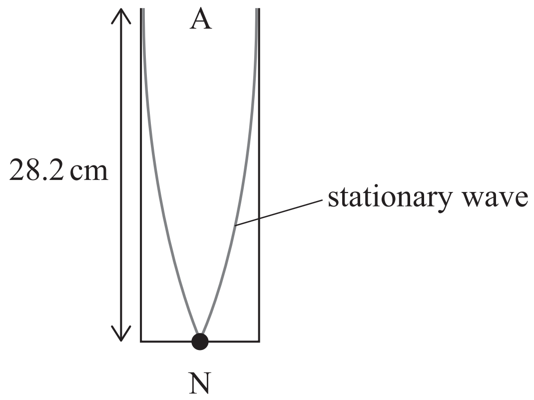
(d) On another day the speed of sound was 340 m s^{-1}. The student produced a stationary wave using the longest pipe. The pipe has a length of 28.2 cm, as shown.



Determine the frequency of this wave.

(3)

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Frequency = ...

(Total for Question 15 = 11 marks)

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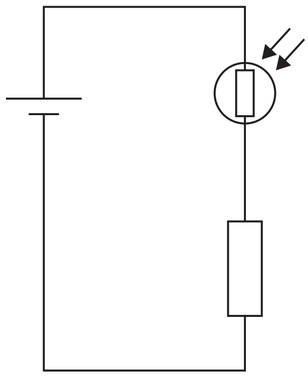
16 A security lamp automatically switches on when the intensity of light incident on an LDR decreases.

Part of the electrical circuit in the security lamp is shown. The cell has negligible internal resistance.



(a) The light intensity incident on the LDR decreases.

Explain what happens to the potential difference across the fixed resistor.

(2)

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(b) The security lamp switches on when the potential difference across the fixed resistor is 0.62 V.

When the lamp switches on, the ratio of the resistance of the LDR to the resistance of the fixed resistor is 3 : 2

The current in the circuit is 28 mA.

Calculate the resistance of the LDR when the security lamp switches on.

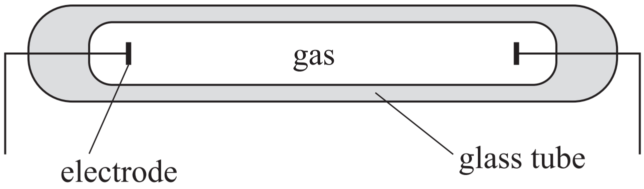
(3)

Resistance = ...

(Total for Question 16 = 5 marks)

17 In the second half of the 19th century, scientists began to investigate interactions between photons and electrons.

(a) A discharge tube is a glass tube containing gas, as shown.



When the discharge tube is connected into an electrical circuit, the gas atoms emit photons. The photons have specific frequencies.

(i) One of the emitted photons has an energy of 3.44×10^{-19} J.

Calculate the frequency of this photon.

(2)

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Frequency of photon = ...

*(ii) The electrical circuit applies a large potential difference (p.d.) across the discharge tube.

Explain how the p.d. across the discharge tube causes photons to be emitted by the gas atoms.

(6)

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(b) Photons with energy 4.75 eV are incident on a metal surface. These photons cause electrons to be emitted from the metal surface.

(i) Show that the maximum speed of the emitted electrons is about $5.3 \times 10^5\,m\,s^{-1}$.

work function of metal = 6.30×10^{-19} J

(3)

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(ii) Calculate the de Broglie wavelength of electrons moving at $5.3 \times 10^5\,m\,s^{-1}$.

(2)

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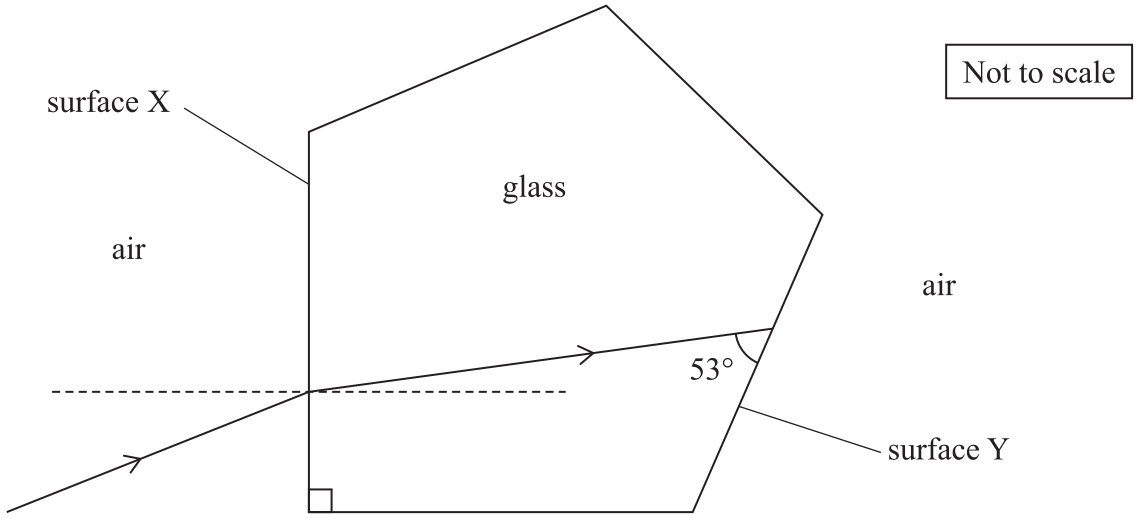
de Broglie wavelength = ...

(Total for Question 17 = 13 marks)

18 A camera includes a five-sided glass prism.

The diagram shows a ray of light incident on the prism at surface X. The ray of light is then transmitted to surface Y.



(a) Explain why the ray of light refracts at surface X, as shown.

(2)

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(b) At surface Y the ray of light must be reflected.

This reflection could be due to total internal reflection.

If the ray of light is not totally internally reflected, the light can be made to reflect by applying a layer of silver to surface Y.

Deduce whether a layer of silver is needed on surface Y.

refractive index of glass used to make prism = 1.52

(4)

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(c) The camera contains a light sensor. The camera can detect the number of photons incident each second on the sensor.

(i) The sensor has a known surface area.

Explain why knowing the number of photons arriving each second at the sensor can **not** be used to determine the intensity of light incident on the sensor.

(2)

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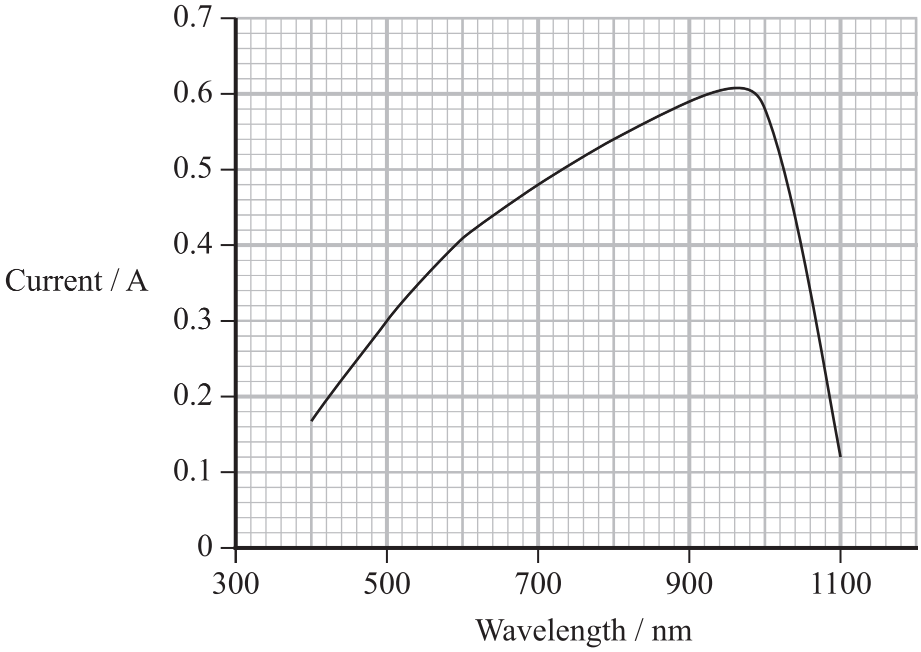
(ii) Light incident on the sensor causes a current in a circuit in the camera.

Light with a power of 1.0 W is incident on the sensor. The graph shows the relationship between the wavelength of the light and the current produced.



The current is proportional to the number of photons detected per second.

Monochromatic light with a wavelength of 600 nm is incident on the sensor. The power of the light is 1.0 W.

Determine the percentage of photons that are detected by the sensor.

(5)

Percentage of photons detected = ...

(Total for Question 18 = 13 marks)

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

List of data, formulae and relationships

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

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 $F = 6\pi\eta rv$

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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