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 17 May 2023

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, 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

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 Waves may spread out as they pass an object.

Which of the following is the name of this process?

☒ **A** diffraction

☒ **B** interference

☒ **C** reflection

☒ **D** refraction

(Total for Question 1 = 1 mark)

2 The time period of a wave decreases.

Which of the following properties of the wave increases?

☒ **A** amplitude

☒ **B** frequency

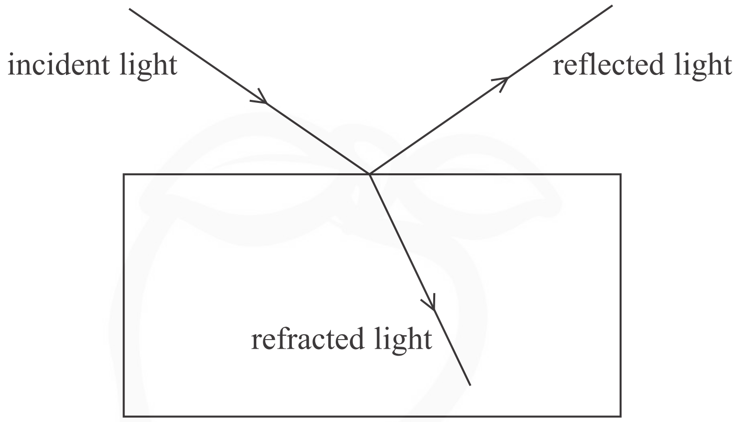
☒ **C** speed

☒ **D** wavelength

(Total for Question 2 = 1 mark)

P 7 1 9 4 6 A 0 2 2 8

3 Monochromatic light is incident on a rectangular glass block. Some of the light is reflected and some of the light is refracted, as shown.



Which of the following properties does **not** decrease when the light is refracted?

☒ **A** frequency

☒ **B** intensity

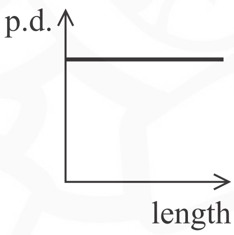
☒ **C** speed

☒ **D** wavelength

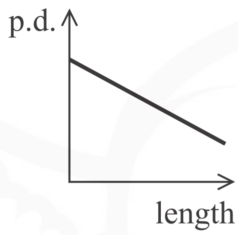
(Total for Question 3 = 1 mark)

4 The current in a length of uniform wire is constant.

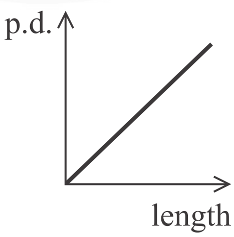
Which of the following graphs shows how the potential difference (p.d.) across the wire varies with the length of the wire?



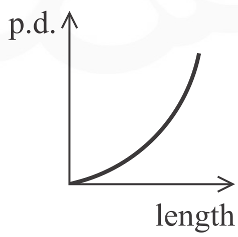
☒ **A**



☒ **B**



☒ **C**



☒ **D**

(Total for Question 4 = 1 mark)

5 An electron has a de Broglie wavelength of 1.55×10^{-9} m.

Which of the following gives the speed, in $m\,s^{-1}$, of this electron?

☒ **A** $\dfrac{9.11 \times 10^{-31}}{6.63 \times 10^{-34} \times 1.55 \times 10^{-9}}$

☒ **B** $\dfrac{1.55 \times 10^{-9} \times 9.11 \times 10^{-31}}{6.63 \times 10^{-34}}$

☒ **C** $\dfrac{6.63 \times 10^{-34} \times 1.55 \times 10^{-9}}{9.11 \times 10^{-31}}$

☒ **D** $\dfrac{6.63 \times 10^{-34}}{1.55 \times 10^{-9} \times 9.11 \times 10^{-31}}$

(Total for Question 5 = 1 mark)

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6 Two waves, of wavelength 12 cm, leave a source in phase.

The waves travel along different paths to a point X. The path difference at X is 18 cm.

Which of the following is the phase difference between the two waves at X?

☒ **A** 0 radians

☒ **B** $\dfrac{\pi}{2}$ radians

☒ **C** π radians

☒ **D** $\dfrac{3\pi}{2}$ radians

(Total for Question 6 = 1 mark)

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7 Two waves are coherent.

Which of the following **must** be true for the two waves?

☒ **A** They are in antiphase with each other.

☒ **B** They are in phase with each other.

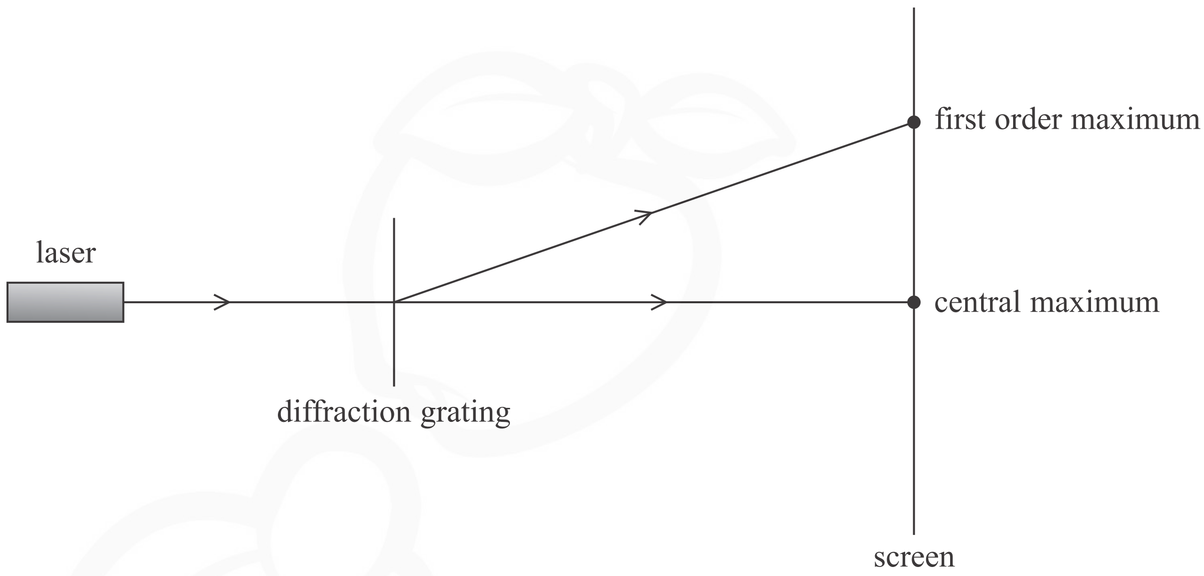
☒ **C** They have the same amplitude.

☒ **D** They have the same frequency.

(Total for Question 7 = 1 mark)

8 Light from a laser is incident on a diffraction grating, causing a series of maxima to be seen on a screen.

The positions of the central maximum and first order maximum are shown.



Which of the following changes would decrease the distance between the central maximum and the first order maximum?

☒ **A** Decreasing the distance from the laser to the diffraction grating

☒ **B** Increasing the distance from the diffraction grating to the screen

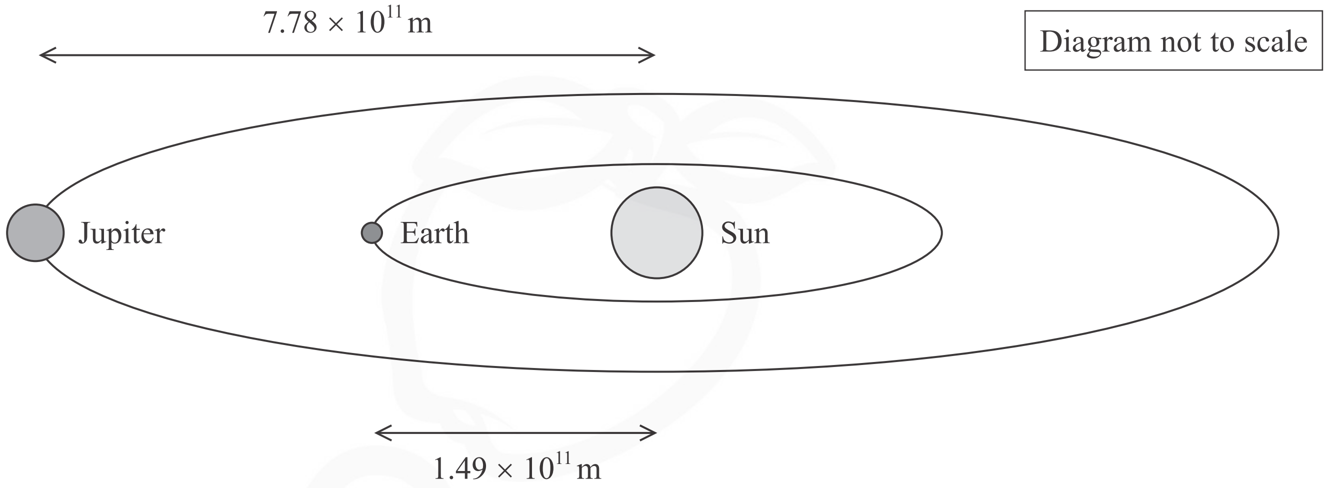
☒ **C** Using a diffraction grating with more lines per millimetre

☒ **D** Using light with a smaller wavelength

(Total for Question 8 = 1 mark)

9 Earth and Jupiter orbit the Sun, as shown.

The distance from Earth to the Sun is 1.49×10^{11} m.
The distance from Jupiter to the Sun is 7.78×10^{11} m.



The intensity of sunlight at Jupiter is I_J.

Which of the following can be used to calculate the intensity of the sunlight at Earth?

☒ **A** $I_J \times \dfrac{(7.78 \times 10^{11})^2}{(1.49 \times 10^{11})^2}$

☒ **B** $I_J \times 4\pi \times \dfrac{(7.78 \times 10^{11})^2}{(1.49 \times 10^{11})^2}$

☒ **C** $I_J \times \dfrac{7.78 \times 10^{11}}{1.49 \times 10^{11}}$

☒ **D** $I_J \times 4\pi \times \dfrac{7.78 \times 10^{11}}{1.49 \times 10^{11}}$

(Total for Question 9 = 1 mark)

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10 As the temperature of the filament in a bulb decreases, the resistance of the filament changes.

Which of the following is the reason for this change in resistance of the filament?

☒ **A** Lattice vibrations decrease

☒ **B** Lattice vibrations increase

☒ **C** Number of conduction electrons decreases

☒ **D** Number of conduction electrons increases

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

SECTION B

Answer ALL questions in the spaces provided.

11 Part of an electrical circuit is shown.

In 60 seconds, 4.80×10^{20} electrons pass point Z.

(a) Show that the current at Z is about 1.3 A.

(3)

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(b) In 60 seconds, the resistor transfers 24 J of energy.

Calculate the potential difference across the resistor.

(2)

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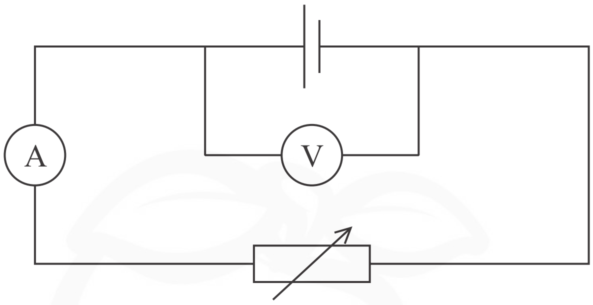
Potential difference = ...

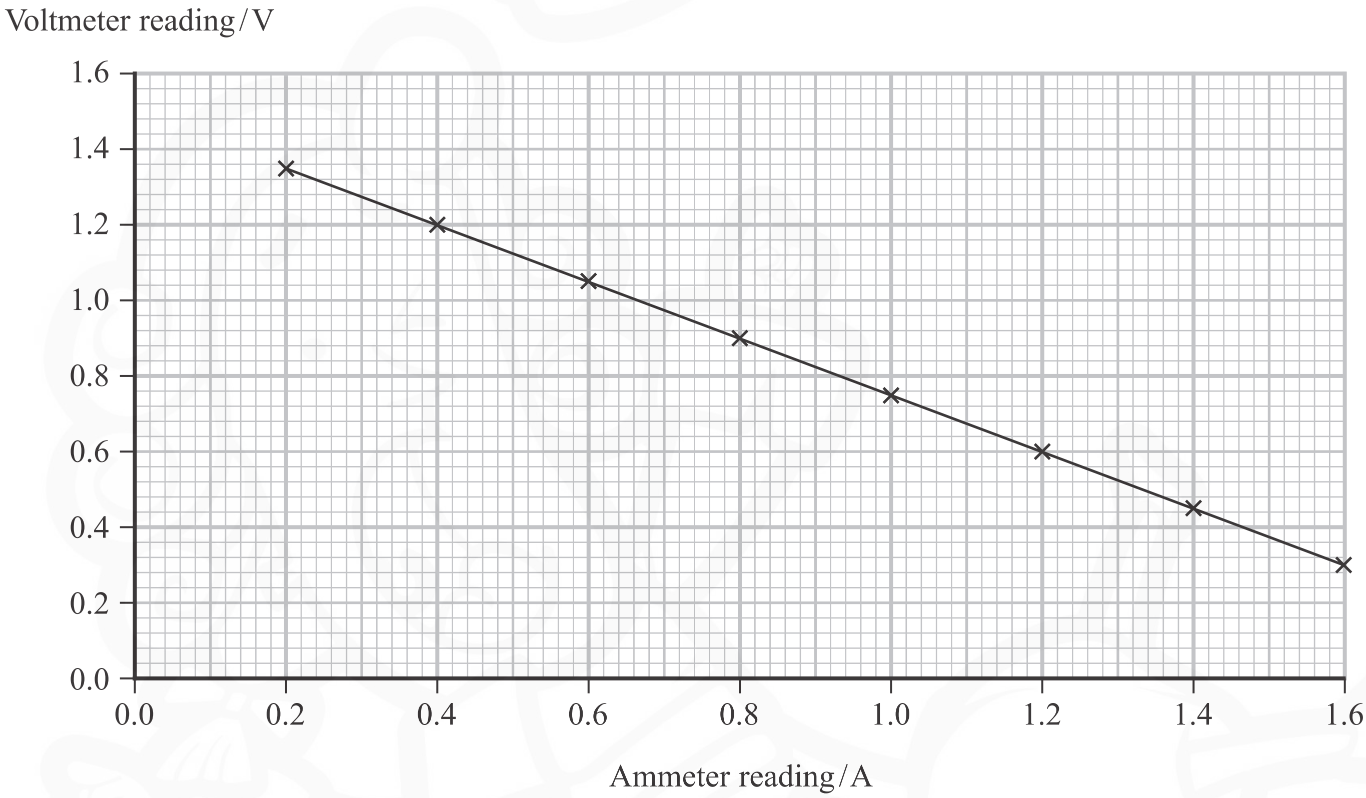
(Total for Question 11 = 5 marks)

12 A student investigated the internal resistance of a cell, using the circuit shown.



The student used the variable resistor to vary the reading on the ammeter. He recorded corresponding readings from the voltmeter.

The student plotted the results on a graph, as shown.



(a) Determine the e.m.f. ε of the cell, and the internal resistance r of the cell.

(3)

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ε = ...

r = ...

(b) The student placed an identical cell in series with the original cell in the circuit. He connected the voltmeter across both cells and repeated the investigation.

The student plotted a new graph of these voltmeter and ammeter readings.

Describe how the new graph is different from the graph for one cell.

(2)

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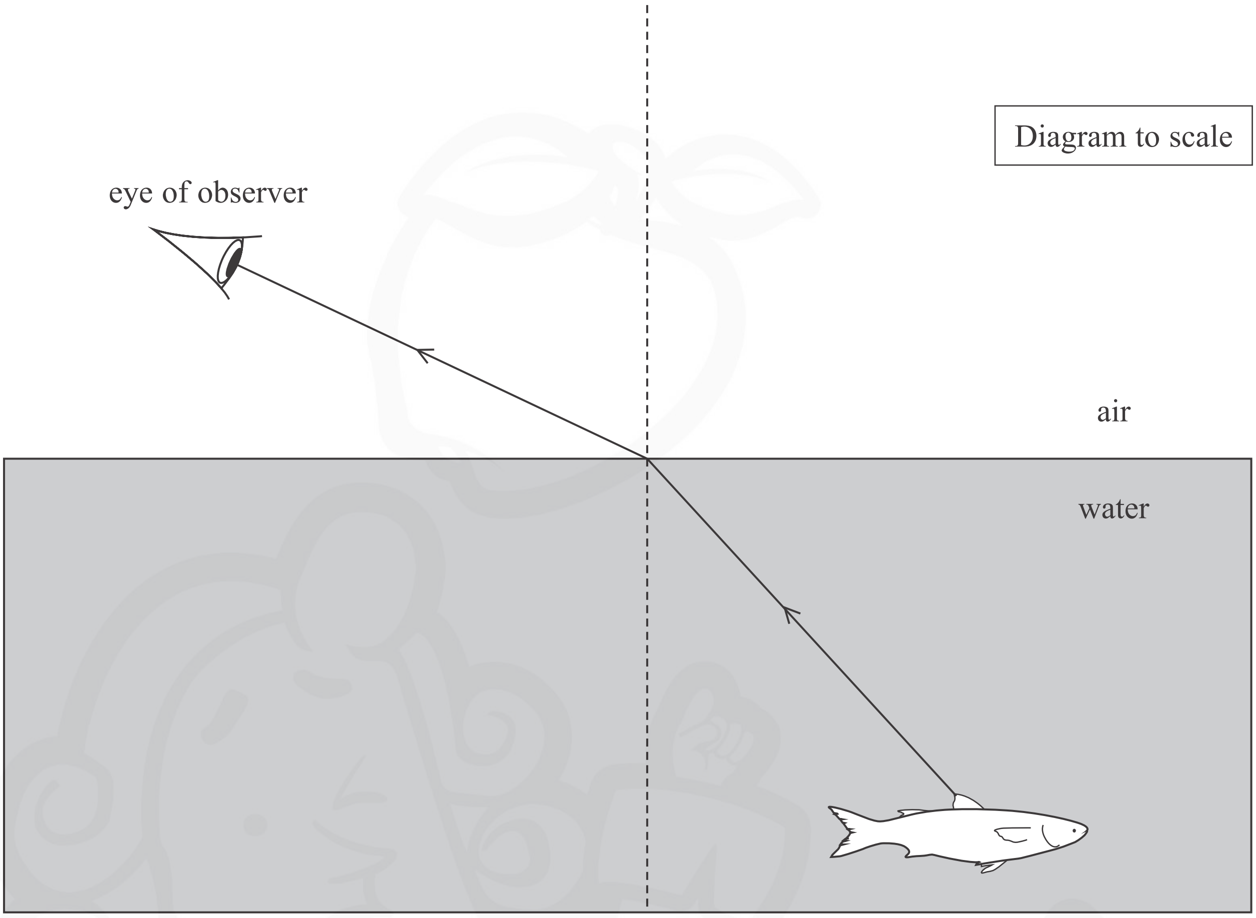
(Total for Question 12 = 5 marks)

13 The diagram shows a ray of light travelling from a fish to an observer. The ray of light refracts at the water-air boundary.



(a) Determine the refractive index of the water.

You should take measurements from the diagram.

(3)

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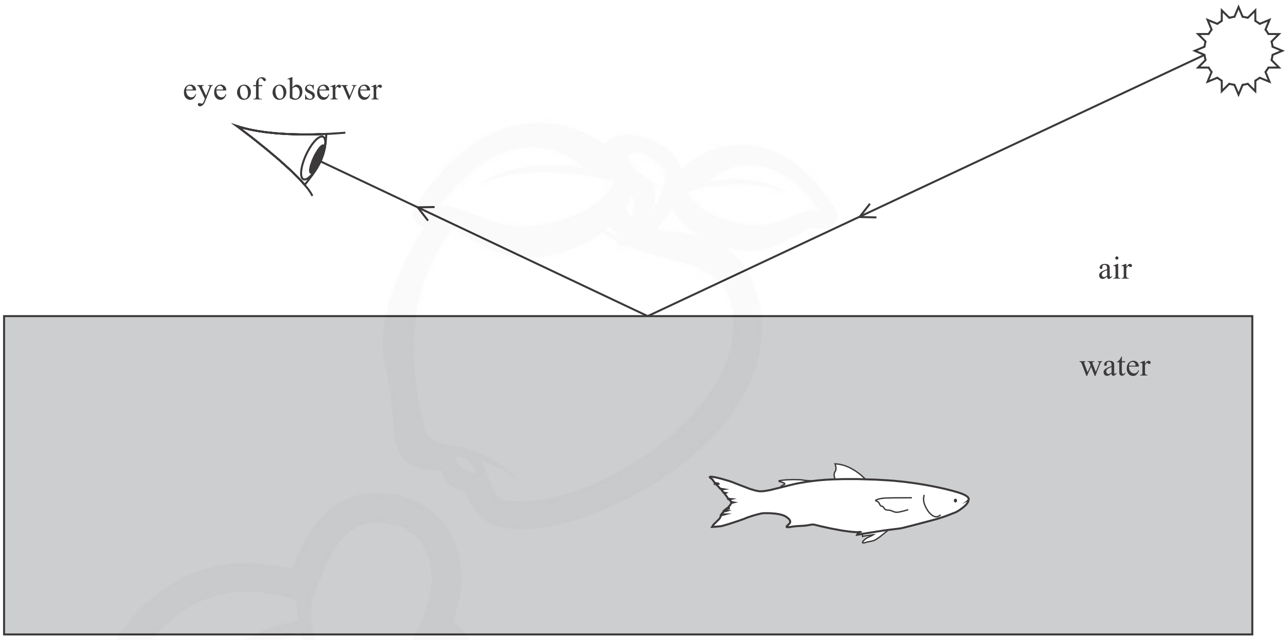
Refractive index = ...

(b) The diagram shows light from the Sun reflecting from the water surface into the eye of the observer.



The reflected light is partially plane polarised.

(i) Explain the difference between unpolarised and plane polarised light.

(3)

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(ii) Reducing the intensity of the reflected light would help the observer see the fish.

Explain how the observer can use a polarising filter to reduce the intensity of the reflected light.

(2)

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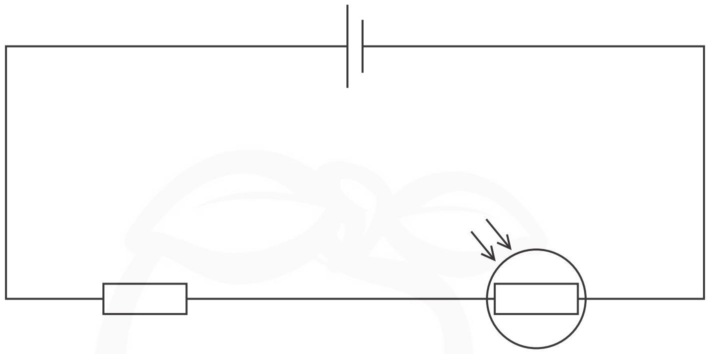
(Total for Question 13 = 8 marks)

***14** The circuit shown contains a fixed resistor and a light dependent resistor (LDR).



Explain why the power dissipated by the whole circuit changes as the intensity of the light incident on the LDR increases.

You should refer to why the resistance of an LDR changes as light intensity increases.

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(Total for Question 14 = 6 marks)

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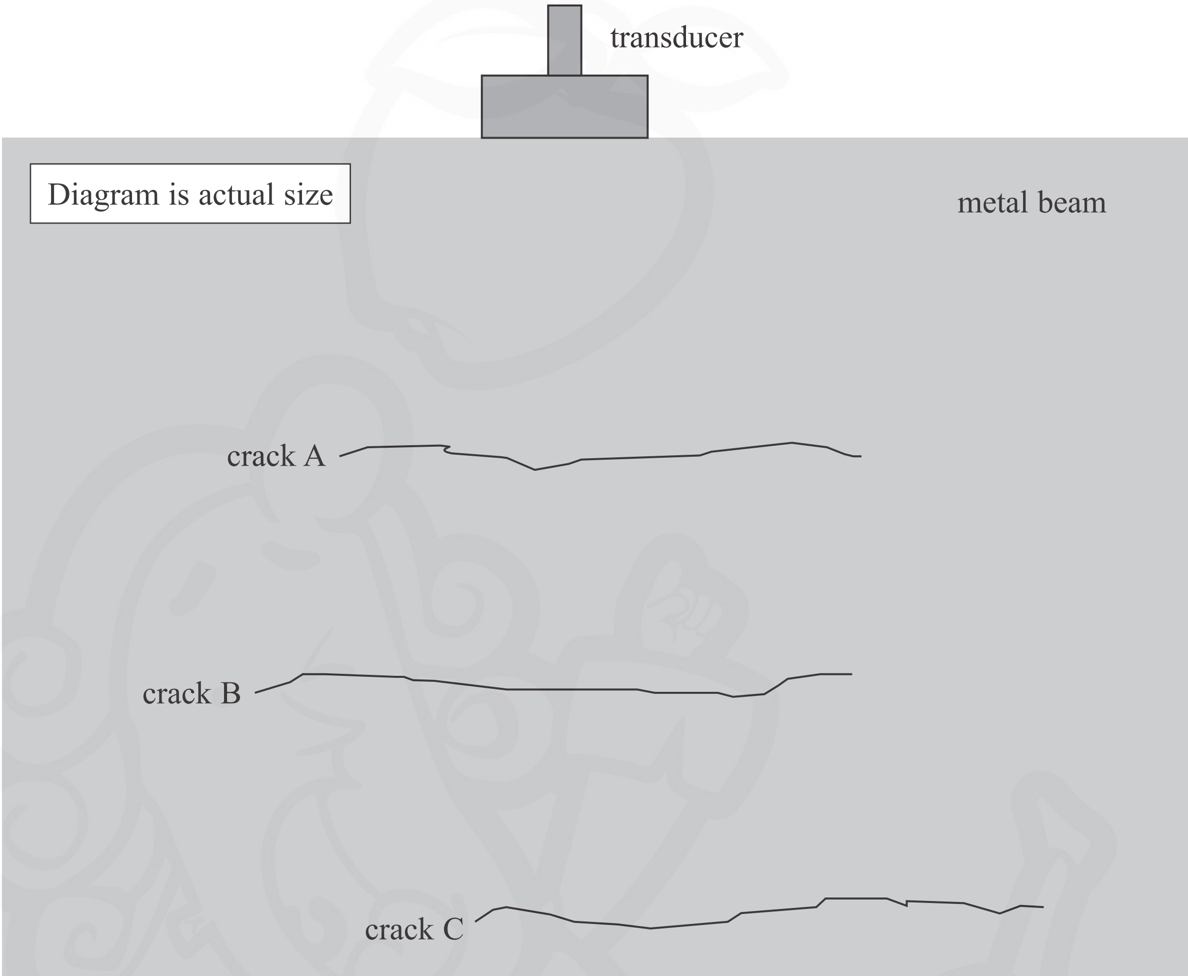
15 Ultrasound can be used to check for cracks in metal beams.

A transducer emits a pulse of ultrasound into a metal beam. The same transducer detects the returning pulses.

Part of a metal beam is shown. The beam contains three cracks, A, B and C.



The transducer detects a returning pulse from each crack.

(a) Explain why there is a returning pulse from crack B.

(3)

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(b) One pulse returns 1.4×10^{-5} s after being emitted by the transducer.

Deduce whether the pulse has returned from crack A, crack B or crack C.

You should take measurements from the diagram.

speed of ultrasound in metal = $5900\,\text{m}\,\text{s}^{-1}$

(3)

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(c) Explain why ultrasound used to detect cracks in metal beams usually has frequencies of MHz, rather than kHz.

(2)

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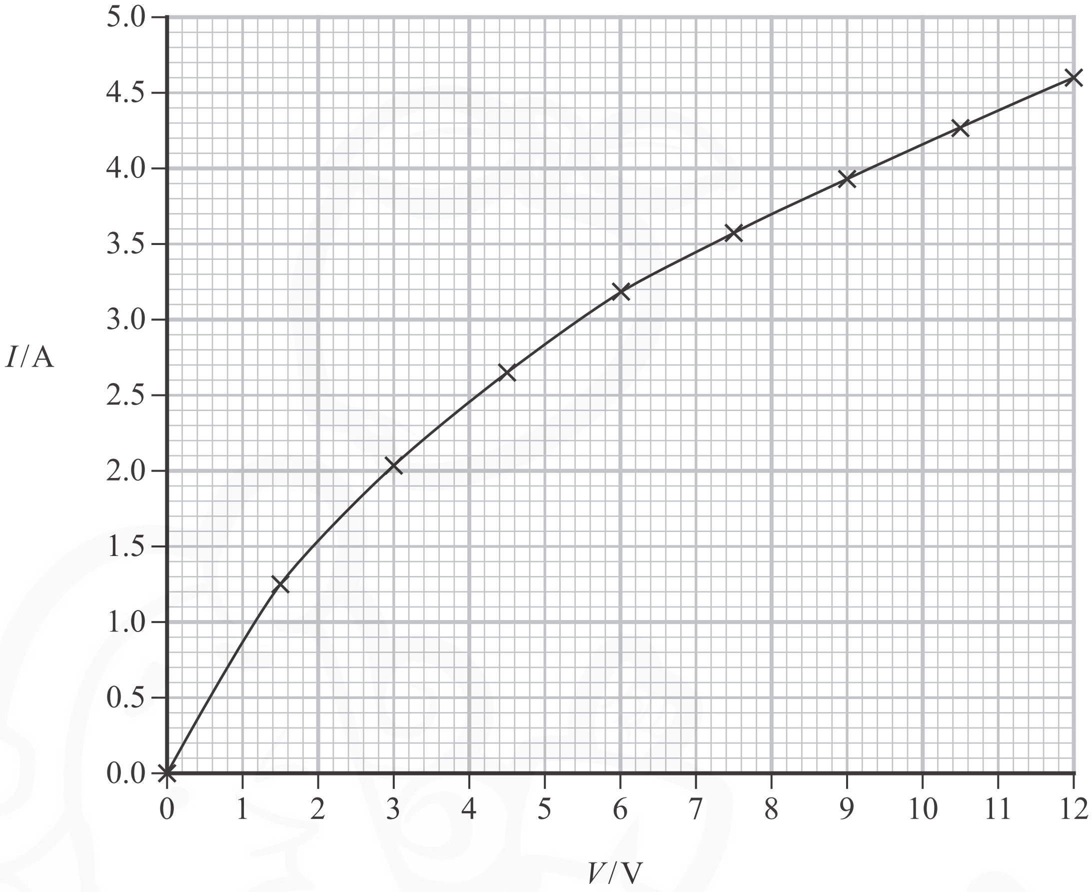
(Total for Question 15 = 8 marks)

16 Drivers use car headlights to emit light in dark conditions.

The graph shows how current I varies with potential difference V for a car headlight.



The headlight will emit light when it dissipates at least 35 W of power.

(a) Determine the minimum potential difference for which the headlight will emit light.

(3)

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Minimum potential difference = ... V

(b) In a car, two headlights are connected in parallel with a 12.0 V battery. The battery has negligible internal resistance.

(i) Explain the advantages of connecting the headlights in parallel with the battery rather than in series.

(3)

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(ii) A student writes the following statement.

When connected to the 12.0 V battery, the combined resistance of two headlights in parallel is one quarter of the combined resistance of two headlights in series.

Deduce whether the student is correct.

Your answer should include calculations using data from the graph.

(3)

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(c) The headlights are connected in the circuit using copper wire. The current in the wire is 4.60 A.

Calculate the drift velocity of electrons in the copper wire.

number of charge carriers per m^3 of copper = $8.49 \times 10^{28}\,m^{-3}$
resistivity of copper = $1.72 \times 10^{-8}\,\Omega\,m$
resistance per unit length of the copper wire = $1.75 \times 10^{-2}\,\Omega\,m^{-1}$

(3)

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Drift velocity = ...

(Total for Question 16 = 12 marks)

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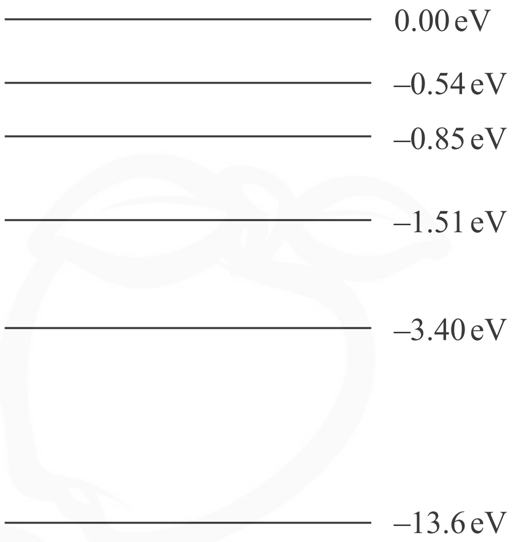
17 The diagram shows the energy levels for an atom of hydrogen.



An electron is in the −13.6 eV (ground state) level of this atom.

(a) A photon interacts with this electron.

Explain why this interaction causes the emission of another photon.

(2)

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(b) A photon has a wavelength of 218 nm.

(i) Determine the energy, in eV, of this photon.

(4)

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Photon energy = ... eV

(ii) Explain whether the atom of hydrogen could emit a photon with this energy.

(2)

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(c) Photons with energy 1.63×10^{-18} J are incident upon the surface of a metal plate. The metal surface releases electrons due to the photoelectric effect.

(i) Calculate the maximum possible speed of the electrons.

work function = 5.89×10^{-19} J

(3)

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Maximum possible speed of the electrons = ...

(ii) Explain why the photoelectric effect demonstrates light behaving as a particle, rather than a wave.

(3)

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(Total for Question 17 = 14 marks)

18 The photograph shows a musical instrument called a violin.

The violin has four strings. Each string is held in a fixed position by a peg and at the bridge.

When a string is plucked, a stationary wave forms on the string.

(a) Explain how a stationary wave forms on the string.

(3)

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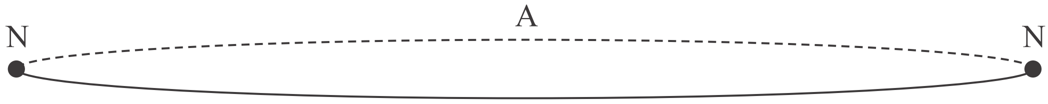
(b) The simplest stationary wave that can be formed on the string has a node (N) at each end and an antinode (A) at the centre, as shown.



The frequency of this wave is called the fundamental frequency.

The strings on a violin have different fundamental frequencies, as shown in the table.

String	**Fundamental frequency / Hz**
1	196
2	294
3	440
4	659

The tension in one of the strings is 71.5 N. The length of the string is 32 cm and the mass per unit length of the string is $2.03 \times 10^{-3}\,\text{kg}\,\text{m}^{-1}$.

Deduce whether this is string 1, 2, 3 or 4.

(4)

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(c) The stationary wave on the string causes sound waves to be transmitted through the air.

Describe the similarities and differences between the stationary wave on the string and the sound waves transmitted through the air.

(5)

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(Total for Question 18 = 12 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 $\varepsilon = \frac{\Delta x}{x}$

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	$\lambda = \frac{h}{p}$