Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Tuesday 15 October 2024

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

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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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 Which of the following describes light intensity?

☒ **A** The energy of light incident on a surface per unit area

☒ **B** The power of light incident on a surface per unit area

☒ **C** The total energy output of a light source

☒ **D** The total power output of a light source

(Total for Question 1 = 1 mark)

2 Light from a discharge tube is viewed through a diffraction grating. An emission line spectrum is observed.

Which of the following explains how electrons in the discharge tube produce the emission line spectrum?

☒ **A** Excited electrons move to higher energy levels and absorb photons.

☒ **B** Excited electrons move to higher energy levels and emit photons.

☒ **C** Excited electrons move to lower energy levels and absorb photons.

☒ **D** Excited electrons move to lower energy levels and emit photons.

(Total for Question 2 = 1 mark)

3 A student stands a distance d from a wall. She makes a loud sound. She hears the echo of the sound from the wall after a time t.

Which of the following expressions gives the speed of the sound wave?

☒ **A** $\frac{2d}{t}$

☒ **B** $\frac{d}{t}$

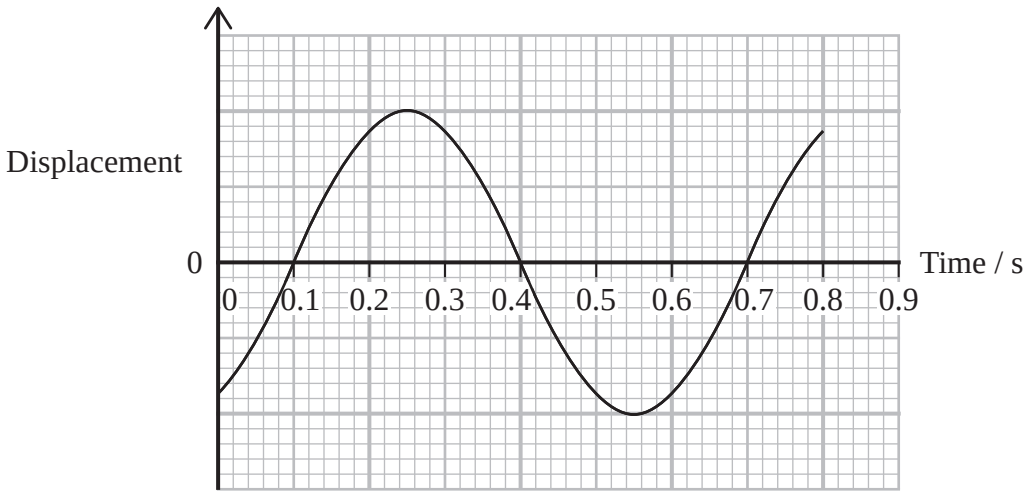
☒ **C** $\frac{d}{2t}$

☒ **D** $\frac{2t}{d}$

(Total for Question 3 = 1 mark)

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4 A displacement-time graph for a point on the surface of a water wave is shown.



Which of the following expressions gives the frequency of the wave in Hz?

☒ **A** $\frac{1}{0.7}$

☒ **B** $\frac{1}{(0.7 - 0.1)}$

☒ **C** $\frac{1}{0.4}$

☒ **D** $\frac{1}{(0.4 - 0.1)}$

(Total for Question 4 = 1 mark)

5 A current in a wire causes the temperature of the wire to increase.

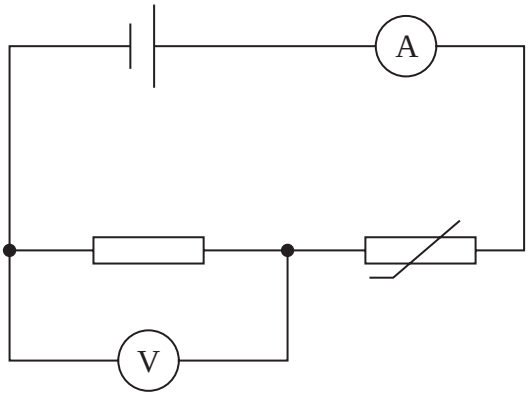
Which row of the table describes the changes to the wire as the temperature increases?

	Amplitude of lattice vibrations in the wire	Resistance of the wire
☒ **A**	decreases	decreases
☒ **B**	increases	decreases
☒ **C**	decreases	increases
☒ **D**	increases	increases

(Total for Question 5 = 1 mark)

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6 The circuit shown includes a thermistor.



The temperature of the thermistor increases.

Which row of the table shows how the readings on the ammeter and voltmeter change?

		Ammeter reading	Voltmeter reading
☒	**A**	decreases	decreases
☒	**B**	decreases	increases
☒	**C**	increases	decreases
☒	**D**	increases	increases

(Total for Question 6 = 1 mark)

7 Particle X of mass m is moving with velocity v and has a de Broglie wavelength λ.

Particle Y has a de Broglie wavelength 0.25λ.

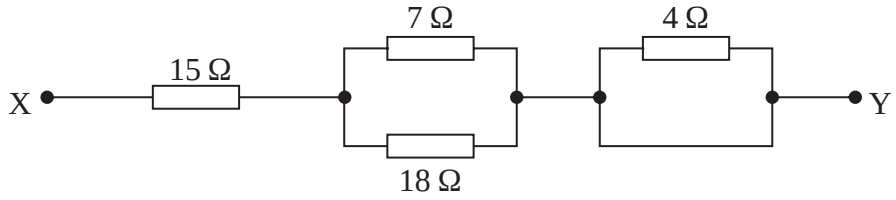
Which row of the table could give the mass and velocity of particle Y?

		Mass	Velocity
☒	**A**	$0.25m$	v
☒	**B**	$0.5m$	$8v$
☒	**C**	m	$2v$
☒	**D**	$2m$	$4v$

(Total for Question 7 = 1 mark)

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8 A student connects four resistors between points X and Y, as shown.



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

☒ **A** $15 + \frac{1}{7} + \frac{1}{18}$

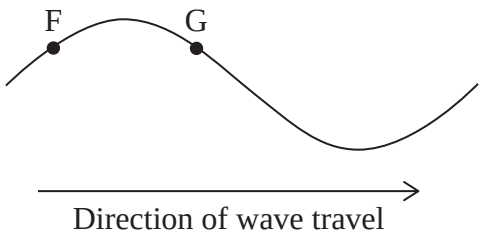
☒ **B** $15 + \frac{1}{7} + \frac{1}{18} + 4$

☒ **C** $15 + \frac{1}{\left(\frac{1}{7} + \frac{1}{18}\right)}$

☒ **D** $15 + \frac{1}{\left(\frac{1}{7} + \frac{1}{18}\right)} + \frac{1}{4}$

(Total for Question 8 = 1 mark)

9 A wave is moving along a length of string in the direction shown.



F and G are two points on the string.

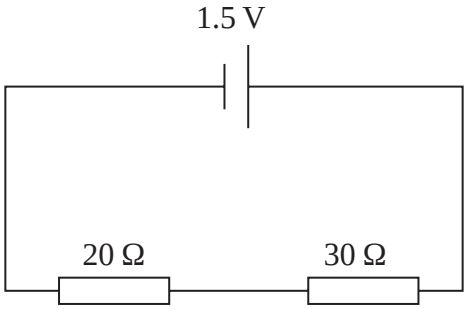
Which row of the table describes the movement of F and G as one complete wave passes?

	F	G
☒ **A**	Down then up	Down then up
☒ **B**	Down then up	Up then down
☒ **C**	Down, then up, then down	Up, then down, then up
☒ **D**	Up, then down, then up	Down, then up, then down

(Total for Question 9 = 1 mark)

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10 The circuit shows a cell connected to two resistors. The cell has negligible internal resistance.



Which of the following expressions gives the power, in watts, transferred by the 20 Ω resistor?

☒ **A** $\frac{1.5}{(20 + 30)}$

☒ **B** $\frac{1.5 \times 20}{(20 + 30)}$

☒ **C** $\frac{1.5}{(20 + 30)} \times \frac{1.5 \times 20}{(20 + 30)}$

☒ **D** $\frac{(20 + 30)}{1.5} \times \frac{(20 + 30)}{1.5 \times 20}$

(Total for Question 10 = 1 mark)

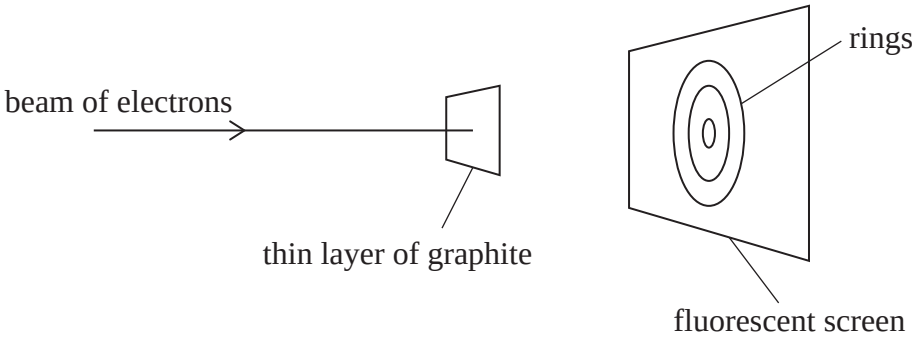
TOTAL FOR SECTION A = 10 MARKS

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SECTION B

Answer ALL questions in the spaces provided.

11 A beam of electrons passes through a thin layer of graphite. The electrons are then incident on a fluorescent screen, causing a series of rings to form, as shown.



Explain what the rings show about the nature of electrons.

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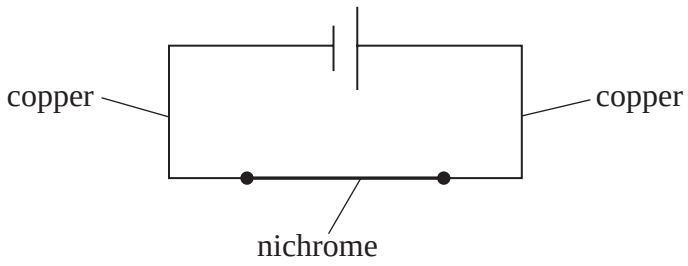
(Total for Question 11 = 2 marks)

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12 Copper wires are used to connect a length of nichrome wire to a cell, as shown.



The copper wires and the nichrome wire have the same diameter.
Copper has a greater number of conduction electrons per metre cubed than nichrome.

Explain how the average velocity of electrons in the copper wires compares with the average velocity of electrons in the nichrome wire.

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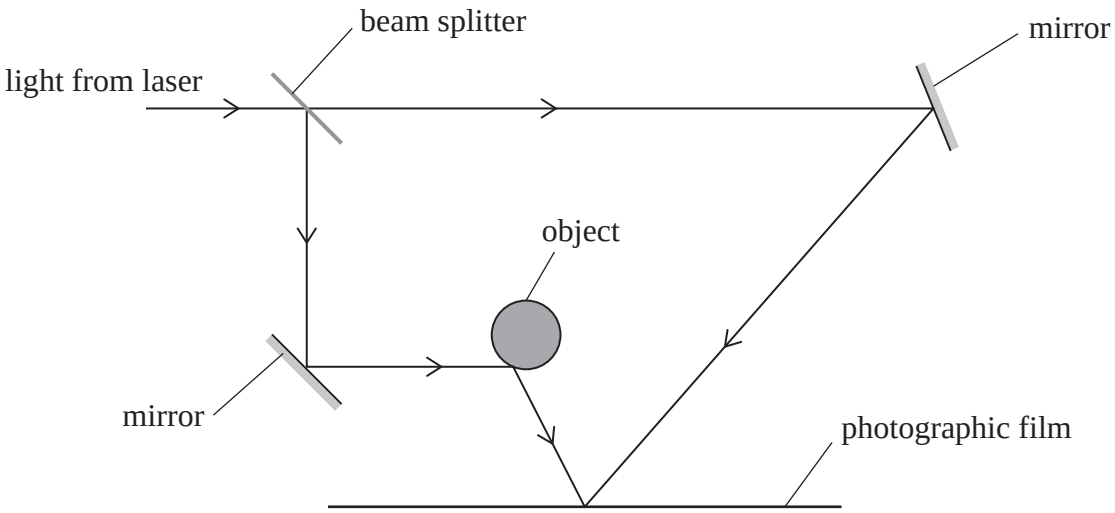
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(Total for Question 12 = 3 marks)

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13 A hologram is an interference pattern that can produce a three-dimensional image.

To form a hologram, a beam of light from a laser is split by a beam splitter. The light then takes two different paths to a photographic film, as shown.



(a) Light is a transverse wave.

State what is meant by a transverse wave.

(1)

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(b) Light arrives at the photographic film from the two paths.

Explain how this could cause constructive interference.

(3)

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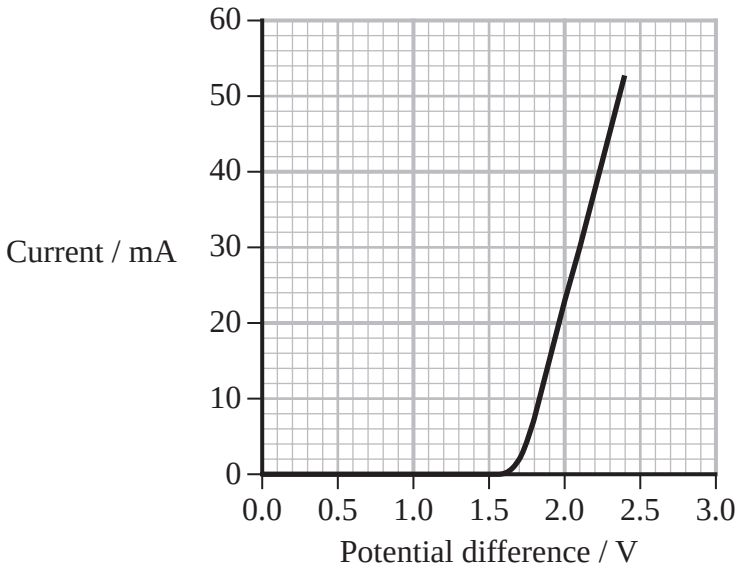
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(Total for Question 13 = 4 marks)

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14 A student investigated the electrical properties of a light emitting diode (LED).

He varied the potential difference (p.d.) across the LED, and recorded corresponding values of the current in the LED. The graph shows the results.



(a) Draw a circuit diagram the student could use for this investigation.

(3)

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(b) Determine the power of the LED when the p.d. across the LED was 2.2 V.

(3)

Power = ...

(c) The student increased the p.d. across the LED from 0 V to 2.4 V.

Describe, without further calculations, how the resistance of the LED changed.

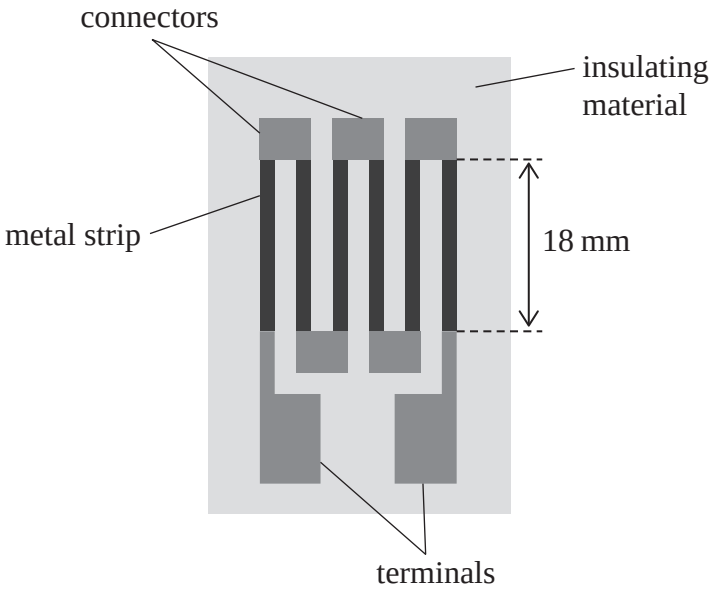
(2)

(Total for Question 14 = 8 marks)

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15 A strain gauge is an electrical component that can be attached to an object to measure mechanical strain.

The strain gauge shown has 6 metal strips attached to a small piece of insulating material. The metal strips are joined together by connectors. The initial length of each metal strip is 18 mm.



(a) Each metal strip has a rectangular cross-section of width 1.40 mm and thickness 0.23 mm.

The resistance between the terminals is 0.16 Ω.

The connectors and terminals have negligible resistance.

Determine the resistivity of the metal used to make the strips.

(4)

Resistivity = ...

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(b) The strain gauge is stretched and the length l of the metal strips increases. The metal strips change shape uniformly along their length.

Explain why a graph of the resistance of the strain gauge against l^2 would be a straight line.

The temperature of the metal strips is constant.
Assume that the volume of each metal strip is constant.

(3)

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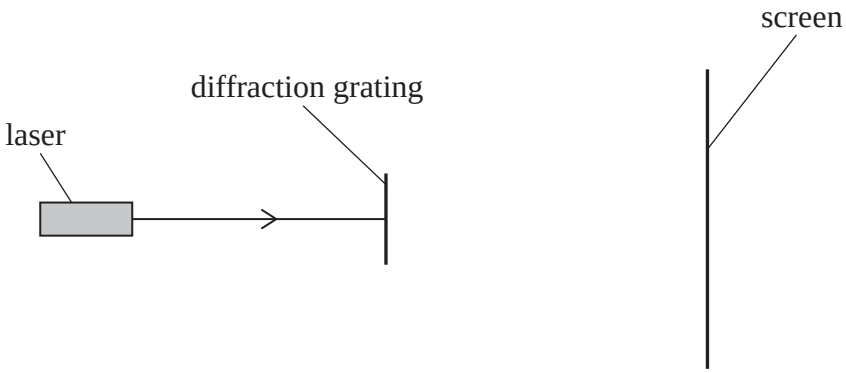
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(Total for Question 15 = 7 marks)

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16 A student investigated the diffraction of light from a laser using a diffraction grating.

The diffraction grating has 250 lines per mm. The diagram shows the arrangement used.



(a) Give **one** safety precaution the student should take during the experiment.

(1)

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(b) State what measurements the student should make to determine the wavelength of the light from the laser.

(2)

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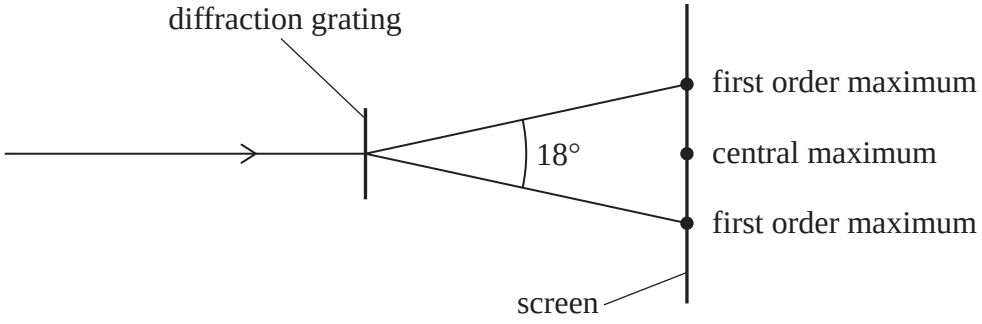
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(c) The student observed the two first order maxima.

The angle between the two first order maxima was 18°, as shown.



(i) Show that the wavelength of the light from the laser is about 600 nm.

(4)

(ii) The student observed maxima beyond the first order.

Determine the greatest order of maximum that the student could observe.

(2)

Greatest order of maximum = ...

(Total for Question 16 = 9 marks)

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17 The refractive index of water is 1.33

(a) Calculate the speed of light in water.

(2)

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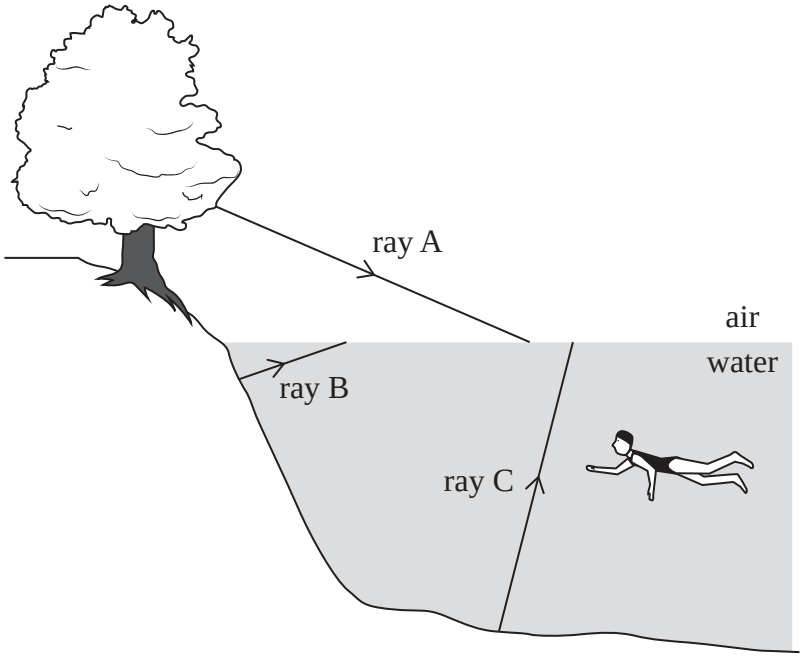
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Speed of light in water = ...

*(b) A person is swimming underwater in a lake. The person looks up towards the surface.

Three rays of light, A, B and C, are incident on the surface of the water, as shown.



Each ray changes direction at the surface of the water.

Light from rays A and B reaches the person's eyes.
Most of the light from ray C does **not** reach the person's eyes.

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Explain the paths of rays A, B and C after each ray changes direction at the surface of the water.

(6)

(Total for Question 17 = 8 marks)

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18 The photograph shows the Golden Gate Bridge in San Francisco, USA.

The bridge has two main cables. Attached to these cables are smaller suspending cables, which support the road.



(Source: © Don White / Getty Images)

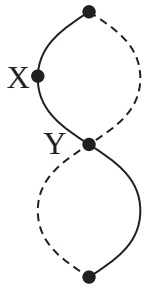
Wind causes each suspending cable to oscillate, so standing waves form on the suspending cables.

(a) Explain how a standing wave can form on a cable that is fixed at both ends.

(3)

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(b) The diagram shows a standing wave on a cable that is fixed at both ends. X and Y are two points on the cable.



Describe the motion of points X and Y on the cable.

(3)

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(c) In strong winds, the Golden Gate Bridge emits a humming sound.

(i) One of the suspending cables on the bridge has a mass of 2.10×10^3 kg and a length of 87.0 m.

Show that the mass per unit length μ of the cable is about 24 kg m^{-1}.

(2)

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(ii) The lowest frequency of the humming sound produced by the bridge is 280 Hz.

The total mass of the road on the bridge is 140×10^6 kg.

The weight of the road is supported equally by 500 suspending cables.

The range of lengths of the suspending cables is from 3.5 m to 160 m.

The value of μ for all of the suspending cables is 24 kg m^{-1}.

Deduce whether the lowest frequency standing waves on the suspending cables could be producing the humming sound.

(6)

(Total for Question 18 = 14 marks)

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19 A photomultiplier is a device that can detect very low intensity light.
In a photomultiplier, a metal plate called a photocathode is connected to the negative terminal of a power supply.

Electromagnetic radiation incident on the photocathode can cause the photoelectric effect.

(a) Describe the photoelectric effect.

(2)

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(b) The photomultiplier can only detect electromagnetic radiation that causes the photoelectric effect.

Explain why the photomultiplier cannot detect some frequencies of electromagnetic radiation.

(2)

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(c) Visible light has a range of wavelengths from 380 nm to 700 nm.

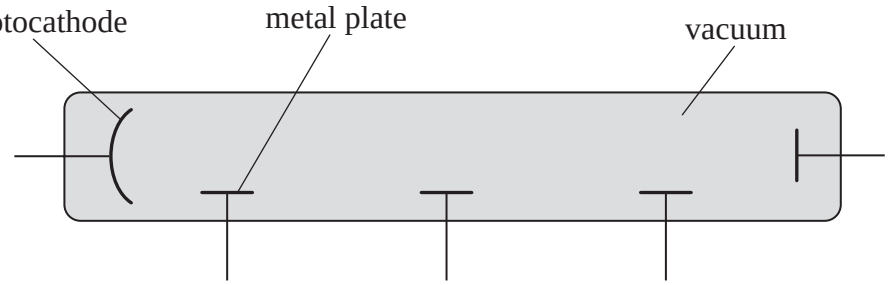
The work function of the material used to make the photocathode is 1.48 eV.

Deduce whether the photomultiplier can detect all wavelengths of visible light.

(4)

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(d) In the photomultiplier, the photocathode and several other metal plates are in a vacuum, as shown.



An electron is emitted from the photocathode with a speed of $1.35 \times 10^6\,\text{m}\,\text{s}^{-1}$.

There is a potential difference (p.d.) of 108 V between the photocathode and the first metal plate. This p.d. causes the kinetic energy of the electron to increase.

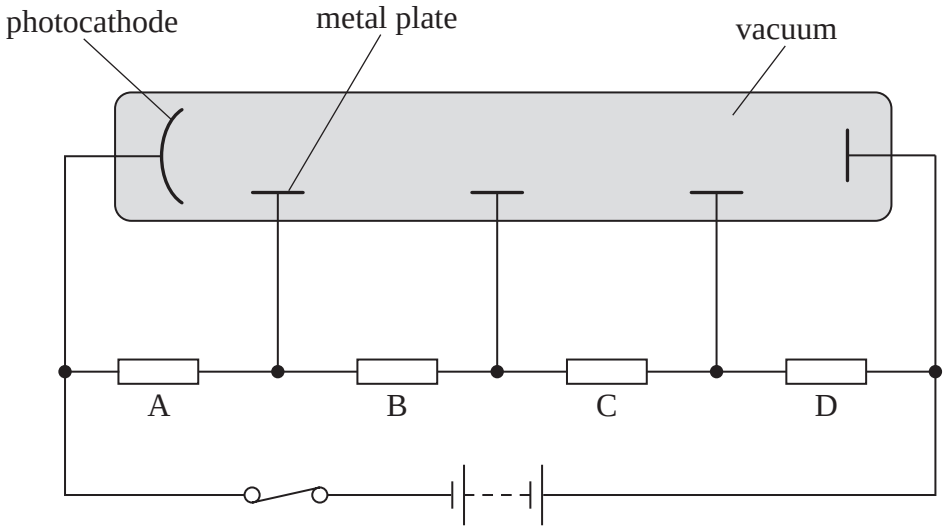
Calculate the kinetic energy, in joules, of the electron at the instant it collides with the first metal plate.

(3)

Kinetic energy = ... J

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(e) The electrical circuit shown includes four resistors, A, B, C and D, which apply a p.d. between adjacent metal plates.



Each resistor has a resistance of 85.0 kΩ.

When the switch is open, the p.d. across the power supply is 1960 V.

When the switch is closed, the p.d. across resistor A is 108 V.

Calculate the internal resistance of the power supply.

(4)

Internal resistance = ...

(Total for Question 19 = 15 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	$g = 9.81 \text{ m s}^{-2}$	(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

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

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

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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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