Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | | | | | | Candidate Number | | | | |

Pearson Edexcel International Advanced Level

Friday 17 January 2025

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

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 the current I in a conductor is $I = nqvA$.

Which of the following gives the meaning of n?

☐ **A** number of conduction electrons in a wire of length 1 m

☐ **B** number of conduction electrons in 1 m^3 of a material

☐ **C** total number of electrons in a wire of length 1 m

☐ **D** total number of electrons in 1 m^3 of a material

(Total for Question 1 = 1 mark)

2 There is a current I in a wire. The charge on an electron is e.

Which of the following gives the number of electrons passing a point on the wire in time t?

☐ **A** Ite

☐ **B** $\frac{I}{te}$

☐ **C** $\frac{Ie}{t}$

☐ **D** $\frac{It}{e}$

(Total for Question 2 = 1 mark)

3 A car has a distance sensor that uses a pulse-echo technique to determine the distance between the car and a nearby object.

The sensor emits a pulse of sound and then detects the echo after time t.
The speed of sound is v.

Which of the following gives the distance between the car and the object?

☐ **A** $2vt$

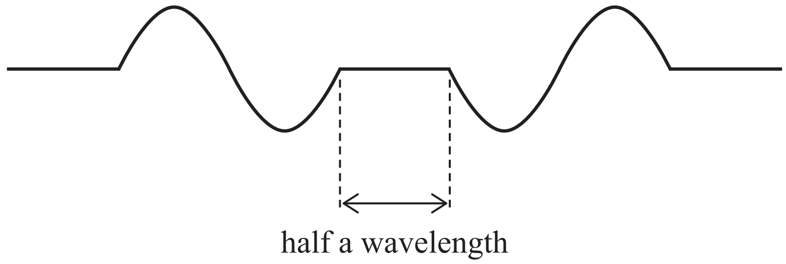
☐ **B** $2vt^{-1}$

☐ **C** $0.5vt$

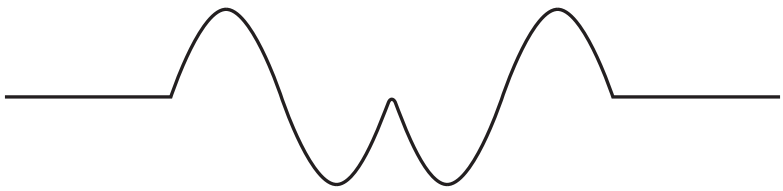
☐ **D** $0.5vt^{-1}$

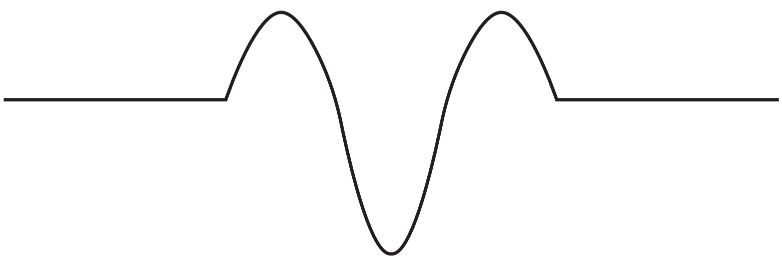
(Total for Question 3 = 1 mark)

4 Two waves on a string move towards each other at the same speed. Both waves have the same wavelength.
The diagram shows the string when the waves are half a wavelength apart.

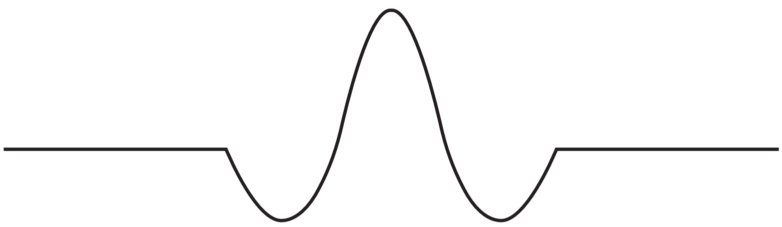


Which of the following shows the string when both waves have moved a distance of half a wavelength?

☒ **A** 

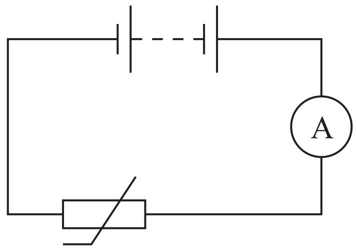
☒ **B** 

☒ **C**

☒ **D** 

(Total for Question 4 = 1 mark)

5 The circuit shown includes a thermistor.

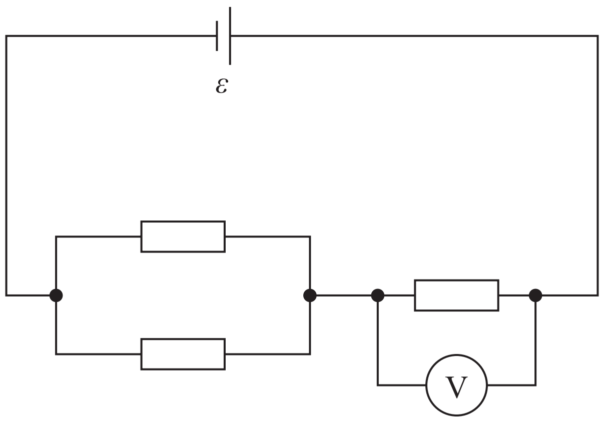


Which of the following explains the change in the ammeter reading as the temperature of the thermistor decreases?

- ☒ **A** The number of conduction electrons decreases so the ammeter reading decreases.
- ☒ **B** The number of conduction electrons decreases so the ammeter reading increases.
- ☒ **C** The number of conduction electrons increases so the ammeter reading decreases.
- ☒ **D** The number of conduction electrons increases so the ammeter reading increases.

(Total for Question 5 = 1 mark)

6 A student connects three identical resistors in the circuit shown.



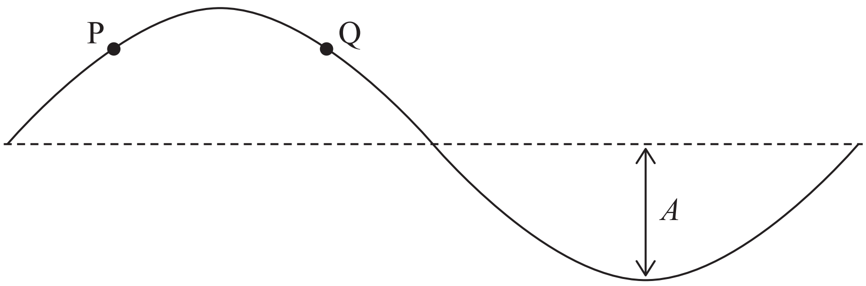
The cell has e.m.f. ε and negligible internal resistance.

Which of the following is equal to the reading on the voltmeter?

- ☒ **A** $\frac{\varepsilon}{2}$
- ☒ **B** $\frac{\varepsilon}{3}$
- ☒ **C** $\frac{2\varepsilon}{3}$
- ☒ **D** $\frac{3\varepsilon}{2}$

(Total for Question 6 = 1 mark)

7 The diagram shows a wave of amplitude *A* on a string.
P and Q are two points on the string.



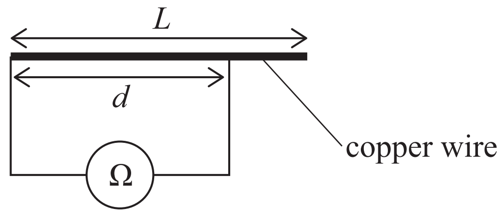
The wave on the string is a stationary wave.

Which row of the table is correct?

		Phase difference between P and Q	Amplitude of oscillation of P and Q
☒	**A**	0°	equal to *A*
☒	**B**	0°	less than *A*
☒	**C**	90°	equal to *A*
☒	**D**	90°	less than *A*

(Total for Question 7 = 1 mark)

8 A student used an ohmmeter to investigate the resistance of a uniform copper wire of length L, as shown.



Length d of the wire has resistance R.

Which of the following gives the total resistance of the copper wire?

☒ **A** $\frac{d}{L} \times \frac{1}{R}$

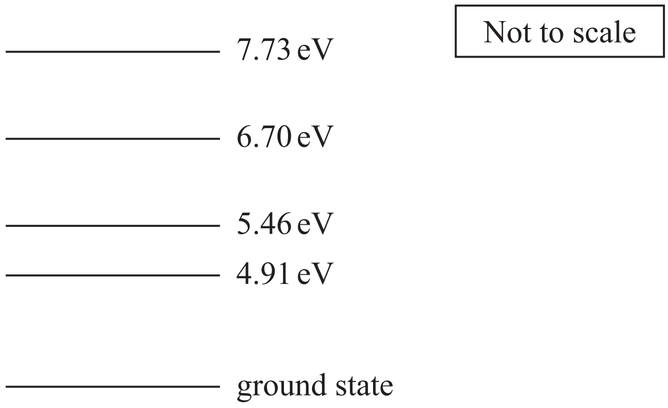
☒ **B** $\frac{d}{L} \times R$

☒ **C** $\frac{L}{d} \times \frac{1}{R}$

☒ **D** $\frac{L}{d} \times R$

(Total for Question 8 = 1 mark)

9 The diagram shows the energy needed for an electron in the ground state of a mercury atom to move to different energy levels.



Photons transfer 8.74×10^{-19} J to electrons in the ground state of mercury atoms.

Which of the following gives the number of different frequencies of light that could be emitted?

☒ **A** 1

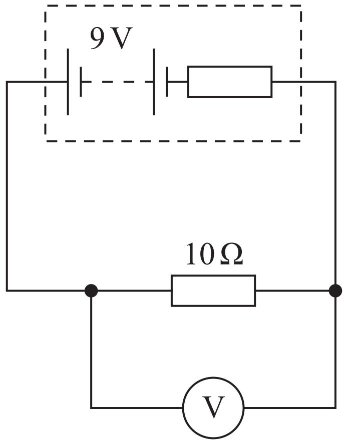
☒ **B** 3

☒ **C** 6

☒ **D** 10

(Total for Question 9 = 1 mark)

10 A student connected the circuit shown.



The reading on the voltmeter was 6 V.

Which of the following expressions gives the internal resistance, in Ω, of the battery?

☒ **A** $\frac{10 \times (9 - 6)}{6}$

☒ **B** $\frac{6 \times (9 - 6)}{10}$

☒ **C** $\frac{10}{6 \times (9 - 6)}$

☒ **D** $\frac{6}{10 \times (9 - 6)}$

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 10 MARKS

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

SECTION B

Answer ALL questions in the spaces provided.

11 An electron is moving with velocity $3.6 \times 10^{7}\,\mathrm{m\,s^{-1}}$.

Calculate the de Broglie wavelength of this electron.

....

....

....

....

....

de Broglie wavelength = ...

(Total for Question 11 = 3 marks)

12 A solar cell of area $6.4\,cm^2$ is used to charge the battery in a watch.

The battery will only charge when the power input to the solar cell is greater than 0.80 W.

Deduce whether the battery will charge when the intensity of light incident on the solar cell is $750\,W\,m^{-2}$.

....

....

....

....

....

....

(Total for Question 12 = 3 marks)

13 An electrical cutting tool uses a heated metal wire to cut polystyrene. The temperature of the metal wire increases when the cutting tool is switched on.

(a) Explain how the resistance of the wire changes as the temperature of the wire increases.

(3)

....

....

....

....

....

....

(b) When the wire is at the correct temperature for cutting, the resistance of the wire is 0.67 Ω.

The wire has a circular cross-section.

Calculate the resistivity of the wire when it is at the correct temperature for cutting.

diameter of wire = 0.51 mm
length of wire = 0.14 m

(3)

....

....

....

....

....

Resistivity = ...

(Total for Question 13 = 6 marks)

14 A student used a diffraction grating to investigate the properties of light.

(a) Light is a transverse wave.

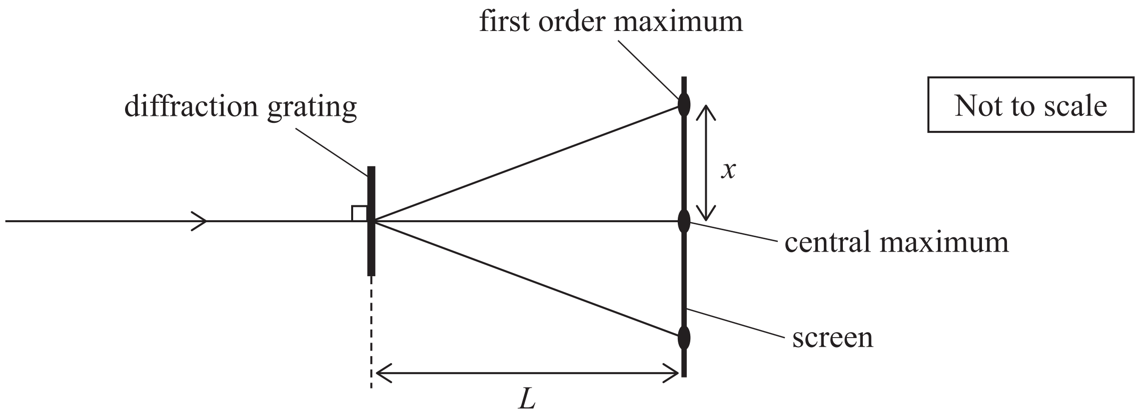
State what is meant by a transverse wave.

(1)

....

....

(b) The student directed monochromatic light of wavelength λ onto the diffraction grating. A series of maxima was produced on a screen a distance L from the diffraction grating, as shown.



The distance between the central maximum and the first order maximum was x.

(i) Calculate the number of lines per mm on the diffraction grating.

λ = 650 nm
L = 1.30 m
x = 0.22 m

(4)

....

....

....

....

....

....

....

Number of lines per mm = ...

(ii) Explain how a first order maximum is produced on the screen.

(3)

....

....

....

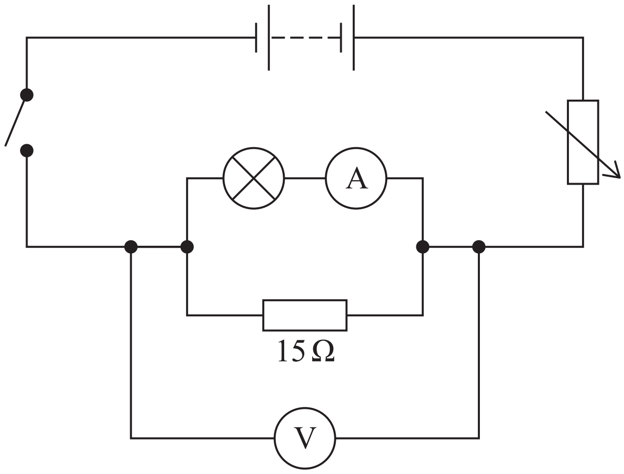
....

....

....

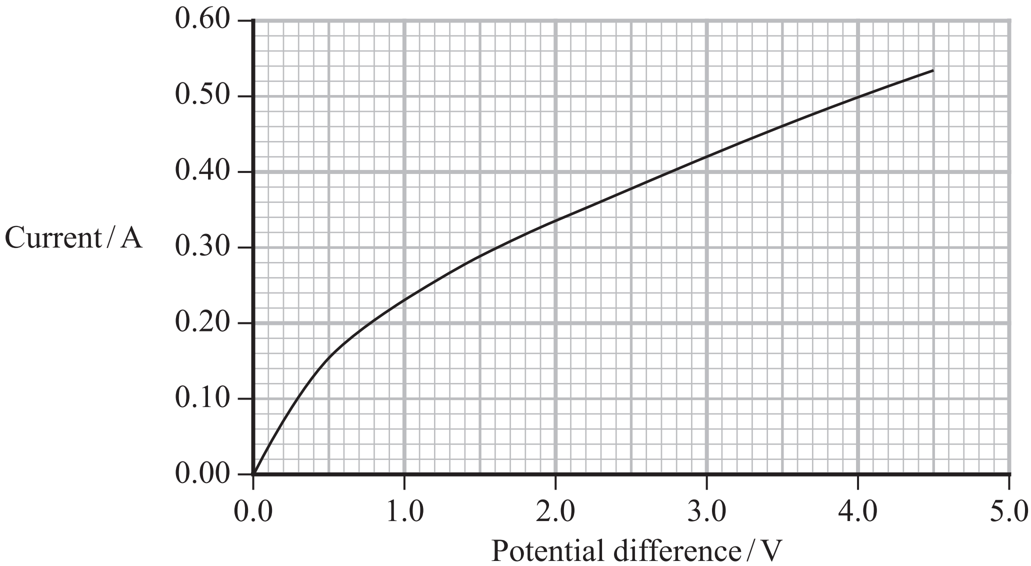
(Total for Question 14 = 8 marks)

15 A student connected the circuit shown.



(a) The student adjusted the variable resistor and recorded corresponding values of current and potential difference for the lamp.

The graph shows the results.



P 7 8 4 7 5 A 0 1 4 3 2

The student adjusted the variable resistor so that the voltmeter reading was 3.6 V.

Show that the combined resistance of the filament lamp and resistor in the circuit was about 5 Ω.

(4)

....

....

....

....

....

....

....

....

(b) The e.m.f. of the battery was 4.5 V. The battery had negligible internal resistance.

Determine the power dissipated in the circuit when the voltmeter reading was 3.6 V.

(3)

....

....

....

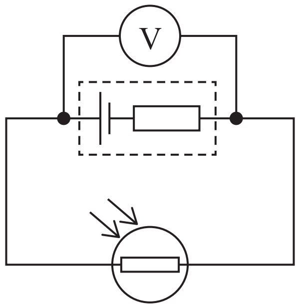
....

....

Power dissipated = ...

(Total for Question 15 = 7 marks)

16 The circuit shows an LDR connected in series with a cell.



(a) State what is meant by the e.m.f. of a cell.

(1)

....

....

*(b) The voltmeter measures the terminal potential difference across the cell.

Explain how increasing the intensity of light incident on the LDR affects the reading on the voltmeter.

(6)

....

....

....

....

....

....

....

....

....

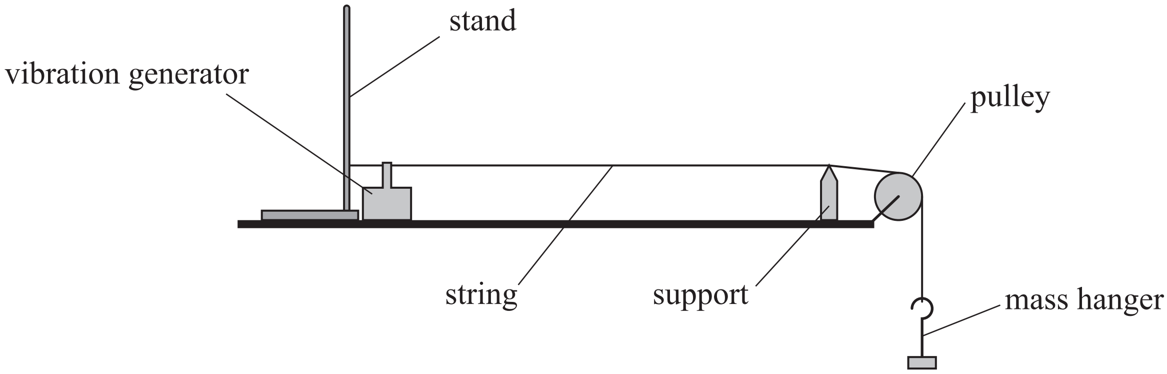
....

....

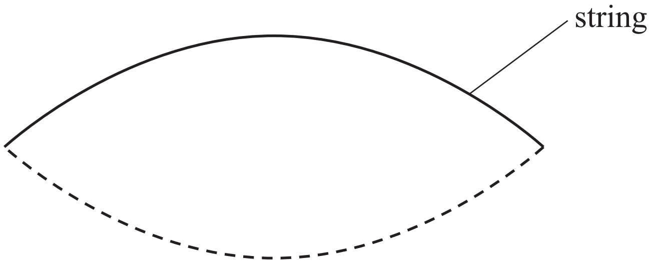
....

(Total for Question 16 = 7 marks)

17 A student investigated stationary waves on a vibrating string using the apparatus shown.



The student adjusted the frequency of the vibration generator until a standing wave formed on the string, as shown below.



(a) Label each node on the standing wave with a letter N, and each antinode with a letter A.

(1)

(b) Explain how a standing wave forms on the string.

(3)

....

....

....

....

....

....

(c) The student added masses to the hanger to vary the tension T in the string. He adjusted the frequency f of the vibration generator until the same shape of standing wave formed. He recorded T and the corresponding value of f.

The student repeated the procedure for different values of T. The length l of the string between the vibration generator and the support was kept constant.

The mass per unit length of the string is μ.

The student plotted a graph of f^2 on the y-axis against T on the x-axis.

(i) Explain why the graph is a straight line with a gradient of $\dfrac{1}{4l^2\mu}$

(3)

....

....

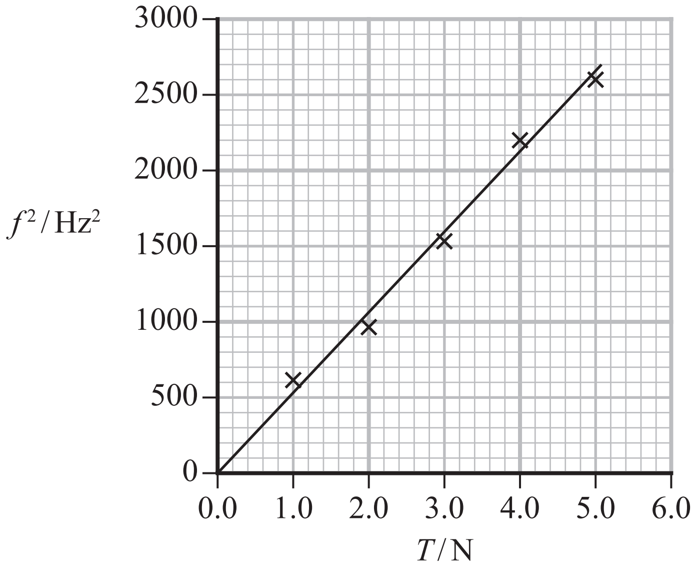
....

....

....

....

(ii) The student's graph is shown below.



Determine the mass per unit length μ of the string.

$l = 0.85\,\text{m}$

(3)

....

....

....

....

....

μ = ...

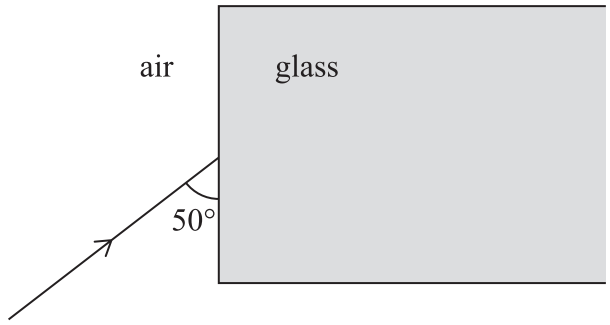
(Total for Question 17 = 10 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

18 Optical fibres can be used to transfer data.

One optical fibre is made from glass with a refractive index of 1.5

(a) The diagram shows a ray of light in air, incident on the end of this optical fibre.



Not to scale

Calculate the angle of refraction of the light as it enters the optical fibre.

(3)

....

....

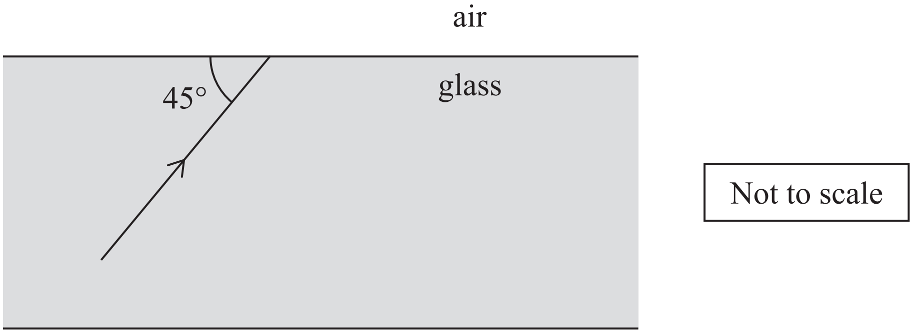
....

....

....

Angle of refraction = ...

(b) The diagram shows one ray of light inside the optical fibre, incident on a boundary with the air.



Deduce whether the ray will be totally internally reflected at this boundary.

(3)

....

....

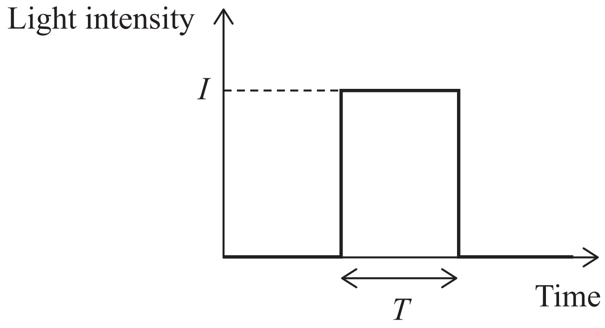
....

....

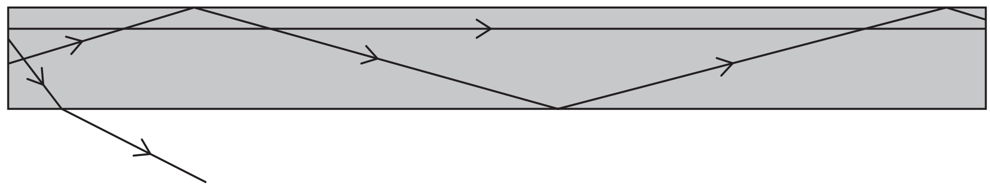
....

....

(c) Data is transmitted along the optical fibre by pulses of light. One pulse of light initially has a constant intensity I for a duration T, as shown.



Light in the pulse can take different paths along the optical fibre. The diagram shows three possible paths of rays of light in the pulse.



Explain how the intensity and the duration of the pulse of light leaving the optical fibre are different from the pulse that entered the optical fibre.

(5)

....

....

....

....

....

....

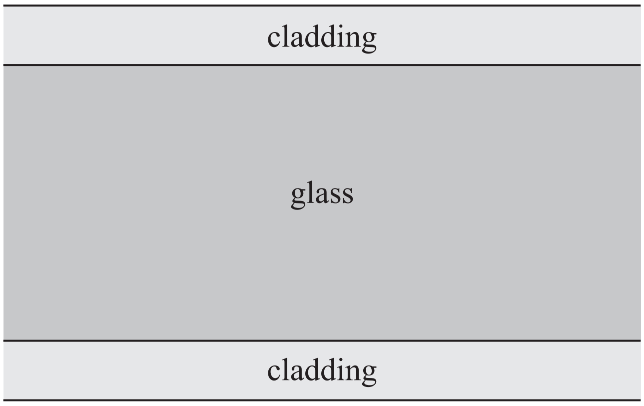
....

....

....

....

(d) Some optical fibres are surrounded by a thin layer of transparent material called cladding, as shown.



The transparent material has a lower refractive index than the glass of the optical fibre.

Explain how the cladding affects the critical angle for light at the boundary of the optical fibre.

(2)

....

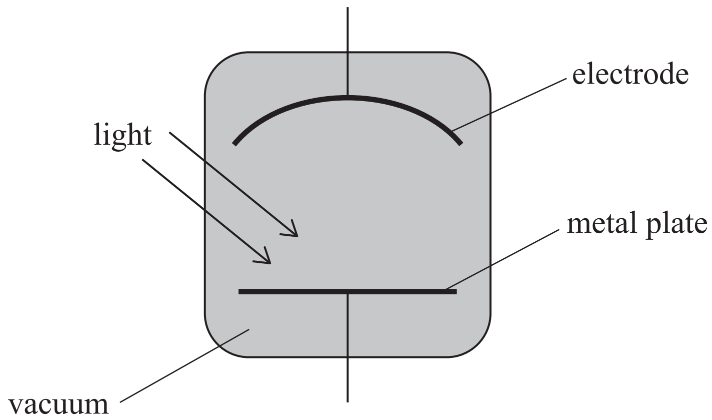
....

....

....

(Total for Question 18 = 13 marks)

19 A scientist used a photocell to investigate the photoelectric effect.
A photocell consists of a metal plate and an electrode, as shown.



Light incident on the metal plate can cause the photoelectric effect.

(a) A beam of monochromatic light is directed onto the metal plate and causes the photoelectric effect. All photons in the beam have the same energy.

Explain why the beam produces photoelectrons with a range of kinetic energies.

(3)

....

....

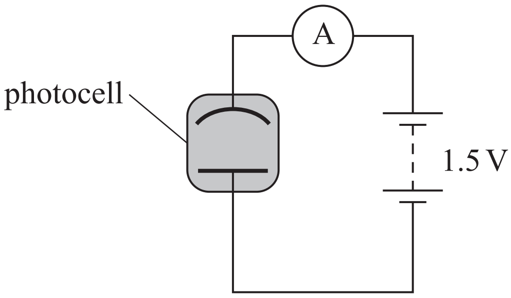
....

....

....

....

(b) The scientist connected the photocell to an ammeter and battery, as shown.



Photoelectrons are attracted to the electrode, causing a current in the circuit.

The scientist directed different frequencies and intensities of light onto the photocell.

She made the following observations:

- white light with a low intensity caused no current
- white light with a high intensity caused no current
- ultraviolet light with a low intensity caused a current.

Explain what these observations show about the nature of light.

(5)

....

....

....

....

....

....

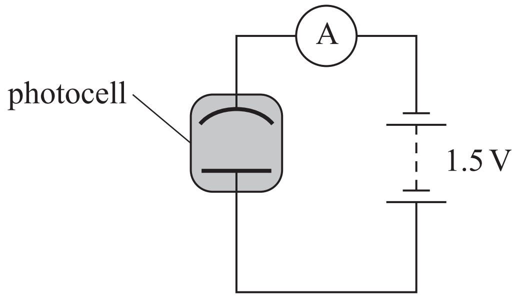
....

....

....

....

(c) The scientist reversed the connections to the battery, as shown.



The battery has negligible internal resistance.

When photoelectrons have enough kinetic energy to overcome the potential difference across the photocell, there is a current in the circuit.

Ultraviolet light of wavelength 250 nm is incident on the photocell.

Deduce whether there is a current in the circuit.

work function of metal plate in photocell = 6.9×10^{-19} J

(5)

....

....

....

....

....

....

....

....

....

....

(Total for Question 19 = 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 $\varepsilon = \frac{\Delta x}{x}$

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

BLANK PAGE

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

BLANK PAGE

BLANK PAGE