GCE AS/A Level

2420U20-1 – NEW AS

PHYSICS – Unit 2

Electricity and Light

P.M. THURSDAY, 9 June 2016

1 hour 30 minutes plus your additional time allowance

Surname ______________________________

Other Names ______________________________

Centre Number ______________________________

Candidate Number 2 ______________________________

JD*(S16-2420U20-1)-18MLP

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	8	
2.	13	
3.	9	
4.	9	
5.	14	
6.	10	
7.	17	
Total	80	

ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a DATA BOOKLET.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen or your usual method. Do not use pencil or gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces provided on the front cover.

Answer ALL questions.

Write your answers in the spaces provided in this booklet. If you run out of space use the continuation pages at the back of the booklet taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

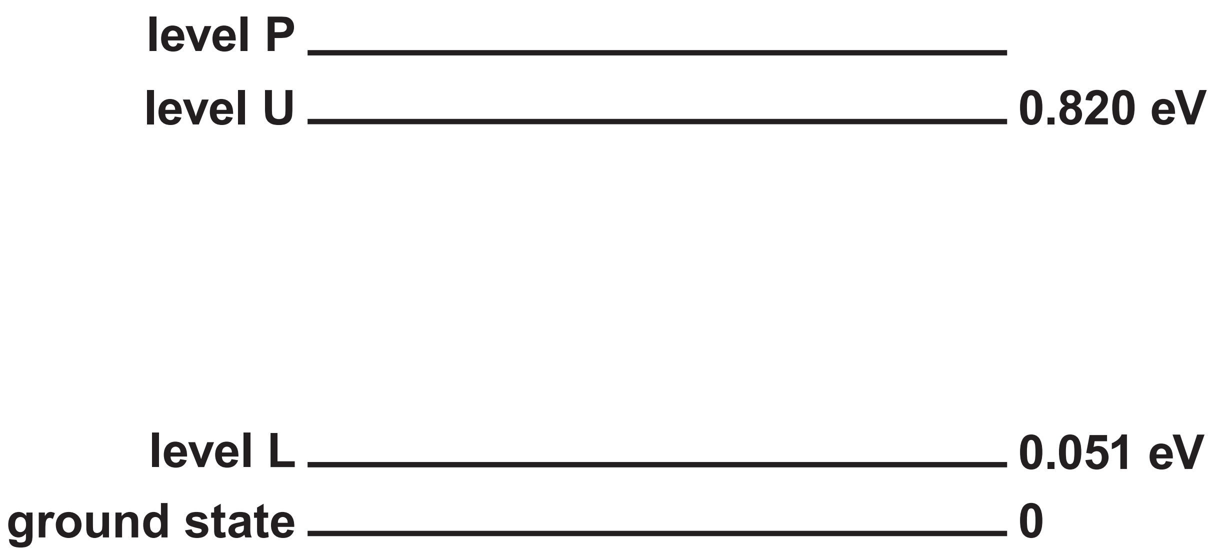
The number of marks is given in brackets at the end of each question or part-question.

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

The assessment of the quality of extended response (QER) will take place in Q7(b)(ii).

Answer ALL questions

1. **A simplified energy level system is given for a particular four-level laser system. Electrons are pumped (by means of infra-red radiation) from the ground state to level P, and drop to U, setting up a population inversion.**



1(a) (i) **Calculate the wavelength of radiation emitted in the transition from level U to level L. [3]**

1(a) (ii) Explain how stimulated emission enables amplification of infra-red radiation of this wavelength. [3]

1(b) Explain the advantage of a four-level laser system over a three-level system. [2]

2(a) (i) Define the WORK FUNCTION of a material.

[1]

2(a)(ii) **When a potassium surface is irradiated with light of frequency 7.4×10^{14} Hz, electrons of maximum kinetic energy 1.2×10^{-19} J are ejected at a rate of 2.0×10^{15} electrons per second.**

I. Explain, in terms of photons, how, if at all, the maximum kinetic energy of the ejected electrons AND their rate of ejection would change if a more intense light of the same frequency were used. [3]

2(a)(ii) II. Determine whether or not electrons would be ejected from a potassium surface by light of frequency 5.1×10^{14} Hz. Give your reasoning.

[4]

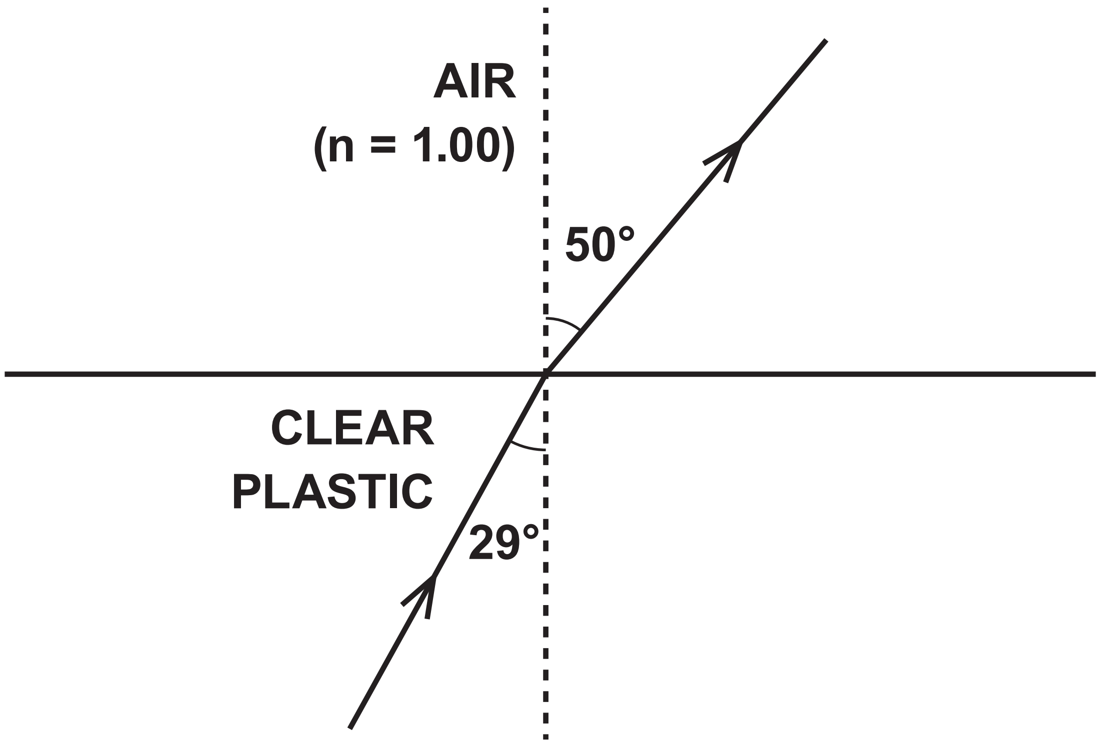
2(b) **A beam of monochromatic light of wavelength, λ and power, P strikes an absorbing surface normally.**

(i) **Derive an expression for the number of photons, N, striking the surface per second, in terms of P, λ, h and c.** **[2]**

2(b) (ii) Hence derive an expression for the momentum change per second of the light when it strikes the surface. [2]

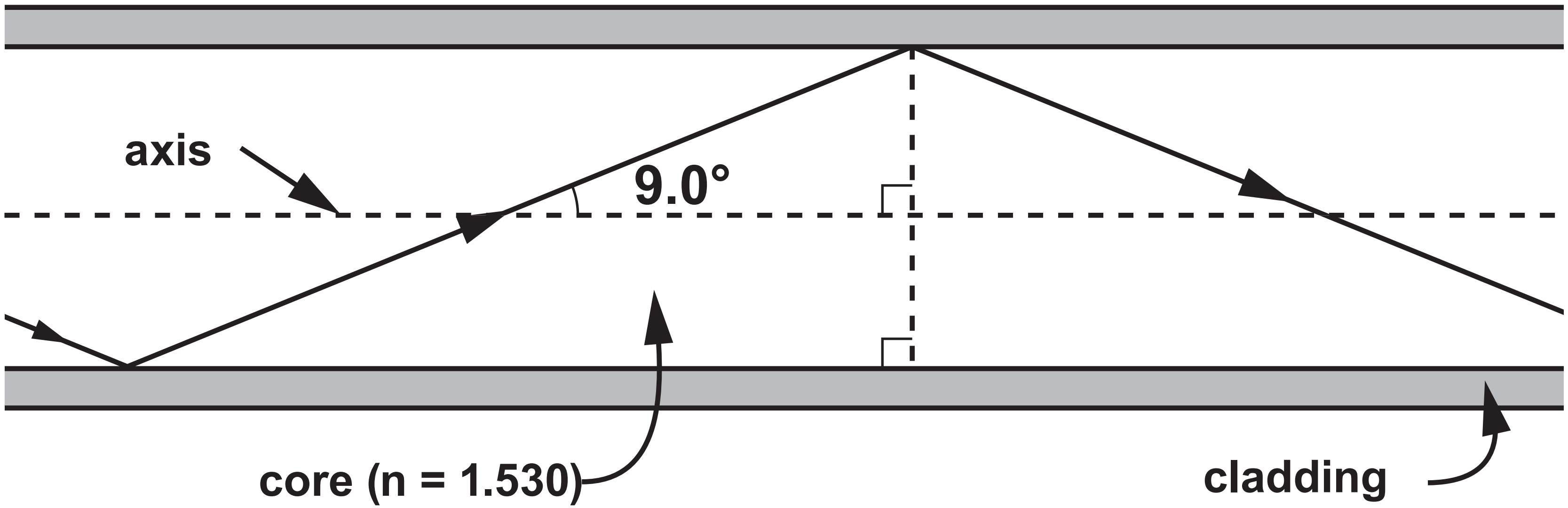
(iii) A student suggests that the answer to (ii) gives the PRESSURE that the light exerts on the surface. What SHOULD she have said instead of PRESSURE? [1]

3. (a) A narrow beam of light is observed to refract as shown between clear plastic and air.



3(a)(i) Calculate the speed of light in the PLASTIC. [2]

(ii) Calculate the critical angle for light approaching air from the plastic. [1]



NOT TO SCALE

3(b) The diagram opposite shows light being transmitted along a multimode fibre, at the greatest angle to the axis for successful transmission.

(i) The refractive index of the core is 1.530. Calculate the refractive index of the cladding. [2]

(ii) Show that the zigzag route in the diagram is 1.0125 times longer than a straight path through the same length of fibre. [1]

3(b)(iii) **The difference in times of travel for a data pulse by these two extreme routes is required to be no more than 7.5 ns. Determine whether or not 150 m of fibre will be too long. Set out your reasoning clearly. [3]**

4. A beam of monochromatic light is shone normally (at right angles) on to a diffraction grating.

(a) EXPLAIN in clear steps why bright beams emerge from the grating at angles, θ, to the normal given by the equation:
$d \sin \theta = n\lambda$ [3]

4(b) The angles, θ, at which the bright beams emerge are given in the table below.

Order, n	θ (mean)	
0	0	
1	16	
2	35	
3	58	

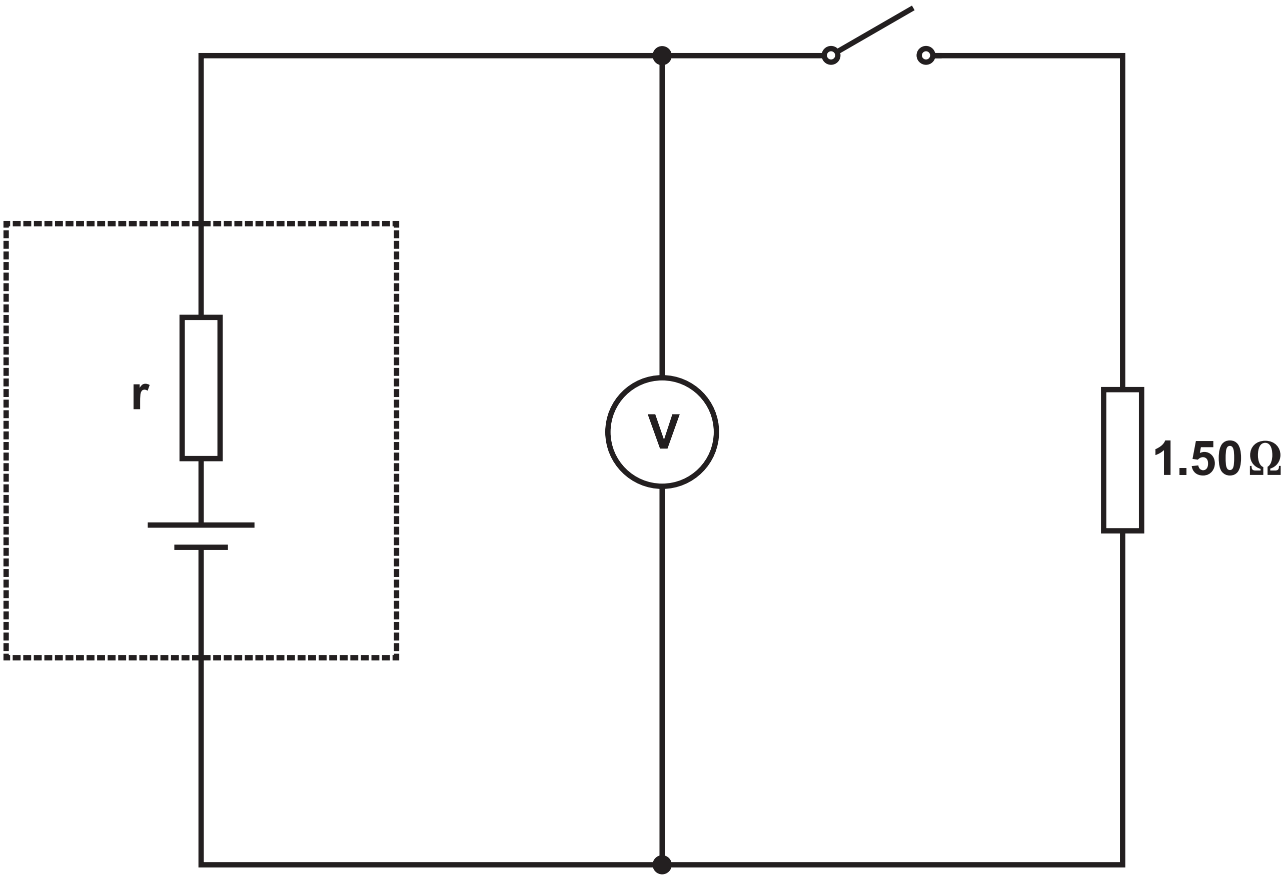
(i) Plot a graph of sin θ (y-axis) against n (x-axis) on the grid opposite. [3]

4(b)(ii) **USE YOUR GRAPH to determine the wavelength of the light. The separation between the centres of slits in the grating is 1 800 nm. Show your working. [3]**

5(a) **Define the POTENTIAL DIFFERENCE between two points in an electric circuit. [2]**

(b) **A cell of emf 1.62 V and internal resistance, r, is included in the circuit shown opposite.**

(i) **State the expected reading on the voltmeter when the switch is open. [1]**


r
V
1.50 Ω

5(b)(ii) **With the switch closed the voltmeter reads 1.38 V. Show in clear steps that the cell's internal resistance, r, is approximately 0.3 Ω. [3]**

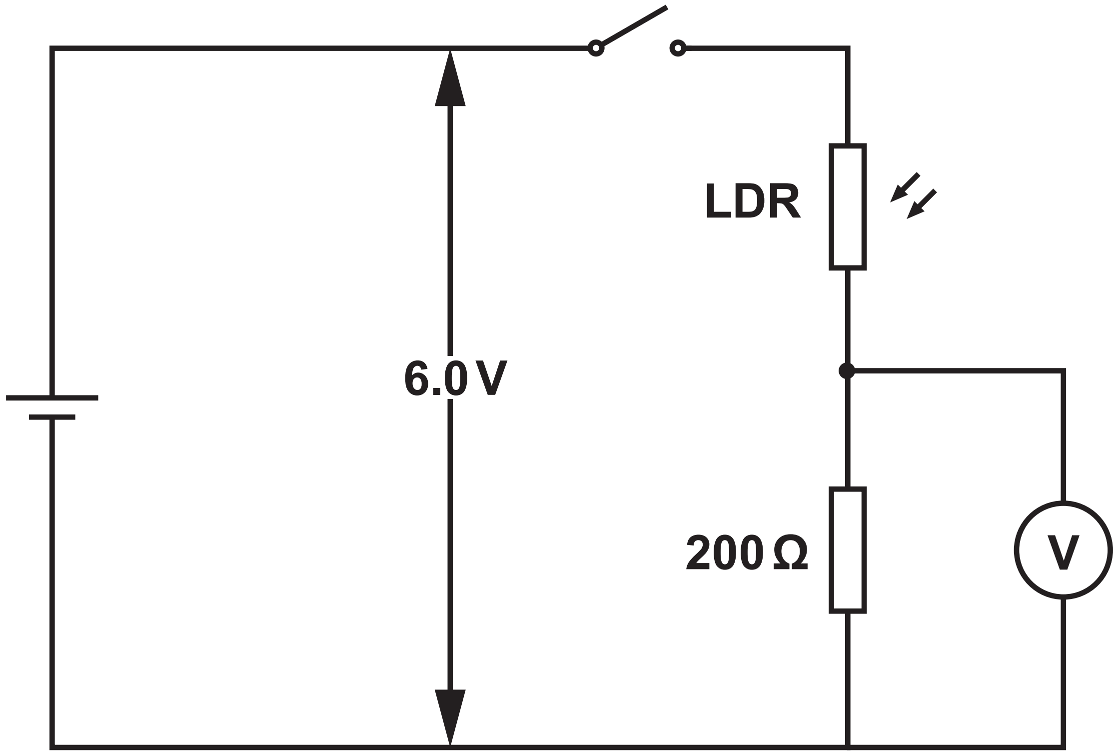
5(b)(iii) 750 J of the cell's energy is dissipated IN TOTAL while the switch is closed. Calculate the time for which the switch is closed. [2]

(iv) Calculate the voltmeter reading when the 1.50 Ω resistor is replaced by a 0.75 Ω resistor, and the switch is closed. [2]

5(c) The circuit shown opposite includes a light-dependent resistor (LDR), whose resistance decreases as the intensity of light falling on it increases. A 6.0 V supply of negligible internal resistance is used.

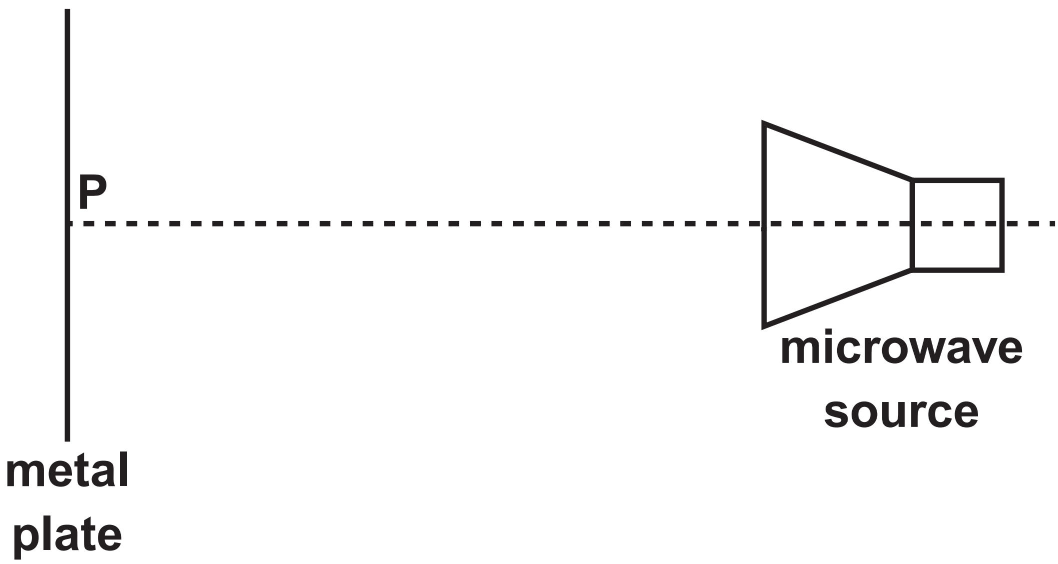
(i) Calculate the voltmeter reading when the resistance of the LDR is 850 Ω and the switch is closed. [2]

(ii) Explain, in clear steps, whether the voltmeter reading will increase or decrease when the intensity of light is increased. [2]



6.0 V
LDR
200 Ω
V

6(a) **In the set-up shown a series of ANTINODES is detected, at the following distances from the metal plate: 8 mm, 24 mm, 40 mm, 56 mm, 72 mm.**



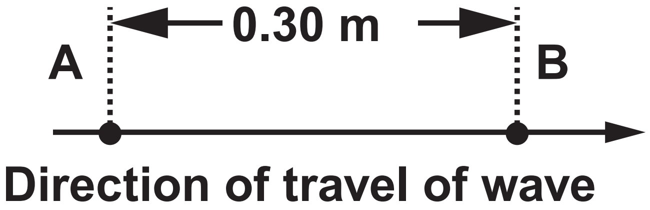
NOT TO SCALE

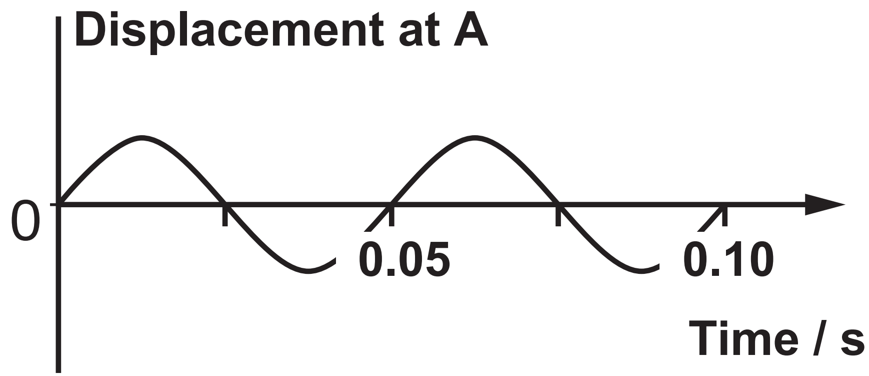
6(a)(i) **Referring to the diagram on the previous page, explain in terms of INTERFERENCE how an antinode is produced.** **[2]**

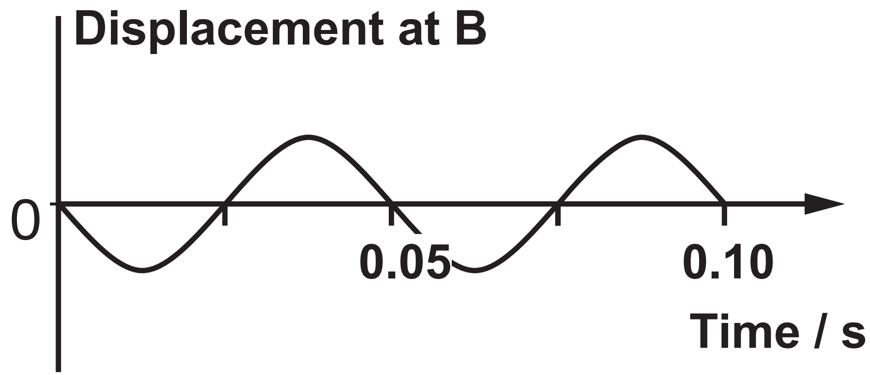
(ii) **From the data, determine whether there is a node or an antinode at point P (on the metal plate). Give your reasoning in terms of wavelength.** **[2]**

6(b) **Displacement–time graphs are given (opposite) for two points, A and B, 0.30 m apart, in the path of a PROGRESSIVE wave.**

(i) **State the phase relationship between the displacements at A and B, then determine the longest, and the second longest, wavelength that the wave could have. [3]**


0.30 m
A
B
Direction of travel of wave


Displacement at A
0
0.05
0.10
Time / s

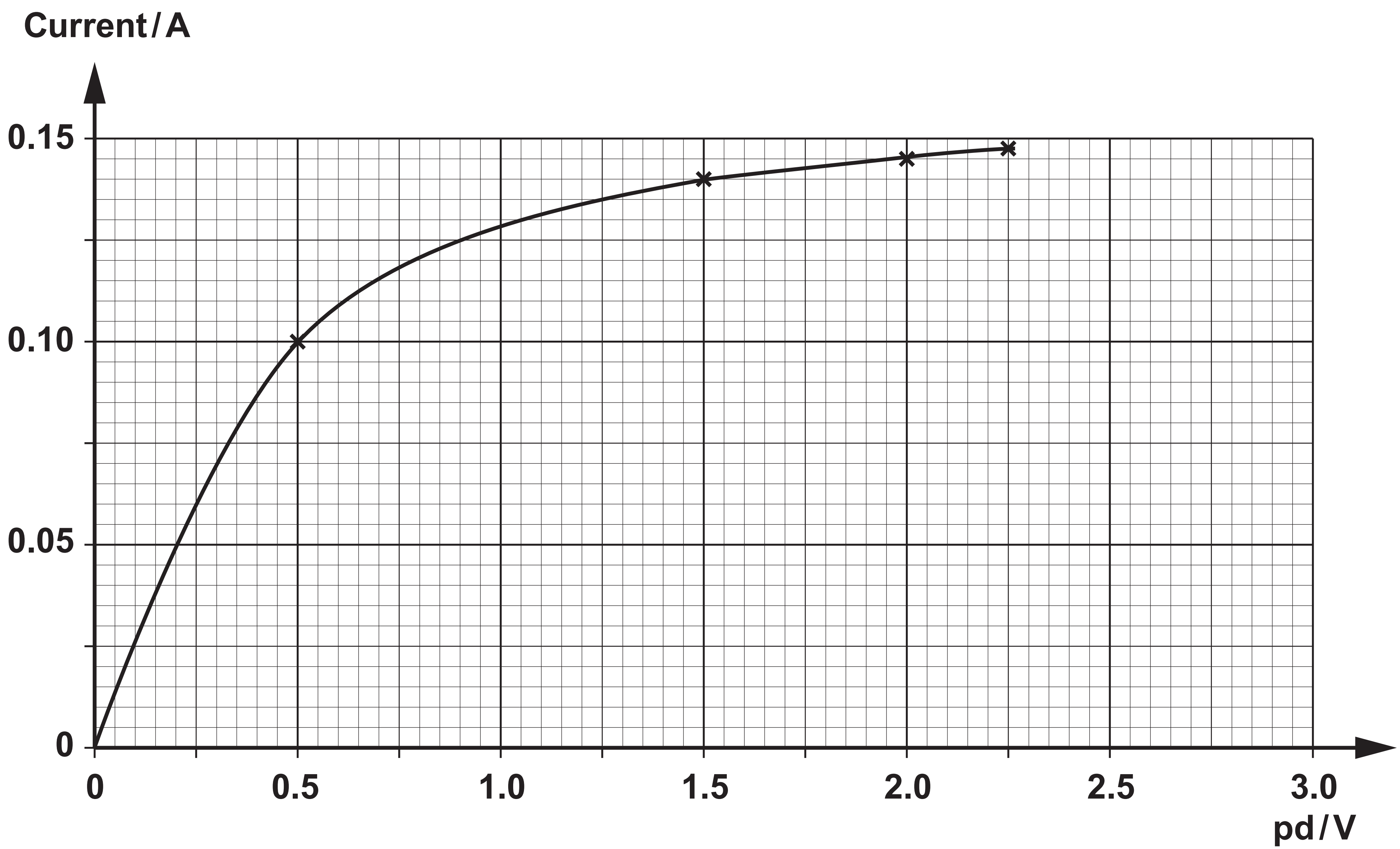

Displacement at B
0
0.05
0.10
Time / s

6(b)(ii) **The speed of the waves is known to be between $10\,\mathrm{m\,s^{-1}}$ and $15\,\mathrm{m\,s^{-1}}$. Determine which of the two wavelengths in (b)(i) is the correct one, giving your reasoning. [3]**

7(a) (i) Draw the circuit diagram for an investigation of how the current through a filament lamp varies with the applied potential difference. [2]

7(a)(ii) **The lamp is labelled "3 V, 0.16 A". The ammeter to be used is a multimeter with a 0 – 200 mA range and a 0 – 10 A range. State which range should be selected, and justify your choice. [1]**

(iii) **The lamp has already been investigated by a student, Sion, who plotted the graph reproduced opposite. State TWO ways in which his investigation (NOT his graph plotting) could have been improved. [2]**



Current / A
0.15
0.10
0.05
0
0
0.5
1.0
1.5
2.0
2.5
3.0
pd / V

7(b)(i) Use the graph opposite page 30 to calculate the ratio: [3]

$$\frac{\text{Resistance of lamp at } 2.00\,\text{V}}{\text{Resistance of lamp at } 0.50\,\text{V}}$$

7(b)(ii) **Explain, in terms of free electrons, why the temperature AND the resistance of a metal wire increase when the potential difference across the wire is increased. [6 QER]**

7(c) A scientist claims to have made a material which is superconducting at room temperature. He publishes his procedure. Several research teams try to follow the same procedure, but without success. Discuss the arguments for and against spending more public money following up the scientist's claim. [3]

END OF PAPER

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

Question number	Additional page, if required. Write the question numbers in the left-hand margin.

Question number	Additional page, if required. Write the question numbers in the left-hand margin.