Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A Level

2420U20-1 – **NEW AS**

S16-2420U20-1

PHYSICS – Unit 2
Electricity and Light

P.M. THURSDAY, 9 June 2016

1 hour 30 minutes

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**	

2420U201
01

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. Do not use pencil or gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

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)**.

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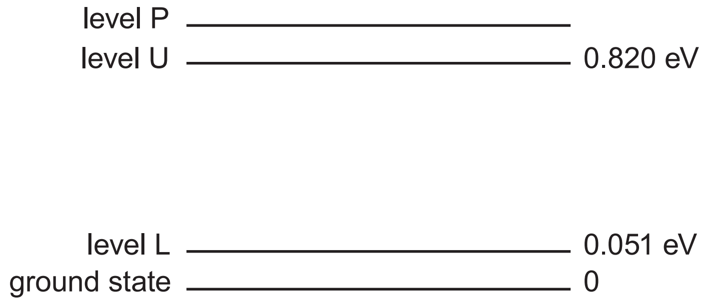
Answer **all** *questions*

1. A simplified energy level diagram 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.



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

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

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

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2. *(a)* (i) Define the *work function* of a material. [1]

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(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]

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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]

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(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]

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

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(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]

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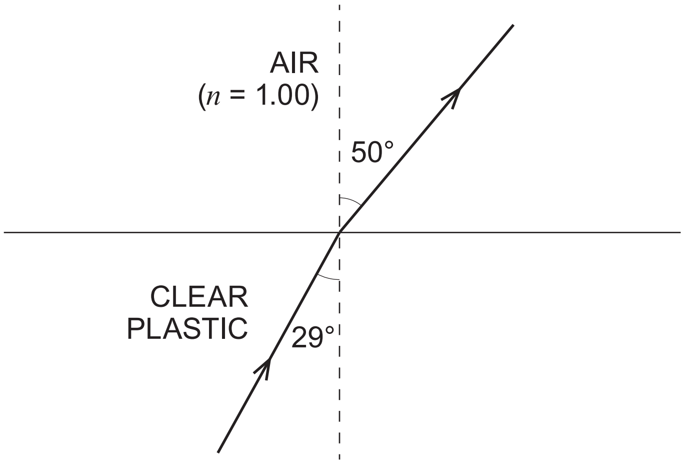
3. *(a)* A narrow beam of light is observed to refract as shown between clear plastic and air.



(i) Calculate the speed of light in the **plastic**. [2]

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

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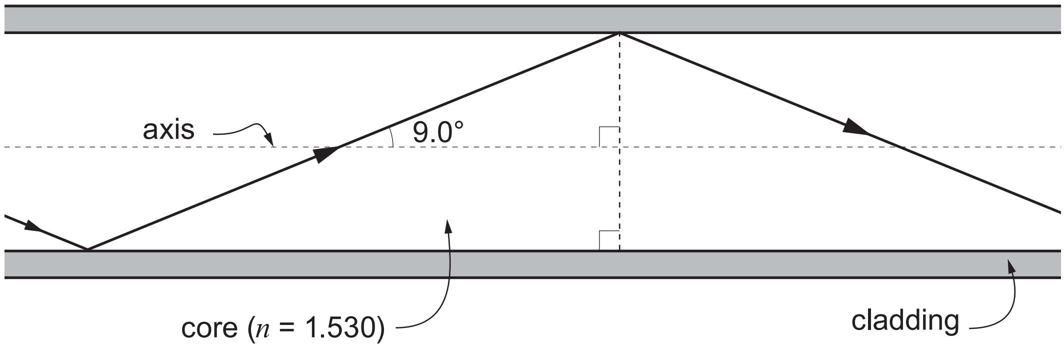
(b) The diagram shows light being transmitted along a multimode fibre, at the greatest angle to the axis for successful transmission.



NOT TO SCALE

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

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(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]

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(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]

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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]

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(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 provided. [3]

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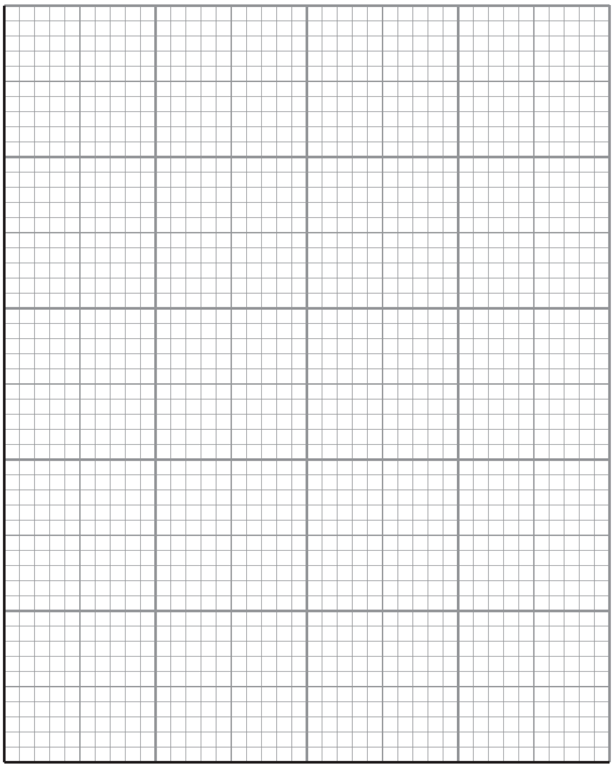

(ii) **Use your graph** to determine the wavelength of the light. The separation between the centres of slits in the grating is 1 800 nm. Show your working. [3]

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

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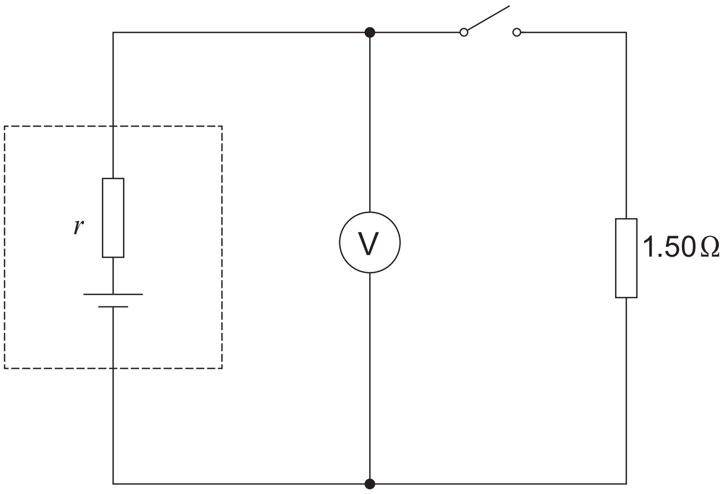
(b) A cell of emf 1.62 V and internal resistance, r, is included in the circuit shown.



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

(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]

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(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]

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(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]

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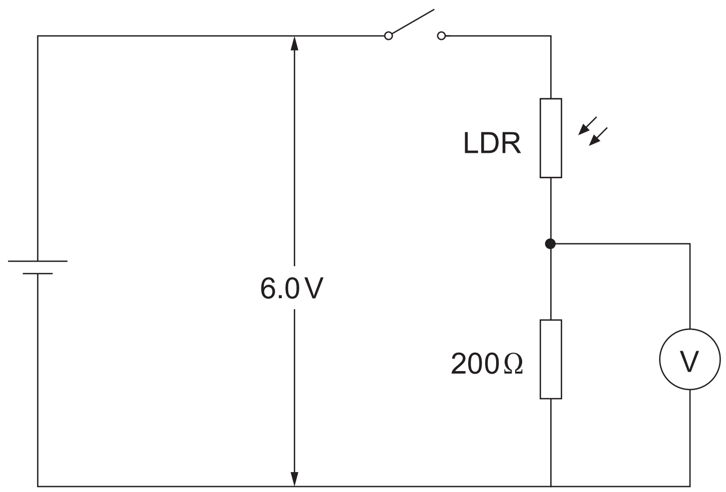
(c) The circuit shown includes a light-dependent resistor (LDR), whose resistance decreases as the intensity of light falling on it increases. A 6.0 V supply of negligible internal resistance is used.



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

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

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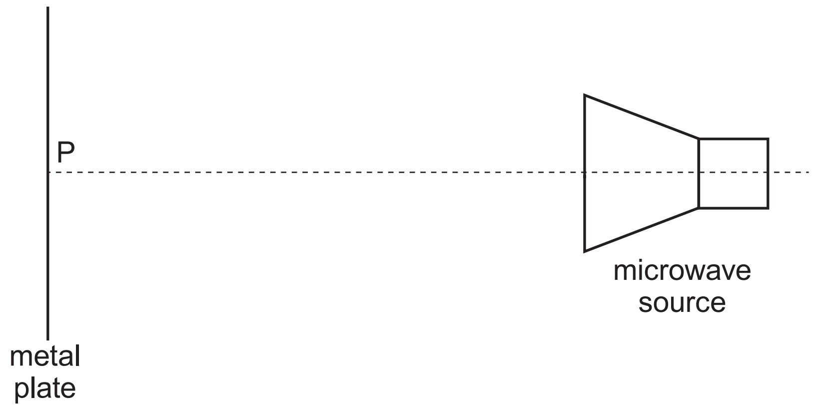
6. *(a)* In the set-up shown a series of *antinodes* is detected, at the following distances from the metal plate: 8 mm, 24 mm, 40 mm, 56 mm, 72 mm.



NOT TO SCALE

(i) Referring to the diagram, explain in terms of *interference* how an antinode is produced. [2]

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(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]

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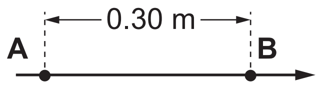
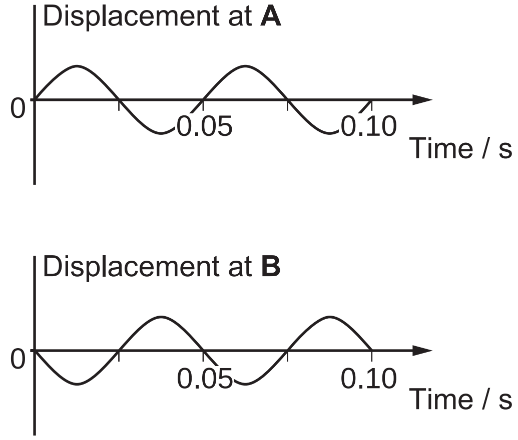
(b) Displacement–time graphs are given for two points, **A** and **B**, 0.30 m apart, in the path of a **progressive** wave.



Direction of travel of 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]

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

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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]

(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]

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

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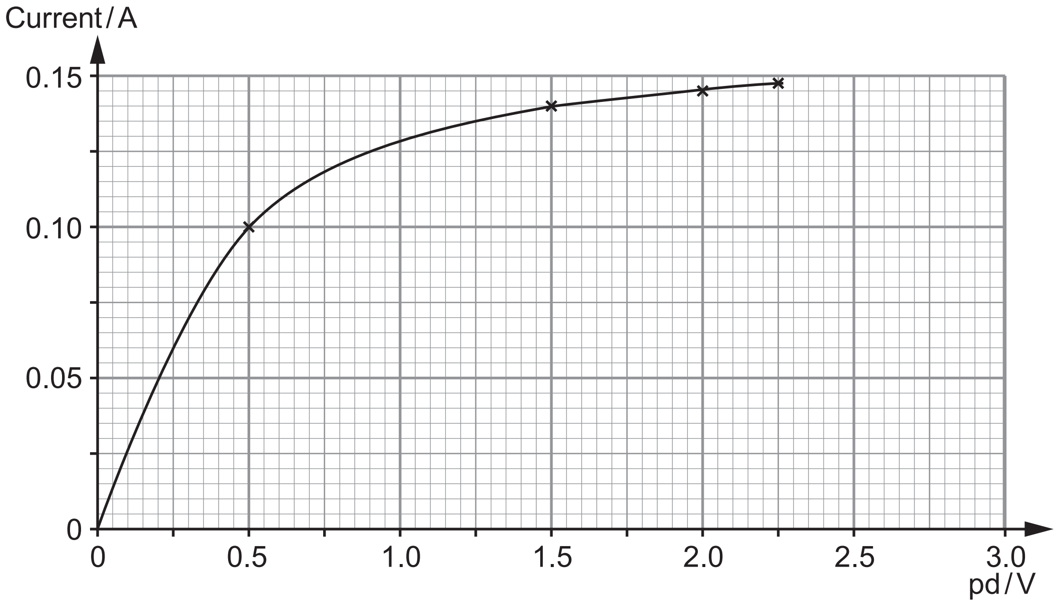

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(b) (i) Use the graph to calculate the ratio: $\dfrac{\text{Resistance of lamp at } 2.00\,\text{V}}{\text{Resistance of lamp at } 0.50\,\text{V}}$ [3]

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(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]

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TURN OVER FOR THE LAST PART OF THE QUESTION

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(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]

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