Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS

B420U20-1

S23-B420U20-1

WEDNESDAY, 24 MAY 2023 – AFTERNOON

PHYSICS – AS component 2
Electricity and Light

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**14**	
3.	**13**	
4.	**8**	
5.	**12**	
6.	**18**	
Total	**75**	

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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 gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

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 additional page(s) 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 75.

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 **Q4(a)**.

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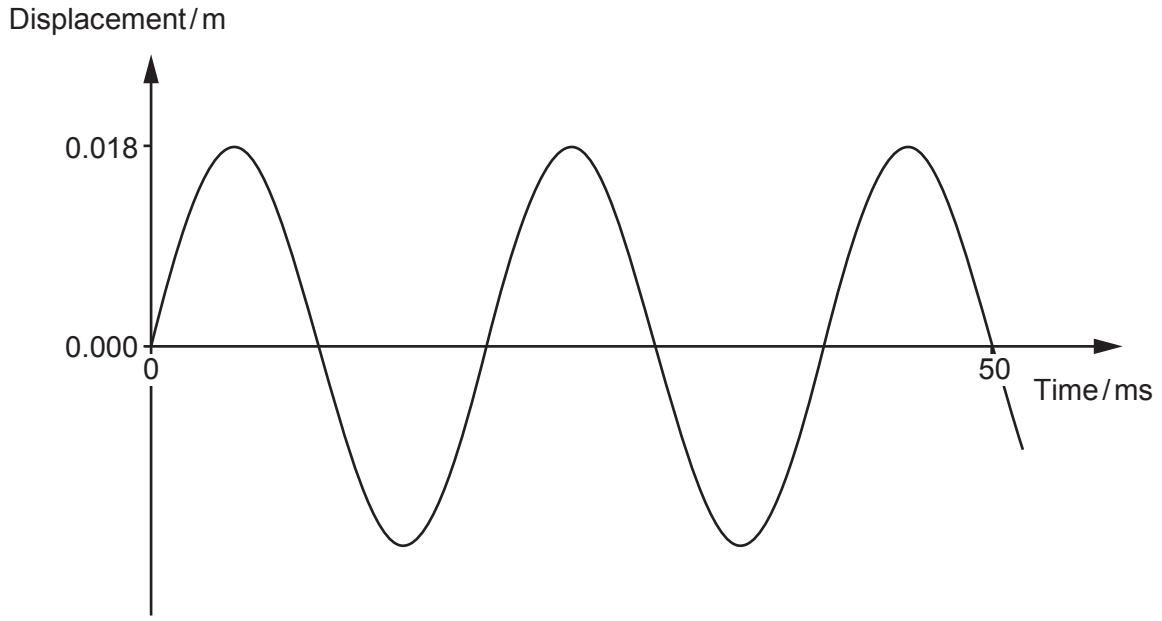
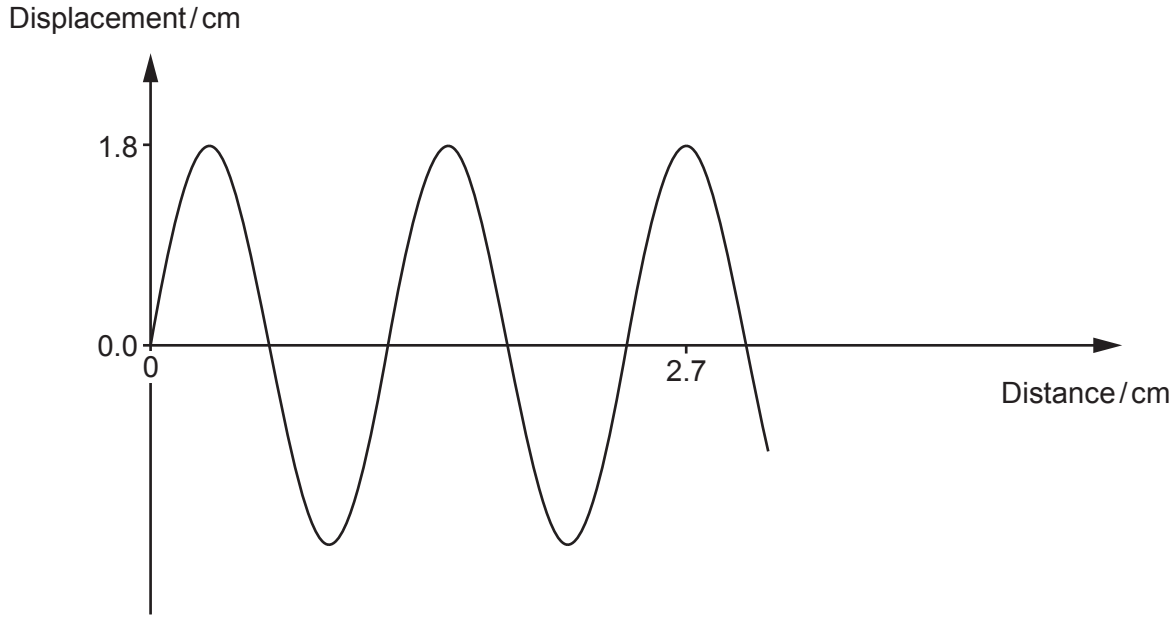
Answer **all** questions.

1. (a) The graphs below show how the variation of the displacement of a certain wave with both time and distance can be represented.





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(i) Calculate the wavelength of the wave. [2]

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(ii) Calculate the frequency of the wave. [3]

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(iii) Calculate the speed of the wave. [2]

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(b) Declan states that it is not possible to determine whether the wave can be polarised based on these two graphs. Evaluate whether Declan is correct. [3]

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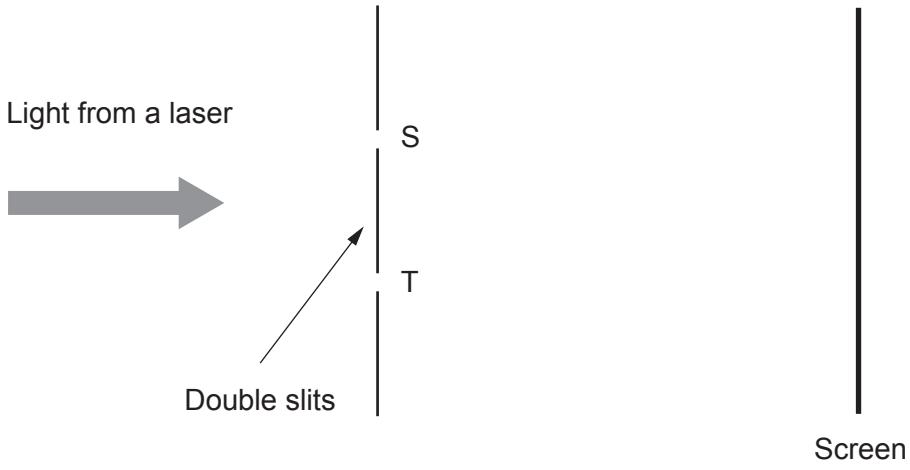
2. Light from a laser is incident on two slits labelled S and T. The light transmitted through these slits is initially in phase and overlaps in the region between the slits and the screen. The resulting interference pattern is observed on the screen.



(a) (i) The arrangement ensures that light emerging from slits S and T is coherent. Explain what is meant by the term **coherent**. [1]

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(ii) The light emerging from slits S and T is in phase. Explain the term **in phase**. [1]

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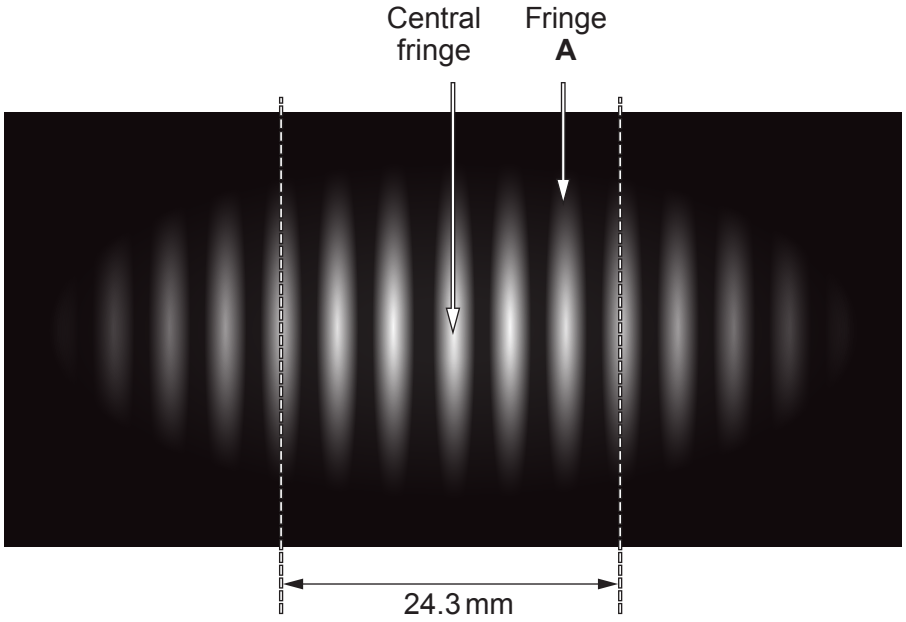
(b) The interference pattern obtained on the screen is a sequence of bright and dark fringes as shown below.



(i) Explain how the **bright** fringe **A** is formed. [2]

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(ii) On the interference pattern obtained, the distance shown is 24.3 mm. The laser light has a wavelength of 6.42×10^{-7} m and the separation of the double slits S and T is 0.66 mm. Calculate the distance between the double slits and the screen. [4]

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(c) A laser produces a light beam of power 6.0 mW consisting of a stream of photons of frequency 2.4×10^{15} Hz.

(i) Show that the number of photons emitted per second is $4 \times 10^{15}\,s^{-1}$. [3]

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(ii) The momentum of a photon is 5.3×10^{-27} kg m s^{-1}. Calculate the force exerted by the light beam on a shiny surface if the beam strikes the surface at right angles and all of the photons are reflected. [3]

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3. An experiment is performed to determine the refractive index, n, of the material of a rectangular transparent block. The following table of results is obtained for light rays passing from air into the block.

Angle of incidence, i/°	Angle of refraction, r/°	sin i	sin r
0	0	0.00	0.00
15	11	.....	.....
30	22	.....	.....
45	32	.....	.....
60	40	.....	.....

(i) **Complete the columns** for sin i and sin r. [2]

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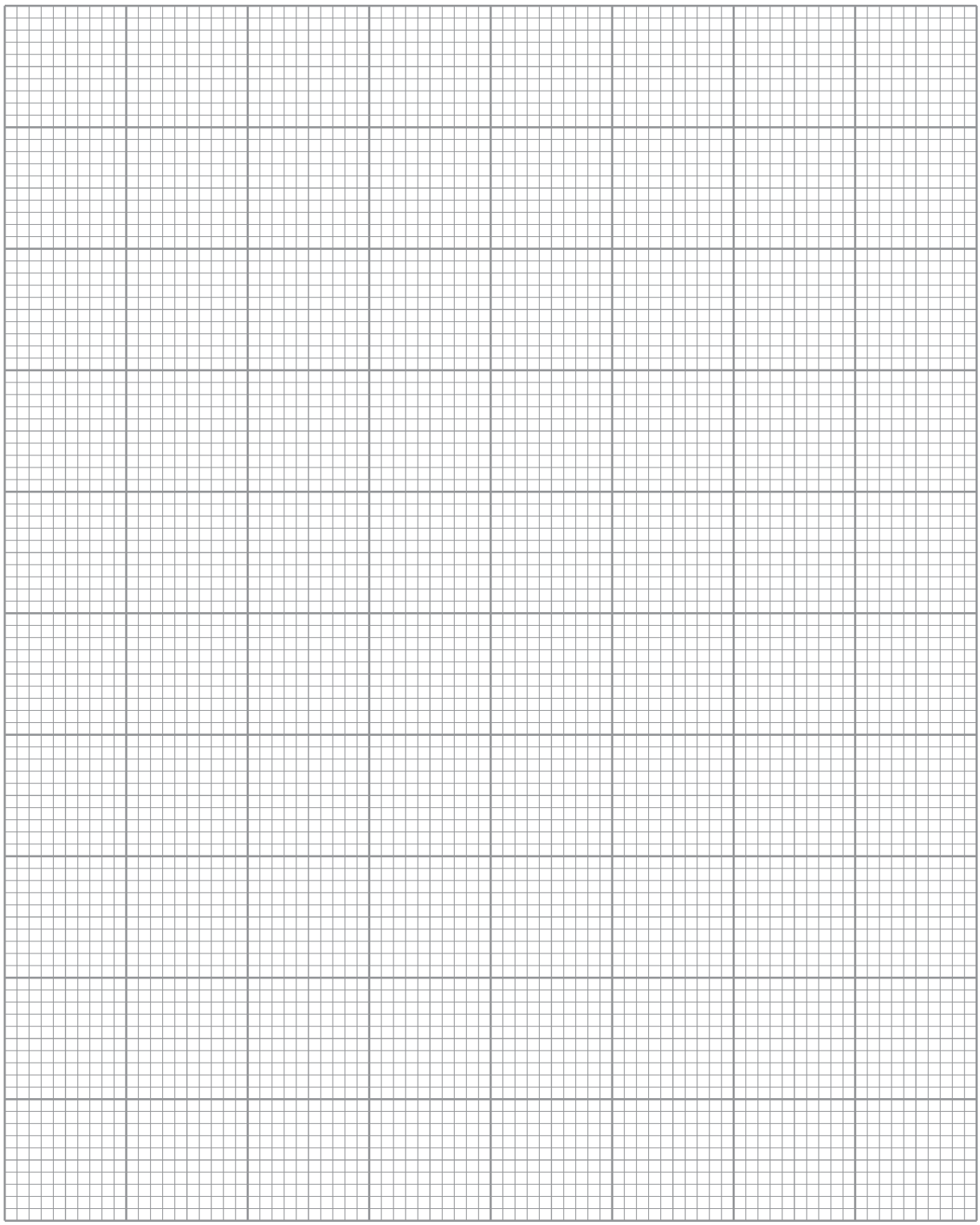
(ii) Plot a graph of sin i (y-axis) against sin r (x-axis). [4]



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(iii) Determine a value for the refractive index, n, of the material of the transparent block. [3]

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(iv) Determine the critical angle for the material-air boundary. [2]

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(v) Calculate the speed of light in the transparent block. [2]

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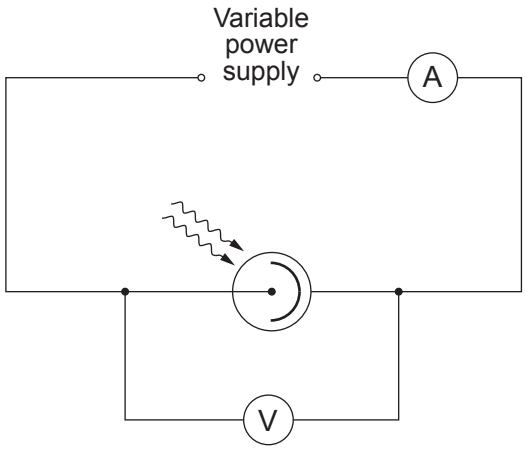
4. (a) Describe how the following apparatus can be used to measure the maximum kinetic energy of the photoelectrons and also, using light of different frequencies, the Planck constant. [6 QER]



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(b) Describe briefly how Einstein's explanation of the photoelectric effect has benefited society. [2]

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5. (a) Explain what is meant by electric current. [1]

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(b) The current, I, in a wire of cross-sectional area, A, is given by the equation:

$$I = nAve$$

(i) Derive the equation giving a clearly labelled diagram. [4]

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(ii) Calculate the mean drift velocity in a wire made of aluminium of cross-sectional area 2.52 mm^2 and carrying a current of 3.45 A. Free electron concentration, $n = 1.82 \times 10^{29}$ m^{-3}. [2]

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(c) Alexander applies a constant potential difference across a piece of aluminium wire. The temperature of the wire increases.

(i) Alexander states that the drift velocity of the electrons in the piece of wire does not depend on the temperature of the wire. Evaluate whether this statement is correct in terms of the motion of the particles. [3]

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(ii) He then states that the resistance of the aluminium wire does not depend on the temperature of the wire. Evaluate whether this statement is correct and state your reasoning clearly. [2]

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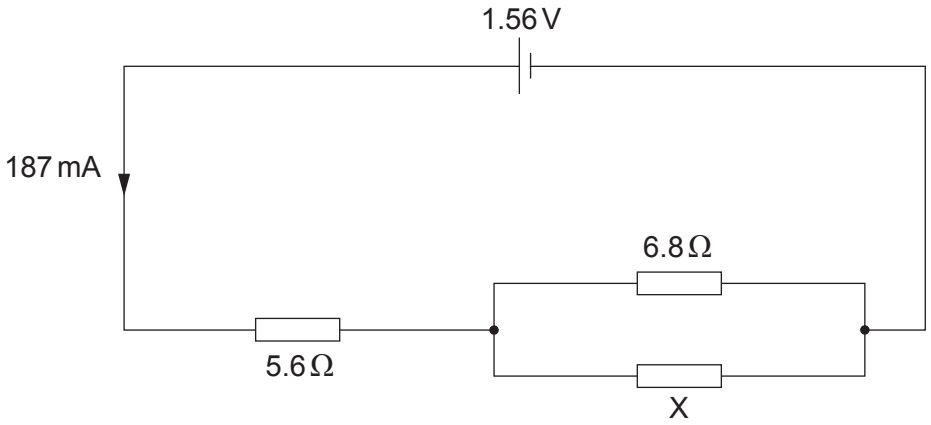
6. The resistor, X, in the following circuit is made from constantan wire.



(a) (i) Calculate the potential difference across the 5.6 Ω resistor. [1]

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(ii) Calculate the resistance of X. [5]

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(iii) A technician claims that the power dissipated by resistor X is less than 0.1 W. Evaluate whether this statement is correct. [2]

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(b) The constantan wire used to make the resistor, X, is 1.31 m long and 0.423 mm in diameter. Determine the resistivity of constantan and state its unit. [4]

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(c) A 1.2 m length of the constantan wire used in part (b) is stretched by a tensile force of 45 N. Determine the Young modulus of constantan if the wire extends by 2.3 mm. [4]

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(d) A metal becomes superconducting at a temperature of 3.7 K. Sketch a graph of resistance against temperature. [2]

END OF PAPER

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