GCE AS/A LEVEL

2420U20-1

WEDNESDAY, 24 MAY 2023 – AFTERNOON

PHYSICS – AS UNIT 2

ELECTRICITY AND LIGHT

1 hour 30 minutes plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**11**	
3.	**12**	
4.	**10**	
5.	**10**	
6.	**8**	
7.	**7**	
8.	**9**	
Total	**80**	

ADDITIONAL MATERIALS

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

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

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

Answer ALL questions.

Write your answers in the spaces provided.
If you run out of space, use the additional 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.

The assessment of the quality of extended response (QER) will take place in question 3 (b).

ANSWER ALL QUESTIONS.

1. (a) Look at Diagram 1 for Question 1 (a) in the separate Diagram Booklet.

Diagram 1 shows a circuit.

Emily sets up the circuit in order to investigate how the resistance of a metal wire varies with length.

Emily connects one crocodile clip on the wire at the 0.0 cm mark while the other clip is moved along at suitable intervals to cover the whole range of the wire.

Look at Diagram 2 for Question 1 (a) in the separate Diagram Booklet.

Diagram 2 shows a graph.

She obtains results as shown in the graph.

continued on the next page . . .

Question 1 (a) continued

1. (a) (i) Use the graph to obtain a value for the resistance at 0.0 cm and suggest the cause of this resistance.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 1 (a) continued

1. (a) (ii) Discuss to what extent Emily's results confirm that the variation of resistance of the wire with length is consistent with the equation:

$$R = \frac{\rho l}{A}$$

[3 marks]

continued on the next page . . .

Question 1 (a) continued

1. (a) (iii) The wire used in the experiment has a mean DIAMETER of 0.23 mm.

Name a measuring instrument that could have been used to take this reading AND state its likely resolution.

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 1 (a) continued

1. (a) (iv) Use the graph and the mean diameter to determine the resistivity of the metal of the wire.

[4 marks]

continued on the next page . . .

Question 1 continued

1. (b) Emily used a 1.5 V cell in her experiment as she was concerned about the size of the electrical current in the wire. Suggest her reasons for using the 1.5 V cell.

[2 marks]

(Total for Question 1 = 13 marks)

2. (a) Define the emf of a cell.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 2 continued

2. (b) Look at the diagram for Question 2 (b) in the separate Diagram Booklet.

The diagram shows a circuit.

Four identical cells each having an emf of 1.50 V are connected in series to form a 6.00 V battery.

The battery is connected across resistor X.

The reading on the ammeter is 0.30 A and the reading on the voltmeter is 5.40 V.

continued on the next page . . .

Question 2 (b) continued

2. (b) (i) Show that the resistance of resistor X is 18 Ω.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 2 (b) continued

2. (b) (ii) Determine the value of the internal resistance of EACH INDIVIDUAL CELL.

[3 marks]

continued on the next page . . .

Question 2 (b) continued

2. (b) (iii) Calculate the total power dissipated in the internal resistance of the 6.00 V battery.

[2 marks]

continued on the next page . . .

Question 2 (b) continued

2. (b) (iv) Resistor X is now replaced with a different resistor, Y. Resistor Y has half the resistance of resistor X. Seren states 'as the resistance is halved, the power dissipated in the internal resistance of the battery will be twice that with resistor X.' Evaluate Seren's claim.

[3 marks]

(Total for Question 2 = 11 marks)

3. (a) Look at the diagram for Question 3 (a) in the separate Diagram Booklet.

A vibration generator attached to one end of a string produces a progressive wave on the string as shown in the diagram (for time $t = 0$).

The wavelength of the waves is 15.0 cm.

(i) State what is meant by the amplitude of a progressive wave.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 3 (a) continued

3. (a) (ii) Look at the diagram for Question 3 (a) (ii) in the separate Diagram Booklet.

The diagram is a graph.

The graph shows the displacement of point A, in the previous diagram, with respect to time.

Determine the speed of the wave.

[3 marks]

continued on the next page . . .

Question 3 (a) continued

3. (a) (iii) Sketch the displacement – time graph of point B ON THE GRID IN part (a) (ii).

[2 marks]

(b) The progressive wave set – up in part (a) can be modified in order to create a stationary wave pattern. Explain how a stationary wave is formed AND describe the similarities and differences between a stationary wave and a progressive wave.

[6 marks QER]

(Total for Question 3 = 12 marks)

4. **Look at the diagram for Question 4 in the separate Diagram Booklet.**

The diagram shows the apparatus set up by some students to investigate the superposition of sound waves.

Two identical loudspeakers (S_1 and S_2) are connected to the same signal generator and act as coherent sources.

The students use an app on their mobile phones to measure the intensity of the sound signal at different positions in the classroom. Mobile phone A detects a maximum of intensity on the central line. Mobile phone B detects the FIRST maximum away from the central maximum.

continued on the next page . . .

Question 4 continued

4. (a) Explain what is meant by coherent sources.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 4 continued

4. (b) (i) The distance S_1B is 8.0 m and the distance S_2B is 7.4 m.

State what is meant by the term path difference AND hence explain why the wavelength of the sound wave must be 0.60 m.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 4 (b) continued

4. (b) (ii) Mobile phone C detects a minimum intensity. Determine TWO possible values of the distance $(S_2C - S_1C)$.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 4 continued

4. (c) (i) State the principle of superposition.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 4 (c) continued

4. (c) (ii) Loudspeaker S_2 develops a fault whose only effect is to reduce the amplitude of the sound waves it emits. Explain why the intensities at A and B decrease AND the intensity at C increases.

[3 marks]

(Total for Question 4 = 10 marks)

5. (a) Define the refractive index of a material.

_____

_____

_____

[1 mark]

(b) Look at the diagram for Question 5 (b) in the separate Diagram Booklet.

The diagram shows material A of unknown refractive index, n, sandwiched between two rectangular blocks of different refractive indices.
A ray of light travels from the top block into material A as shown in the diagram.

continued on the next page . . .

Question 5 (b) continued

5. (b) (i) Show that the refractive index of material A is approximately 1.5

[2 marks]

continued on the next page . . .

Question 5 (b) continued

5. (b) (ii) Determine the time taken for the ray of light to travel through material A from X to Y.

[3 marks]

continued on the next page . . .

Question 5 continued

5. (c) (i) Confirm that total internal reflection will occur at Y.

[3 marks]

continued on the next page . . .

Question 5 (c) continued

5. (c) (ii) ON THE DIAGRAM for part (b) continue the path of the light ray inside material A.

[1 mark]

(Total for Question 5 = 10 marks)

---

6. (a) State what is meant by the work function, ϕ , of a metal surface.

_____

_____

_____

[1 mark]

(b) Sodium will undergo the photoelectric effect when illuminated by visible light, but zinc requires ultraviolet radiation. EXPLAIN which material has the greater work function.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 6 continued

6. (c) (i) Use Einstein's photoelectric effect equation to show that the maximum wavelength, λ_{max} for emission is given by the equation:

$$\lambda_{max} = \frac{hc}{\phi}$$

[2 marks]

continued on the next page . . .

Question 6 (c) continued

6. (c) (ii) A mixture of red ($\lambda = 650$ nm), green ($\lambda = 550$ nm) and blue ($\lambda = 450$ nm) light is incident on a metal surface of work function of 3.7×10^{-19} J. Determine which wavelength or wavelengths of light will be UNABLE to release electrons from the metal surface.

[2 marks]

continued on the next page . . .

Question 6 (c) continued

6. (c) (iii) Explain, in terms of photons whether or not the intensity of the light will affect the maximum kinetic energy of the released electrons.

[2 marks]

(Total for Question 6 = 8 marks)

7. (a) Look at the diagram for Question 7 (a) in the separate Diagram Booklet.
The diagram shows a circuit.

Lewis uses the circuit in the diagram to find the minimum pd, V_{min} across an LED at which light is emitted by the diode. He collects his data in a dark room where he varies the pd of the power supply until the LED lights.

Lewis measures the minimum pd, V_{min} five times and his results are shown below.

V_{min} / V	1.81	1.87	1.93	1.84	1.90

continued on the next page . . .

Question 7 (a) continued

7. (a) (i) Determine the mean value for V_{min} along with its PERCENTAGE uncertainty.

[3 marks]

continued on the next page . . .

Question 7 (a) continued

7. (a) (ii) Lewis uses the following equation to calculate the wavelength of the light expected to be produced by the LED:

$$eV_{min} = \frac{hc}{\lambda}$$

Calculate the mean value for λ and its ABSOLUTE uncertainty.

[3 marks]

Question 7 continued

7. (b) Lewis noted the value for V_{min} when he noticed that the LED had turned on.

Suggest an improvement to his method.

_____

_____

_____

_____

[1 mark]

(Total for Question 7 = 7 marks)

8. Look at the diagram for Question 8 in the separate Diagram Booklet.

The diagram shows the energy levels for the amplifying medium in a $4-$ level gas laser.

(a) The laser transition between level U and level L produces stimulated photons of wavelength 1.06×10^{-6} m. Determine the value of energy level L in eV.

[3 marks]

Question 8 continued

8. (b) When explaining the operation of this laser, a student writes the following:

‘Pumping is required to move electrons from ground level to level P which is a metastable state. This creates a population inversion between P and ground which is needed for the laser to work.’

State TWO mistakes in the student’s explanation.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 8 continued

8. (c) Semiconductor lasers are regularly used in DVD players and bar code scanners. State TWO advantages that these semiconductor lasers have over gas lasers.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 8 continued

8. (d) As electronic technology advances, outdated electronic devices and their components are discarded. It has been estimated that 50 million tonnes of electronic waste is produced each year and roughly 80% of this is finding its way into landfill. Discuss the effects this electronic waste may have on society.

[2 marks]

(Total for Question 8 = 9 marks)

END OF PAPER

TOTAL 80 MARKS

Question number	Additional pages, if required. Write the question number(s) in the left - hand margin.

Question number	Additional pages, if required. Write the question number(s) in the left - hand margin.

Question number	Additional pages, if required. Write the question number(s) in the left - hand margin.

GCE AS/A LEVEL

2420U20-1

WEDNESDAY, 24 MAY 2023 – AFTERNOON

PHYSICS – AS UNIT 2

ELECTRICITY AND LIGHT

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Diagram Booklet

Surname: _____

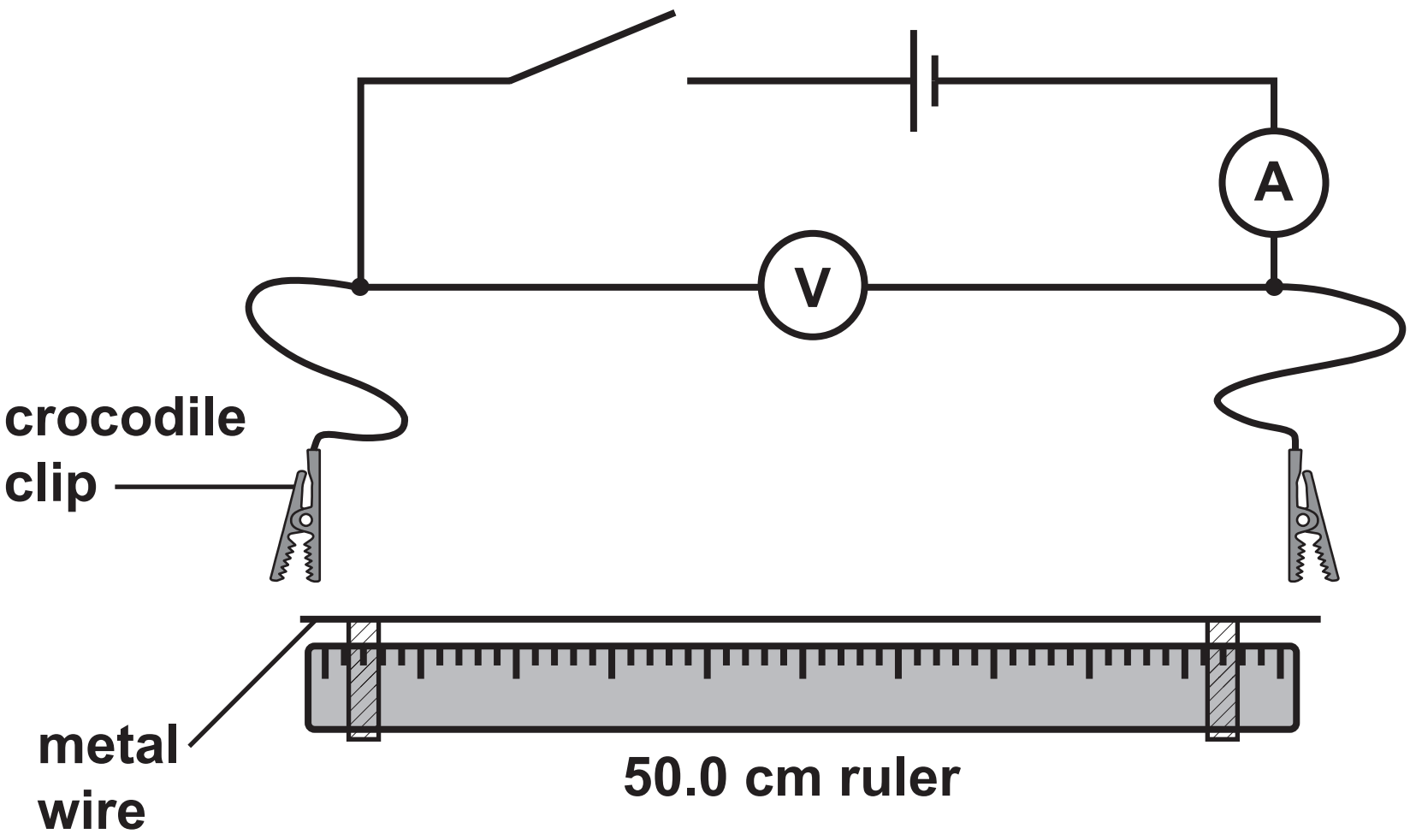
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

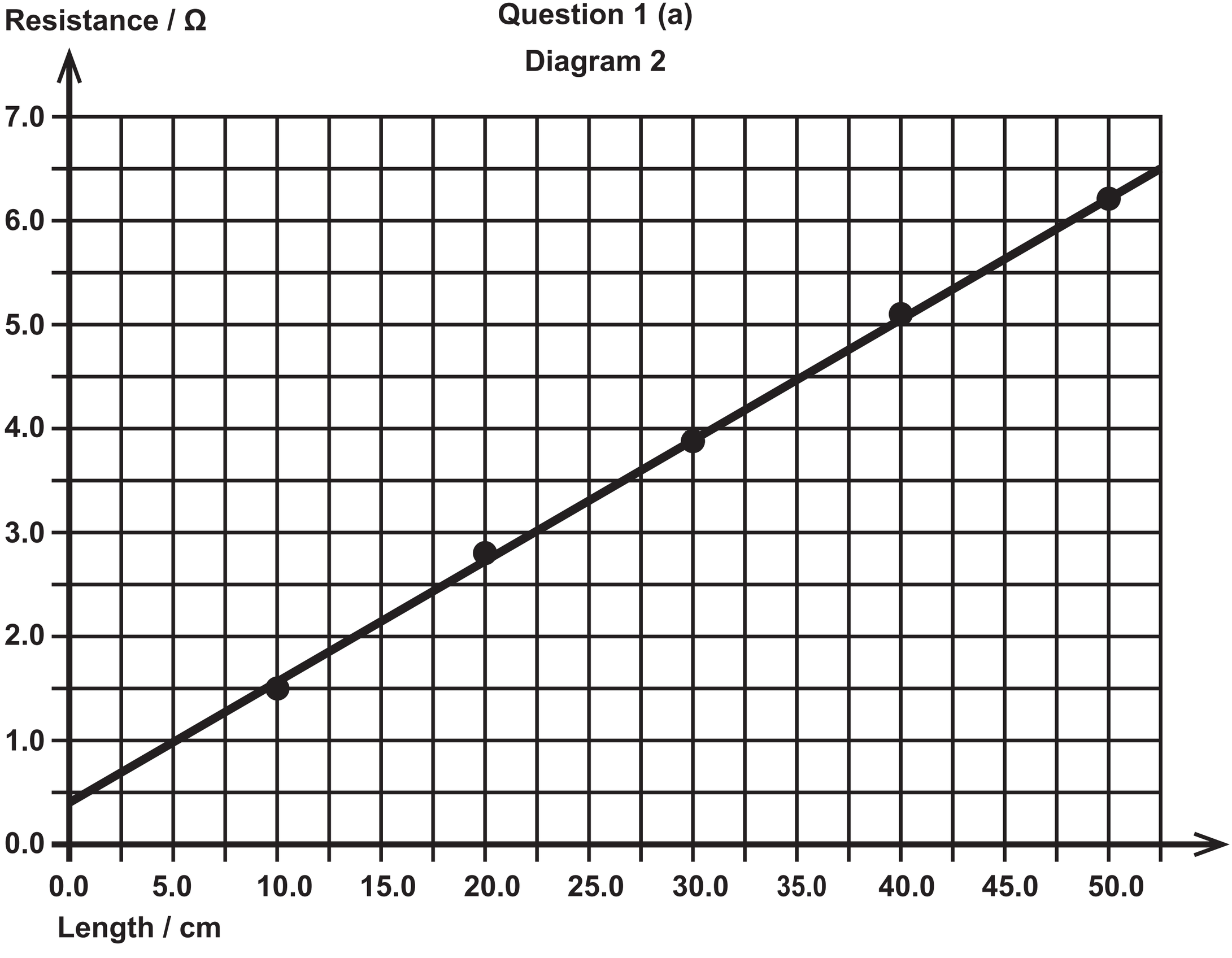
Question 1 (a)

Diagram 1

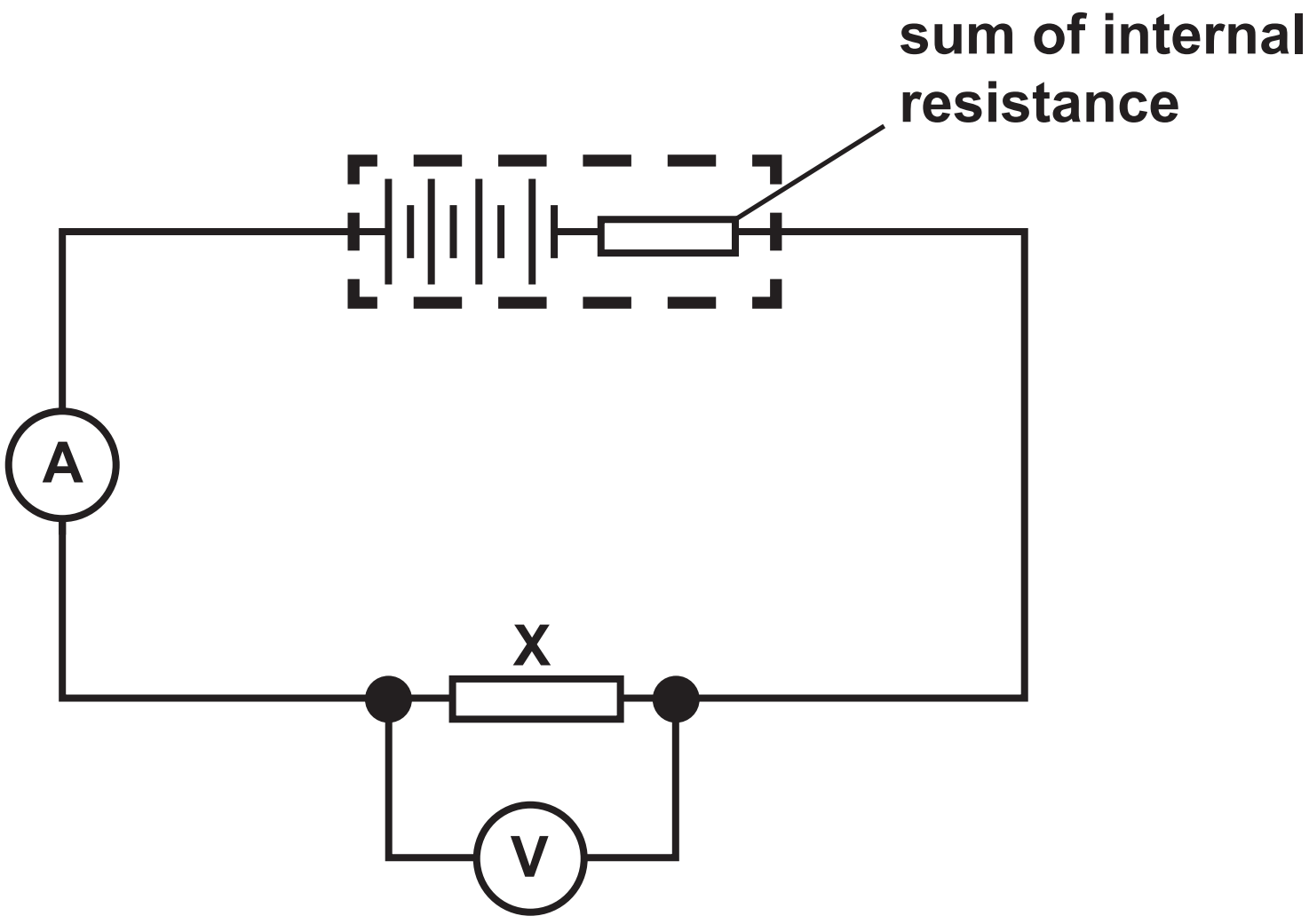


Question 1 (a)

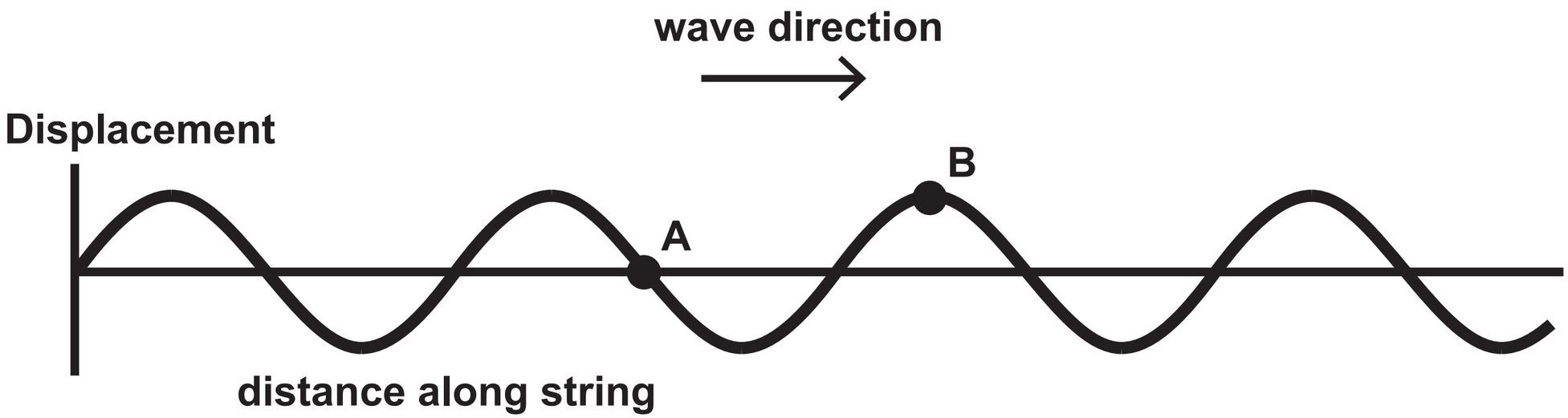
Diagram 2



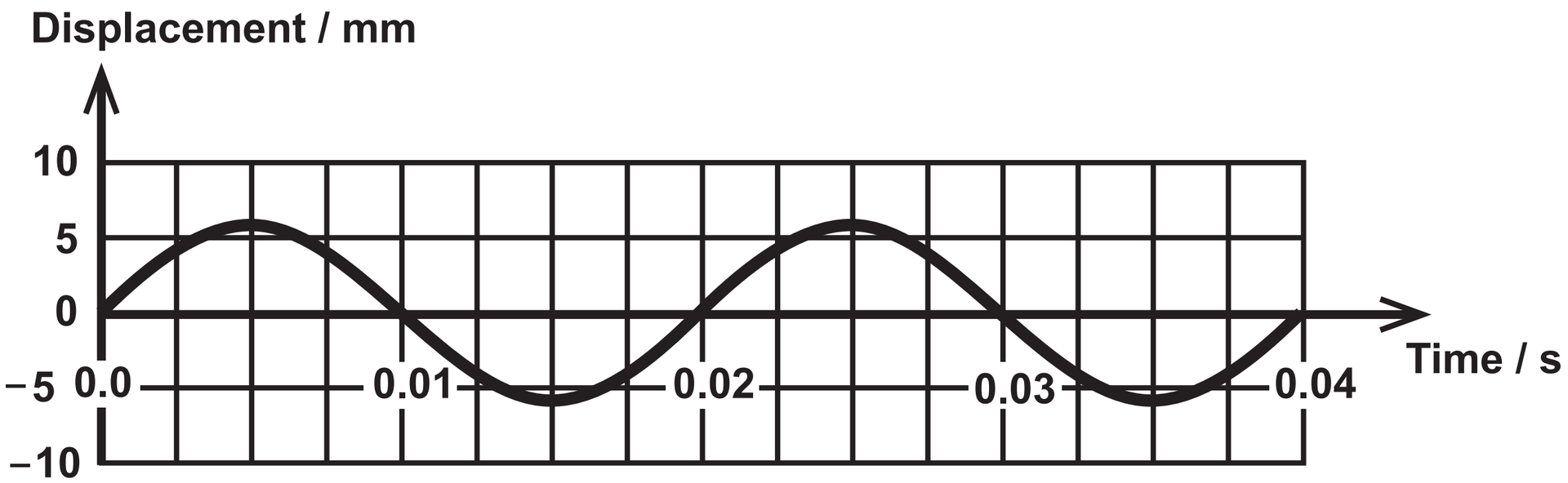
Question 2 (b)



Question 3 (a)

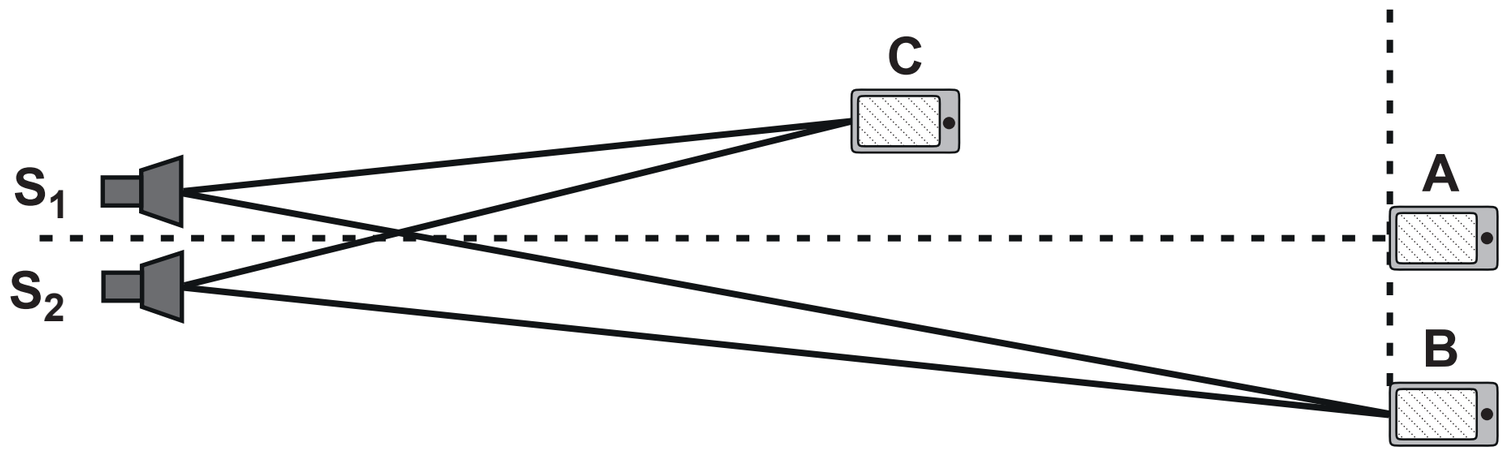


Question 3 (a) (ii)

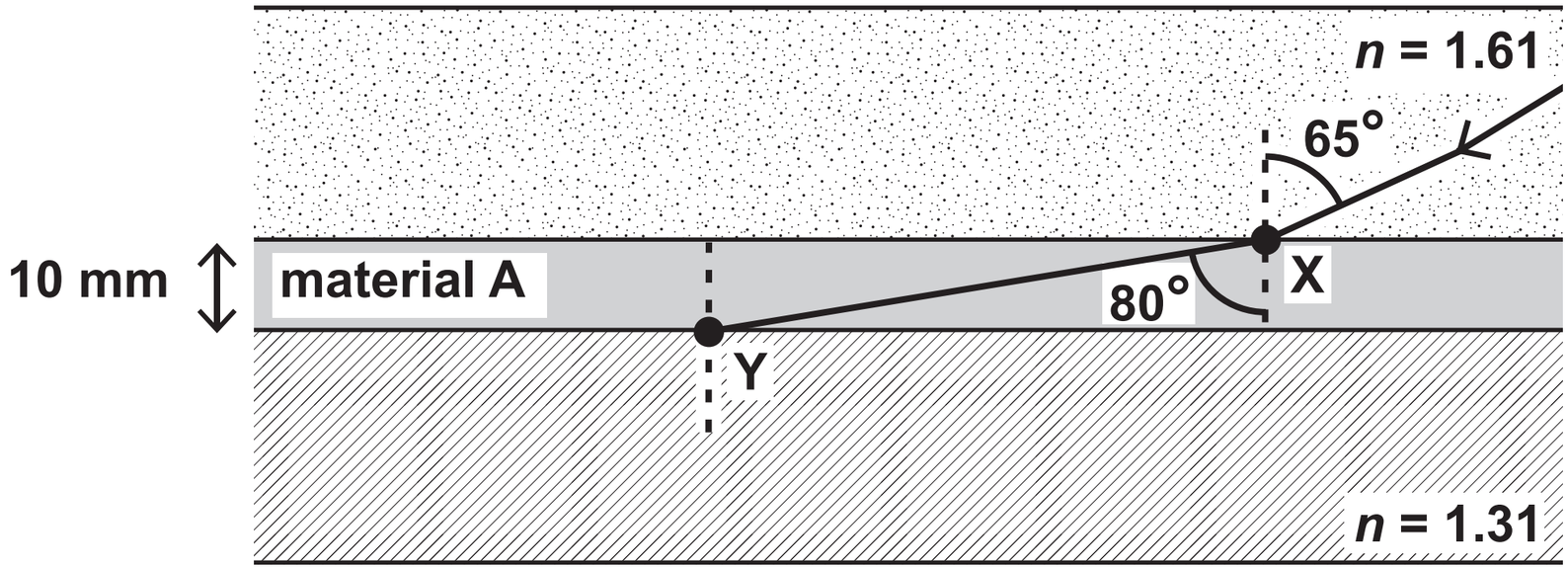


Question 4

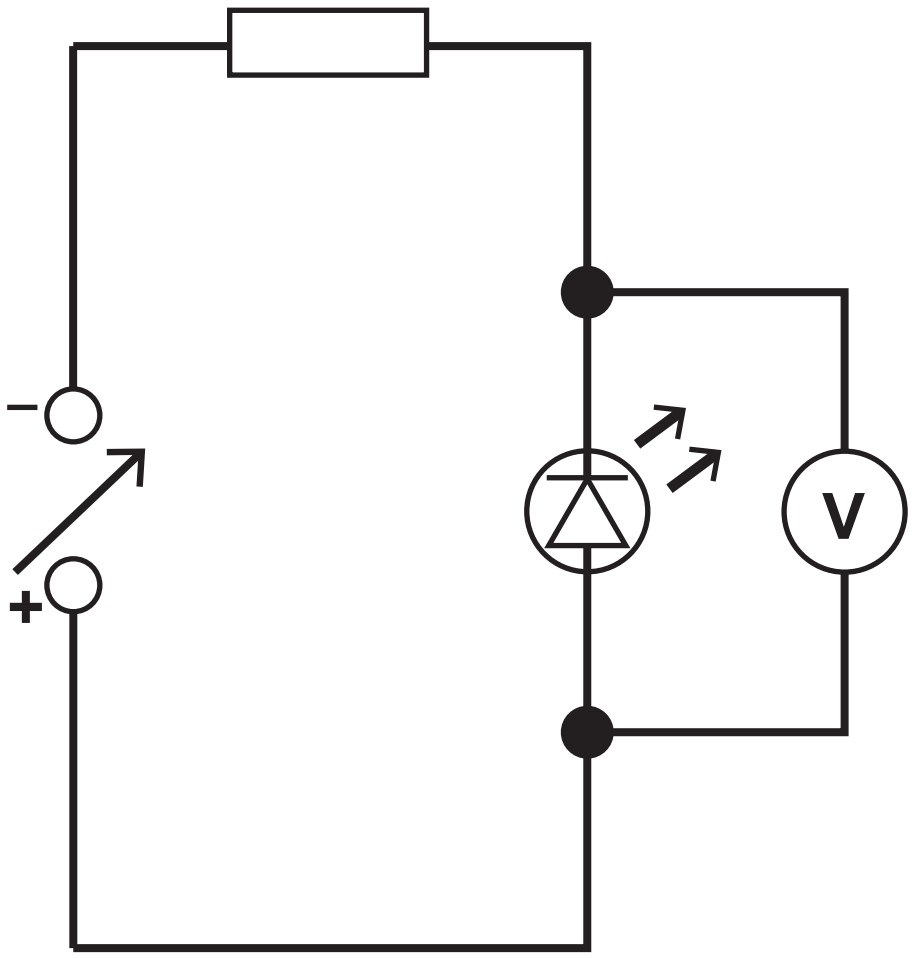
Diagram NOT drawn to scale



Question 5 (b)



Question 7 (a)



Question 8