



GCE A LEVEL



A420U30-1

THURSDAY, 15 JUNE 2023 – MORNING

PHYSICS – A LEVEL COMPONENT 3

LIGHT, NUCLEI AND OPTIONS

2 hours 15 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
SECTION A	1.	12	
	2.	15	
	3.	8	
	4.	12	
	5.	6	
	6.	7	
	7.	14	
	8.	7	
	9.	11	
	10.	8	
SECTION B	Option	20	
	Total	120	

(Turn over)

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a DATA BOOKLET (provided by WJEC).

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.

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

This paper is in 2 sections, A and B.

Section A: 100 marks. Answer ALL questions.

You are advised to spend about 1 hour 50 minutes, plus your additional time allowance, on this section.

Section B: 20 marks. Options.

Answer ONE OPTION ONLY.

You are advised to spend about 25 minutes, plus your additional time allowance, on this section.

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 5.

SECTION A**ANSWER ALL QUESTIONS**

- 1. (a) State what is meant by the wavelength of a SOUND WAVE.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (b) (i) Explain clearly why the speed, c , of a wave is given by:

$$c = \frac{\lambda}{T}$$

where λ is the wavelength of the wave and T its period.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

- 1. (b) (ii) A student carries out an experiment to measure the speed of sound by using the echo from a distant wall. She measures the distance to the wall as 90.0 m and the time for the echo to arrive back as 0.51 s. Calculate the speed of sound using the student's data.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

- 1. (b) (iii) Extending her investigation, the student measures the wavelength of low frequency sound waves generated by a loudspeaker. By looking directly at the slow – moving loudspeaker and using a stopwatch, she notices that the loudspeaker takes 7.55 s to complete 20 oscillations. Calculate the wavelength of the sound waves produced.**

[3 marks]

(Turn over)

Question 1 (b) continued

- 1. (b) (iv) The student uses a stroboscope to check the frequency of oscillation of the loudspeaker. She concludes that the frequency of the loudspeaker is **1.3 Hz** because the loudspeaker appears stationary when the stroboscope flashes short pulses of light at a frequency of **1.3 Hz**. Explain whether this method or that of part (iii) has produced the more accurate value of frequency on this occasion.**
-
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[3 marks]

(Total for Question 1 = 12 marks)

(Turn over)

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

COMPLETE THE DIAGRAM to show the diffraction of waves after passing through the slit.

[3 marks]

- (b) It is often stated that a diffraction grating should be called an interference grating because the pattern produced is usually called an interference pattern. Explain briefly the importance of **DIFFRACTION** in producing this interference pattern.

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (c) Look at the diagram for Question 2 (c) in the separate Diagram Booklet.**

John carries out an experiment to measure the number of lines PER CM of a high – quality diffraction grating. John’s set – up is shown along with the high – quality data that he obtained (he used the wall of the laboratory to maximise the distances he was measuring).

- (i) Calculate the number of lines PER CM for the diffraction grating, quoting your final answer to an appropriate number of significant figures.**

[5 marks]

continued on the next page . . .

(Turn over)

Question 2 (c) continued

- 2. (c) (ii) Explain why maximising the distances John was measuring improved the precision of the final answer.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

- 2. (d) The unknown wavelength of a laser can be measured using a diffraction grating or a double slit. Kevin states that it is better to use a diffraction grating. Evaluate to what extent Kevin is correct.**

[illegible]

[3 marks]

(Total for Question 2 = 15 marks)

(Turn over)

3. (a) Helen and Valentina carry out a standard experiment to measure the refractive index of a perspex block. They vary the angle of incidence and measure the angle of refraction each time.

Look at the table for Question 3 (a) in the separate Diagram Booklet. Their results are tabulated in the table.

(i) COMPLETE THE TABLE.

[1 mark]

continued on the next page . . .

Question 3 (a) continued

- 3. (a) (ii) Look at the diagrams for Question 3 (a) (ii) in the separate Diagram Booklet. There are two graphs. Helen produces GRAPH 1. Valentina produces GRAPH 2.**

Based on her graph, Helen concludes, “My data show that there is a definite relationship between the angle of incidence and angle of refraction. As the angle of incidence increases, the angle of refraction increases. We know that our results are good because all our points are close to the line of best fit.”

Based on her graph, Valentina concludes, “My data confirms Snell’s law”.

continued on the next page . . .

Question 3 (a) (ii) continued

Suggest TWO improvements to EACH of these conclusions that are consistent with the graphs that they have drawn.

[illegible]

(Turn over)

[4 marks]

3. (b) Calculate the best value of the refractive index of the perspex block and explain why you chose this method.

[3 marks]

(Total for Question 3 = 8 marks)

(Turn over)

4. (a) State a typical value for the wavelength of:

(i) microwave radiation

[1 mark]

(ii) ultraviolet radiation.

[1 mark]

(b) (i) Define the work function for a metal surface.

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (ii) Most metals have a work function of A FEW eV. USING YOUR VALUES FROM PART (a), show that microwaves will not produce the photoelectric effect whereas ultraviolet radiation will.

[illegible]

[3 marks]

(Turn over)

Question 4 (b) continued

- 4. (b) (iii) Gold has a work function of 5.1 eV. Calculate the maximum SPEED of electrons emitted from a gold surface when irradiated by photons of wavelength 200 nm.**

[5 marks]

(Total for Question 4 = 12 marks)

(Turn over)

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

You are given a set of LEDs of known wavelengths and the circuit shown in the diagram.

Explain how you would use this apparatus to measure the Planck constant. In your answer you should also explain how you would obtain the Planck constant from a suitable graph.

(Total for Question 5 = 6 marks)

6. The metastable energy level of a laser system is (indirectly) pumped at a rate of 5×10^{18} electrons per second.

(a) State what is meant by a metastable energy level.

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (b) If the half – life of the metastable energy level is 2.4 ms, explain why the equilibrium number of electrons in the metastable energy level is approximately 1.7×10^{16}

(hint: use $A = \lambda N$ or $\frac{\Delta N}{\Delta t} = -\lambda N$).

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (c) Hence, explain why it is desirable for the metastable state in a laser system to have a long half – life.

[3 marks]

(Total for Question 6 = 7 marks)

(Turn over)

7. (a) Naturally occurring uranium is composed of **99.28%** of $^{238}_{92}\text{U}$ and **0.72%** of $^{235}_{92}\text{U}$

The lighter of the 2 isotopes ($^{235}_{92}\text{U}$)

decays via a chain of **7** alpha decays and **4** beta decays to an isotope of lead (**Pb**).

- (i) Calculate the proton number and nucleon number of the lead (**Pb**) isotope into which the uranium – **235** decays.

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

7. (a) (ii) When uranium – **235** decays to lead, the longest half – life by far is the half – life of uranium – **235**, which is **704** million years (all other half – lives are tiny and negligible in comparison). A rock is discovered with **80.0%** of the original uranium – **235** remaining undecayed. Determine the age of the rock.

[4 marks]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

7. (a) (iii) Gareth discovers that uranium – 235 and uranium – 238 are produced in a supernova in the ratio:

$$\frac{N_{92}^{235}\text{U}}{N_{92}^{238}\text{U}} = 1.5$$

He then concludes that the supernova that produced Earth's uranium occurred around 6400 million years ago. Determine whether Gareth is correct.

Current abundance of uranium – 235 = 0.72%

Current abundance of uranium – 238 = 99.28%

Half – life of uranium – 235 = 704×10^6 year

Half – life of uranium – 238 = 4.47×10^9 year

(Turn over)

[5 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

- 7. (b) Radon gas is an alpha emitter and is in the decay – chain of uranium. It usually accounts for approximately 50% of background radiation. A builder is told by the local council that she must provide an expensive pump system to eliminate radon gas in new buildings in an area with 10 times the normal background radiation. The builder refuses to do so, stating that it is pointless for buildings that do not have a basement. She also states correctly that 10 times the normal background radiation increases the probability of lung cancer before the age of 75 from 0.4% to only 0.5%**

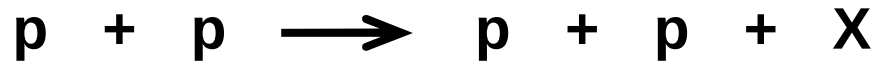
Discuss briefly whether the builder has used scientific knowledge appropriately in refusing to install the radon pump system.

[3 marks]

(Total for Question 7 = 14 marks)

(Turn over)

8. In a high energy proton – proton collision, the following reaction is observed:



where X is an unknown particle.

- (a) Use conservation of baryon number, charge and lepton number to identify particle X .

[4 marks]

(Turn over)

Question 8 continued

8. (b) The unknown particle **X** is then seen to decay as follows:



where each gamma photon has an energy of **67.5 MeV**.

Calculate the mass of particle **X** in **kg**.

[3 marks]

(Total for Question 8 = 7 marks)

(Turn over)

9. Look at the diagram for Question 9 in the separate Diagram Booklet.

Alpha particles, from the source shown in the diagram, are accelerated in a synchrotron.

The alpha particles are accelerated by the varying electric field four times during each complete orbit of the synchrotron.

The initial speed of the alpha particles is $1.6 \times 10^7 \text{ m s}^{-1}$ along the dotted circle.

- (a) PLACE AN ARROW on the dotted circle to indicate the direction of motion of the alpha particles, and state the name of the rule you used to obtain the direction.
-
-

[2 marks]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (b) Calculate the initial magnetic flux density of the synchrotron to ensure that the alpha particles $\left({}_2^4\text{He}\right)$ follow a circular path.

[3 marks]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (c) Calculate the initial frequency of the **pd** supplied to the synchrotron.

[3 marks]

continued on the next page . . .

(Turn over)

Question 9 continued

9. (d) Explain why the kinetic energy (in eV) of the alpha particles in the synchrotron is:

$$\text{kinetic energy (in eV)} = 5.3 \times 10^6 + (8 \times n \times V)$$

where n is the number of orbits completed by the alpha particles and V is the pd of the synchrotron (in volt).

(Turn over)

[3 marks]

(Total for Question 9 = 11 marks)

- 10. (a) Look at the diagram for Question 10 (a) in the separate Diagram Booklet.**

A conductor slides horizontally along parallel conductors placed on the ground, as shown in the diagram. The only magnetic field present is the Earth's magnetic field and the resistances of the conductors are negligible.

- (i) Explain why the current induced only depends on the VERTICAL component of the Earth's field.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

- 10. (a) (ii) In the northern hemisphere, the vertical component of the Earth's field is downwards. Explain the direction of the induced current in the circuit.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

- 10. (a) (iii) Calculate the vertical component of the Earth's magnetic flux density.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 10 continued

- 10. (b) Look at the diagram for Question 10 (b) in the separate Diagram Booklet.**

Rhianna claims that the induced current in this set – up increases after the sliding conductor reaches point X because of the narrowing of the track. Determine whether or not she is correct.

[2 marks]

(Total for Question 10 = 8 marks)

(Turn over)

SECTION B: OPTIONAL TOPICS**Option A – ALTERNATING CURRENTS**☐**Option B – MEDICAL PHYSICS**☐**Option C – THE PHYSICS OF SPORTS**☐**Option D – ENERGY AND THE ENVIRONMENT**☐**Answer the question on ONE TOPIC ONLY.**

**Place a tick (✓) in ONE of the boxes above,
to show which topic you are answering.**

**YOU ARE ADVISED TO SPEND ABOUT 25 MINUTES
PLUS YOUR ADDITIONAL TIME ALLOWANCE ON
THIS SECTION.**

(Turn over)

Option A – ALTERNATING CURRENTS

11. Look at the diagram for Question 11 in the separate Diagram Booklet.

Daniel is investigating a.c. circuits and sets up the circuit shown in the diagram.

(a) (i) Show, in clear steps, that the resonance frequency, f_0 , of the circuit is given by:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 (a) continued

- 11. (a) (ii) Calculate the maximum possible resonance frequency for the circuit.**

[2 marks]

- (iii) Explain why the maximum rms current in this circuit is approximately 5 A.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 continued

- 11. (b) Look at the diagram for Question 11 (b) in the separate Diagram Booklet.**

Daniel continues his investigation by connecting a different resistor, R , and a fixed capacitor, C , in series with a variable frequency a.c. supply.

This new circuit is shown in the diagram.

continued on the next page . . .

Question 11 (b) continued

- 11. (b) (i) Use a labelled phasor diagram to explain why the impedance of the circuit, Z , is given by:**

$$Z = \sqrt{R^2 + X_C^2}$$

Space for diagram:

(Turn over)

[4 marks]

11. (b) (ii) Hence show that:

$$Z^2 = \frac{1}{\omega^2 C^2} + R^2$$

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 (b) continued

- 11. (b) (iii) Look at the diagram for Question 11 (b) (iii) in the separate Diagram Booklet.**

Using the circuit, Daniel determines Z for a number of different values of ω and plots a graph of Z^2 against $\frac{1}{\omega^2}$

Daniel's graph is shown in the diagram.

Use the graph to determine the values of the resistor, R , and capacitor, C .

[5 marks]

continued on the next page . . .

(Turn over)

Question 11 (b) continued

- 11. (b) (iv) While carrying out the investigation, Daniel notices that the pd across the resistor, V_R , is small at low frequencies and approaches the supply pd at high frequencies. Explain why this happens.**

[3 marks]

(Total for Question 11 = 20 marks)

(Turn over)

Option B – MEDICAL PHYSICS

- 12. (a) (i) An X – ray tube operating with a power of 7.5 kW has a current of 250 mA. Determine its operating voltage.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 12 (a) continued

12. (a) (ii) Look at the diagram for Question 12 (a) (ii) in the separate Diagram Booklet.

The diagram is a graph.

The graph shows the intensity spectrum for the X – ray tube.

Label any features AND include a numerical value for the minimum wavelength. Space has been left for calculations.

[3 marks]

continued on the next page . . .

Question 12 (a) continued

- 12. (a) (iii) ON THE DIAGRAM, draw an intensity spectrum for the same X – ray tube with an operating voltage of 40 kV; again, include a numerical value for the minimum wavelength.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 12 (a) continued

- 12. (a) (iv) Discuss if it would be possible to reduce the minimum wavelength to zero.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 12 continued

- 12. (b) Doctors are concerned that there is a faulty aortic valve in a patient's heart. They have decided to investigate this further and have the choice of the following:**

X – RAY
MRI
ULTRASOUND B – SCAN
RADIOACTIVE TRACERS
CT SCAN

Evaluate the suitability of ALL FIVE types of imaging techniques for diagnosing the patient.

[5 marks]

continued on the next page . . .

(Turn over)

Question 12 continued

- 12. (c) Doctors order further tests to examine the rate of blood flow around the body. To determine this, they use ultrasound at a wavelength of 0.45 mm and angle to the blood cells' motion of 15° . Ultrasound travels through blood at a speed of 1400 m s^{-1} . The received wavelength from the red blood cells was found to be shifted by $0.55 \text{ }\mu\text{m}$. Determine the speed of the blood flow.**
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[3 marks]

- 12. (d) Explain the operation of PET scans;
include which part of the electromagnetic
spectrum they detect.**

[3 marks]

(Total for Question 12 = 20 marks)

(Turn over)

Option C – THE PHYSICS OF SPORTS

- 13. (a) Look at the diagram for Question 13 (a) in the separate Diagram Booklet.**

An athlete carries out a balancing exercise using a rope and a pivot while a friend pushes down on the athlete's feet as shown in the diagram.

Calculate the tension, T , in the rope assuming that the athlete is in equilibrium.

[3 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

- 13. (b) State what is meant by the moment of inertia of an object.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

13. (c) A cricket ball is rotating at **300** revolutions per minute.

The moment of inertia of the ball is given

by the equation $I = \frac{2}{5}mr^2$ where

its mass, m , is **0.159** kg and its radius, r , is **3.6** cm.

- (i) Calculate the angular momentum of the ball.

[3 marks]

continued on the next page . . .

(Turn over)

Question 13 (c) continued

- 13. (c) (ii) The cricket ball is struck by a batsman and the ball acquires a linear speed of 30 m s^{-1} and an angular velocity of 210 rad s^{-1} (about its centre). A sports analyst states that the rotational kinetic energy acquired by the cricket ball is negligible compared with its linear kinetic energy. Show that this statement is correct on this occasion.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

- 13. (d) (i) Look at the diagram for Question 13 (d) (i) in the separate Diagram Booklet.**

The diagram is NOT drawn to scale.

The bowler in the diagram aims to bowl the ball so that it lands 8.0 m from the batsman. Evaluate whether this can be achieved if the ball is released from a height of 2.0 m at an angle of 8° to the horizontal with a speed of 45 m s^{-1}

Assume that the effects of air resistance are negligible.

[5 marks]

continued on the next page . . .

(Turn over)

Question 13 (d) continued

- 13. (d) (ii) Look at the diagram for Question 13 (d) (ii) in the separate Diagram Booklet.**

The bowler applies topspin to the ball so that it rotates about the horizontal axis as it moves through the air. DRAW ARROWS ON THE BALL in the diagram to show the directions of the air resistance force and the 'lift' force acting on the ball.

[2 marks]

continued on the next page . . .

Question 13 (d) continued

- 13. (d) (iii) Explain briefly what effect these forces have on the position where the ball lands.**

[2 marks]

(Total for Question 13 = 20 marks)

(Turn over)

Option D – ENERGY AND THE ENVIRONMENT

- 14. (a) Look at the diagram for Question 14 (a) in the separate Diagram Booklet.**

The diagram shows how the mean intensity of solar radiation reaching the Earth system (which includes the Earth and its atmosphere) is distributed.

- (i) It is suggested that the fraction of incoming radiation absorbed by the Earth SYSTEM is approximately 0.7**
Use the diagram to determine whether this suggestion is correct.

[2 marks]

continued on the next page . . .

(Turn over)

Question 14 (a) continued

14. (a) (ii) State what is meant by the greenhouse effect.

[2 marks]

continued on the next page . . .

(Turn over)

Question 14 (a) continued

- 14. (a) (iii) The Earth system emits 240 W m^{-2} of infra – red radiation into space. This is less than the solar radiation that is absorbed and has caused the temperature of the Earth system to increase. Researchers state this imbalance has approximately doubled since 2005.**

- I. Explain how human activities are contributing to this change.**

[3 marks]

14. (a) (iii) II. Describe how an increase in the temperature of the Earth system may lead to further increases in this imbalance.

[2 marks]

continued on the next page . . .

(Turn over)

Question 14 continued

- 14. (b) Look at the diagram for Question 14 (b) in the separate diagram Booklet.**

The diagram is NOT drawn to scale.

A student tests the efficiency of a photovoltaic solar panel using light with an intensity of 350 W m^{-2}

The student positions the light source at an angle of 62° above the horizontal, as shown in the diagram.

The panel has an area of 1.9 m^2 and produces a power output of 128 W . Determine the efficiency of the panel.

[4 marks]

continued on the next page . . .

(Turn over)

Question 14 continued

14. (c) An uninsulated external wall has a

U – value of $1.51 \text{ W m}^{-2} \text{ K}^{-1}$

(i) Explain what this statement means.

[2 marks]

continued on the next page . . .

(Turn over)

Question 14 (c) continued

- 14. (c) (ii) Look at the diagram for Question 14 (c) (ii) in the separate Diagram Booklet.**

Charlie replaces part of his uninsulated external wall (BEFORE) with patio doors and adds insulation to the remainder of the wall (AFTER) as shown in the diagram.

Look at the graph for Question 14 (c) (ii) in the separate Diagram Booklet.

The graph shows how the rate of energy transfer from the original uninsulated external wall varies with external temperature on a windless day.

continued on the next page . . .

Question 14 (c) (ii) continued

- 14. (c) (ii) I. Use the graph to show that the area of the original wall is approximately 12 m^2**

$(U\text{-value} = 1.51 \text{ W m}^{-2} \text{ K}^{-1})$

[2 marks]

continued on the next page . . .

(Turn over)

Question 14 (c) (ii) continued

14. (c) (ii) II. After the renovation, under the same windless conditions, the heat transfer from the insulated external wall with patio doors is found to be 65 W when the temperature difference between the inside and outside is 10°C . The U -value of the patio doors is $1.34 \text{ W m}^{-2} \text{ K}^{-1}$
- Charlie calculates the U -value of the insulated wall to be less than $0.2 \text{ W m}^{-2} \text{ K}^{-1}$
- Determine whether Charlie is correct.

80

[3 marks]

(Total for Question 14 = 20 marks)

END OF PAPER

TOTAL 120 MARKS

(Turn over)

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

[illegible]



GCE A LEVEL



A420U30-1

THURSDAY, 15 JUNE 2023 – MORNING

PHYSICS – A LEVEL COMPONENT 3

LIGHT, NUCLEI AND OPTIONS

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

Diagram Booklet

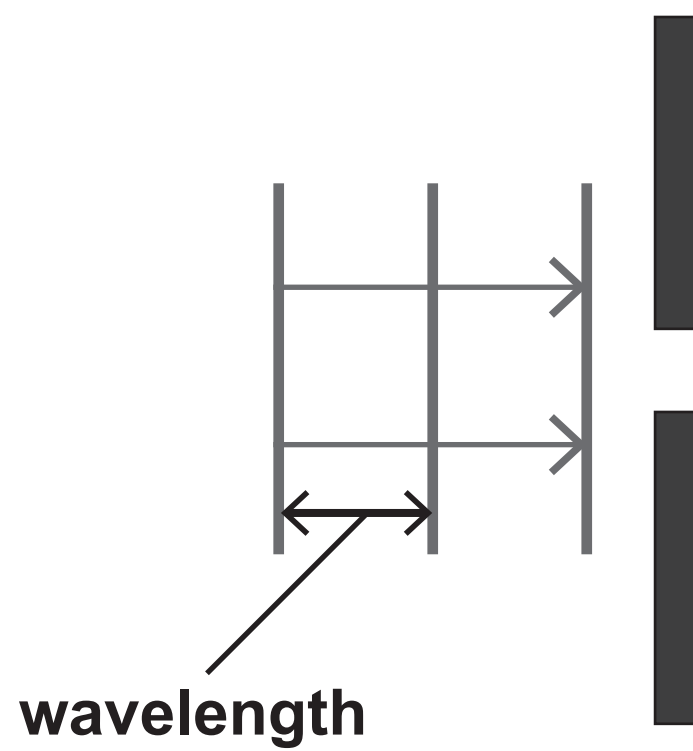
Surname: _____

First name(s): _____

Centre Number: _____

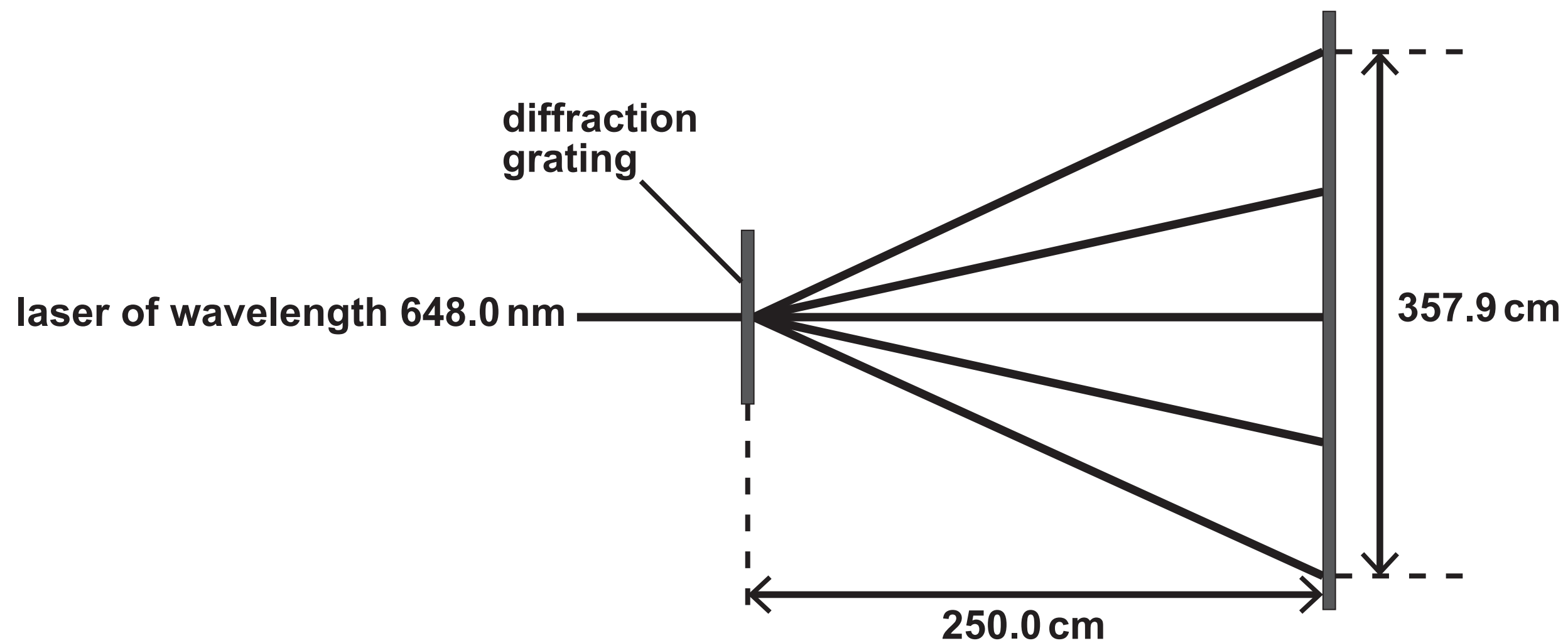
Candidate Number: 2 _____

Question 2 (a)



Question 2 (c)

Diagram not drawn to scale



Question 3 (a)

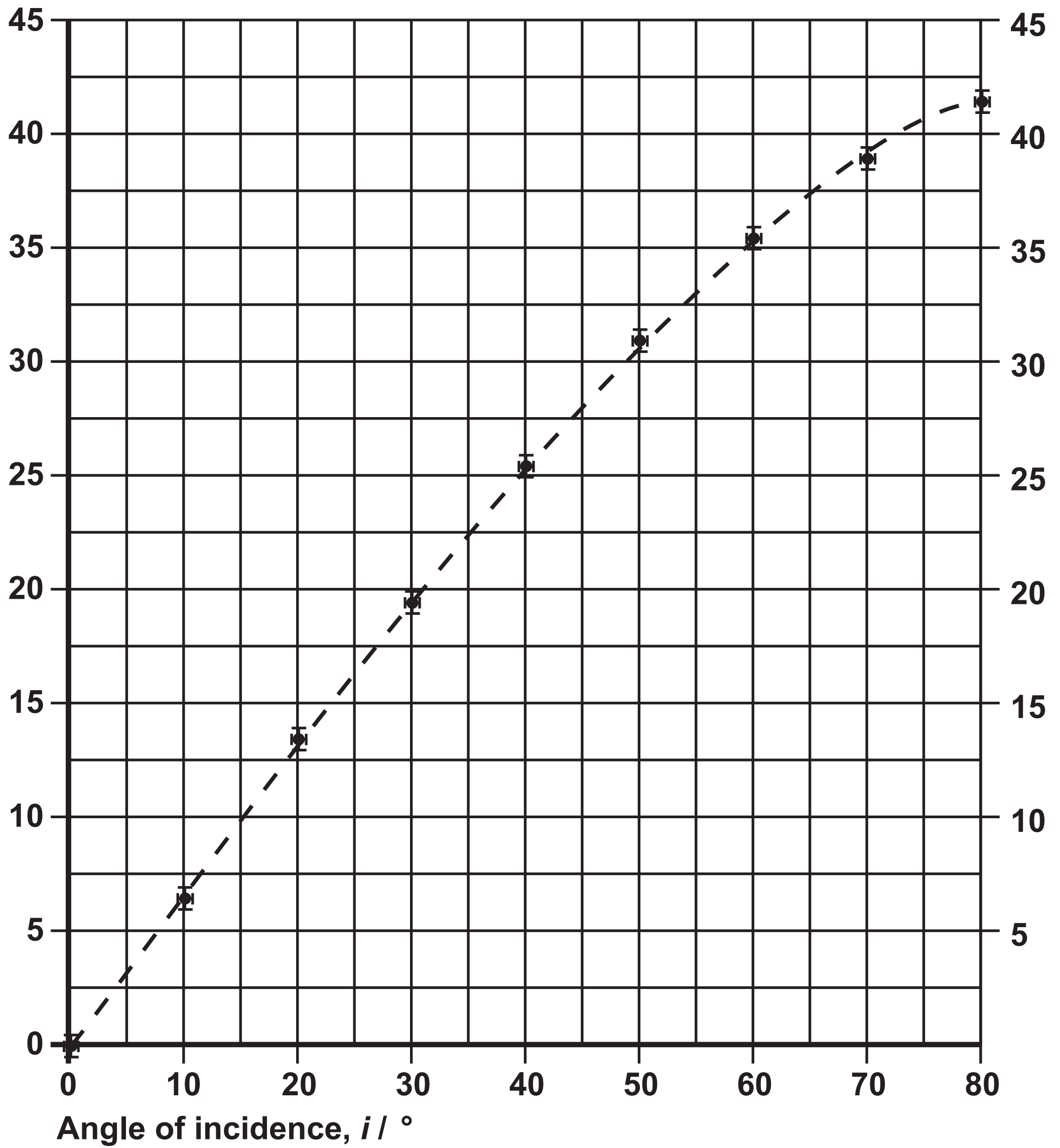
Table

Angle of incidence, $i / ^\circ$ ($\pm 0.5^\circ$)	Angle of refraction, $r / ^\circ$ ($\pm 0.5^\circ$)	$\sin i$	$\sin r$
0.0	0.0	0.000	0.000
10.0	6.5	0.174	0.113
20.0	13.5	0.342	0.233
30.0	19.5	0.500	0.334
40.0	25.5	0.643	0.431
50.0	31.0	0.766	0.515
60.0	35.5	0.866	0.581
70.0	39.0		0.629
80.0	41.5	0.985	0.663

Question 3 (a) (ii)

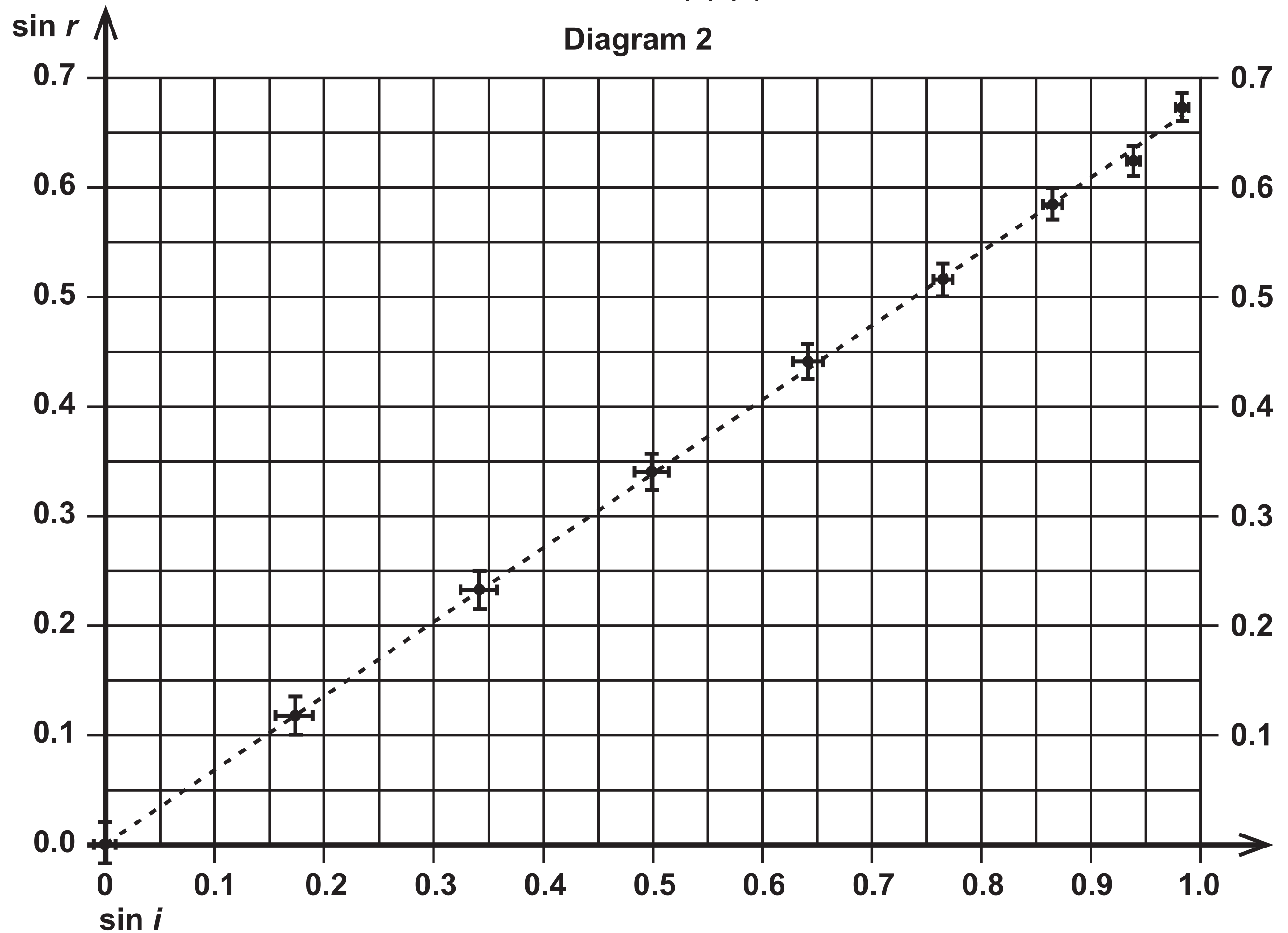
Diagram 1

Angle of refraction, $r / ^\circ$

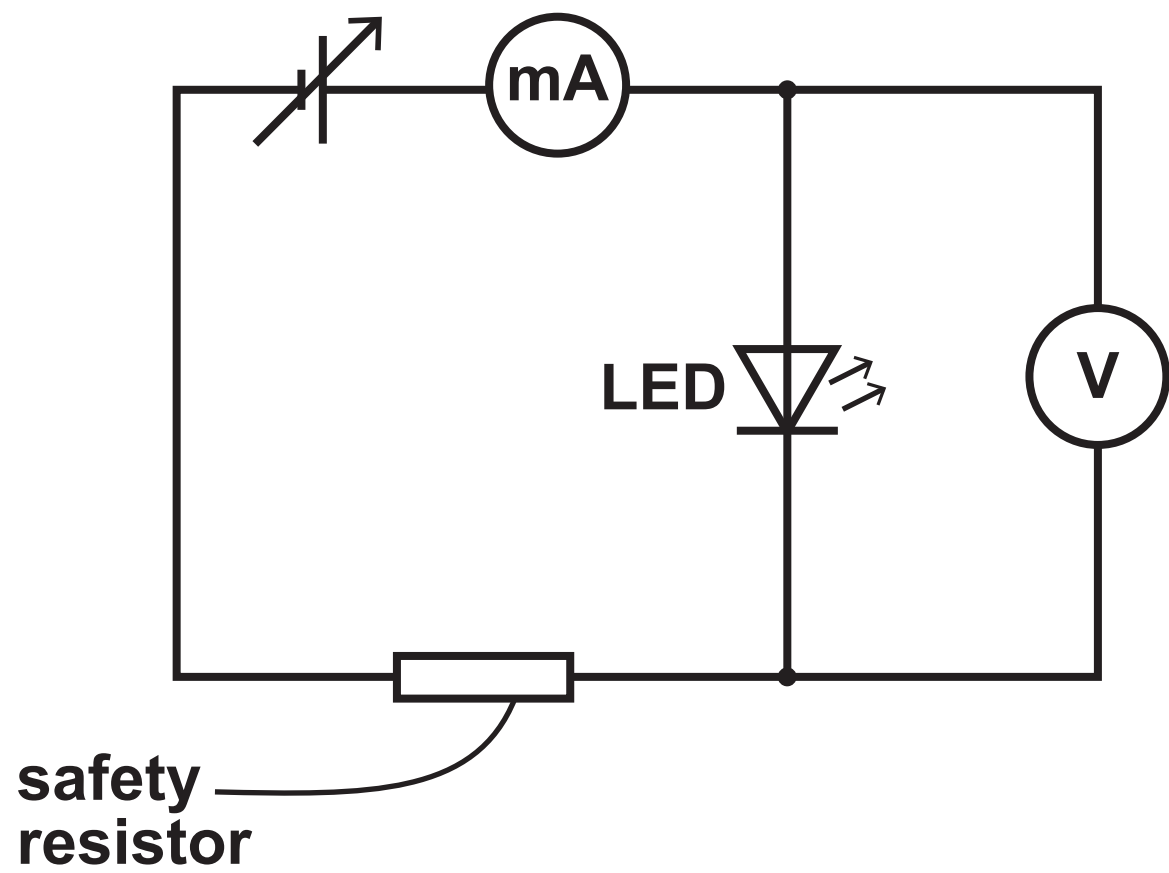


Question 3 (a) (ii)

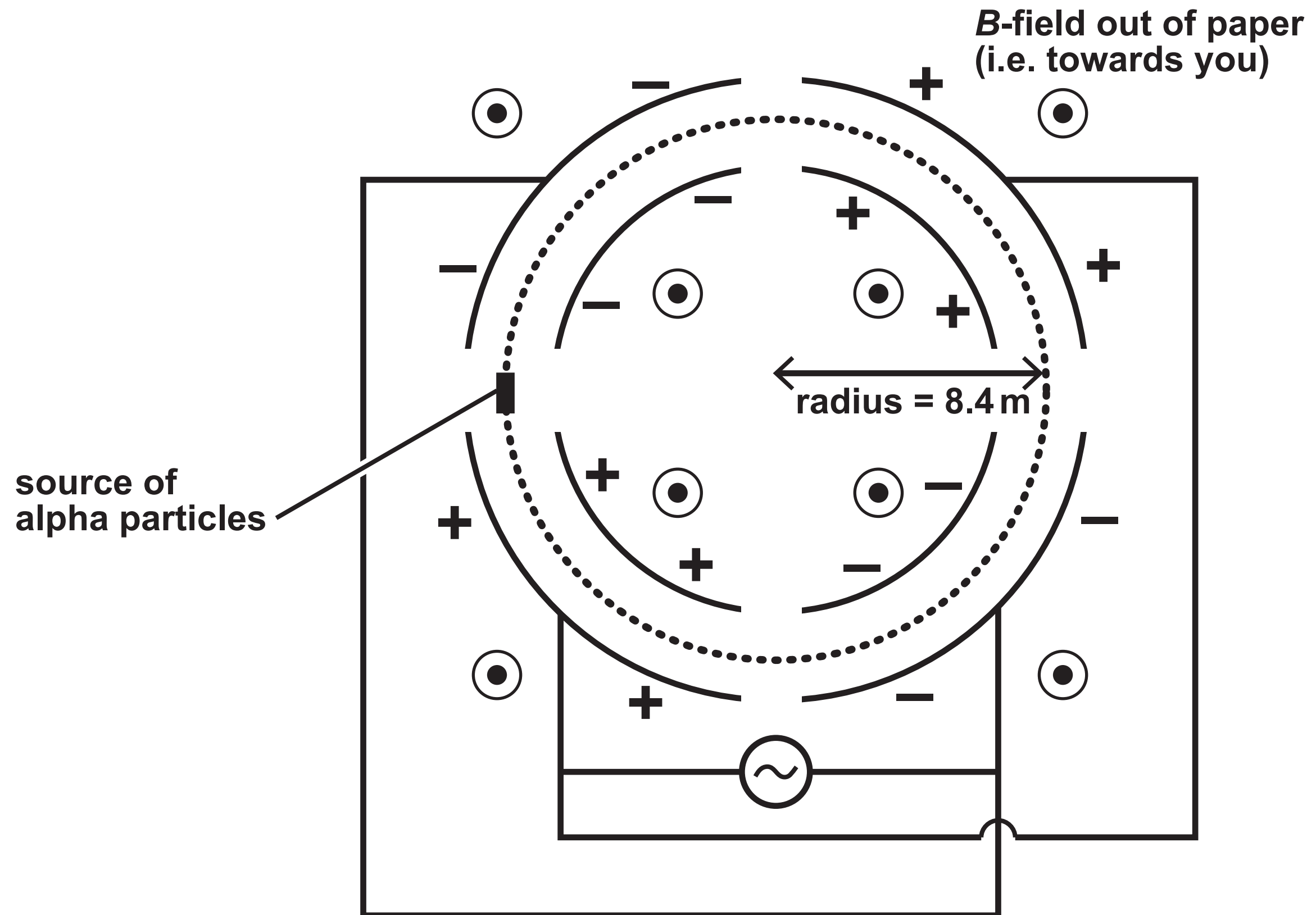
Diagram 2



Question 5

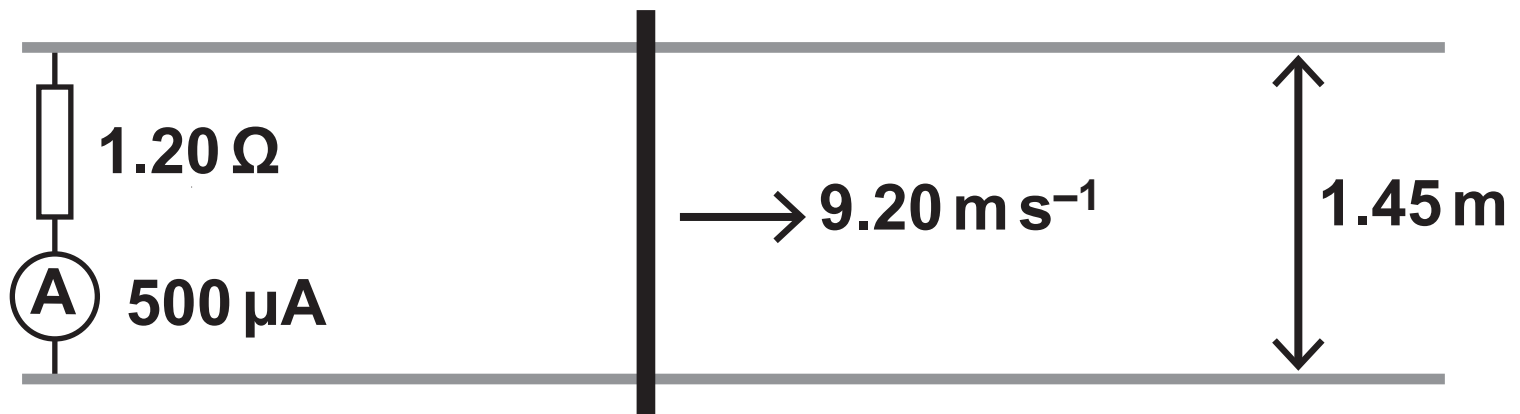


Question 9



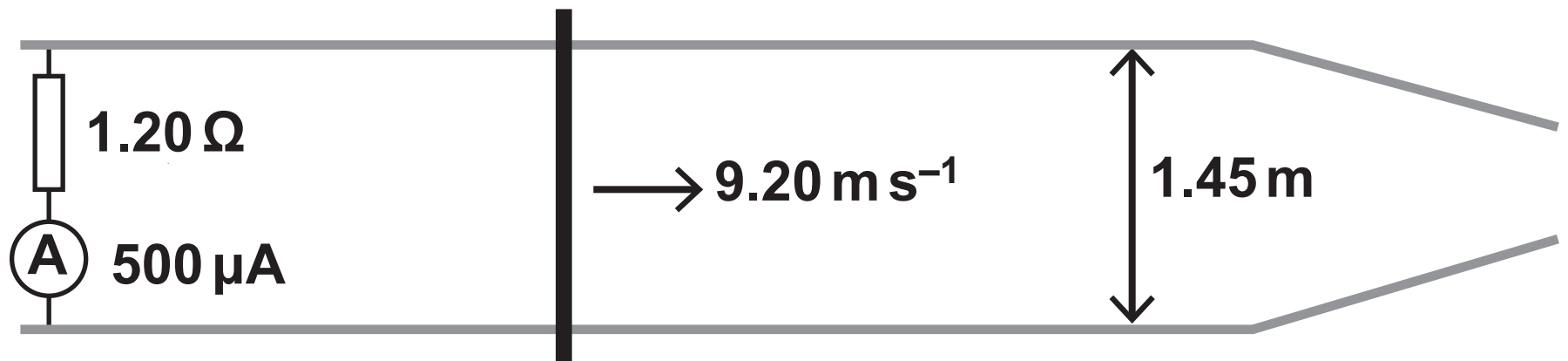
Question 10 (a)

view from above



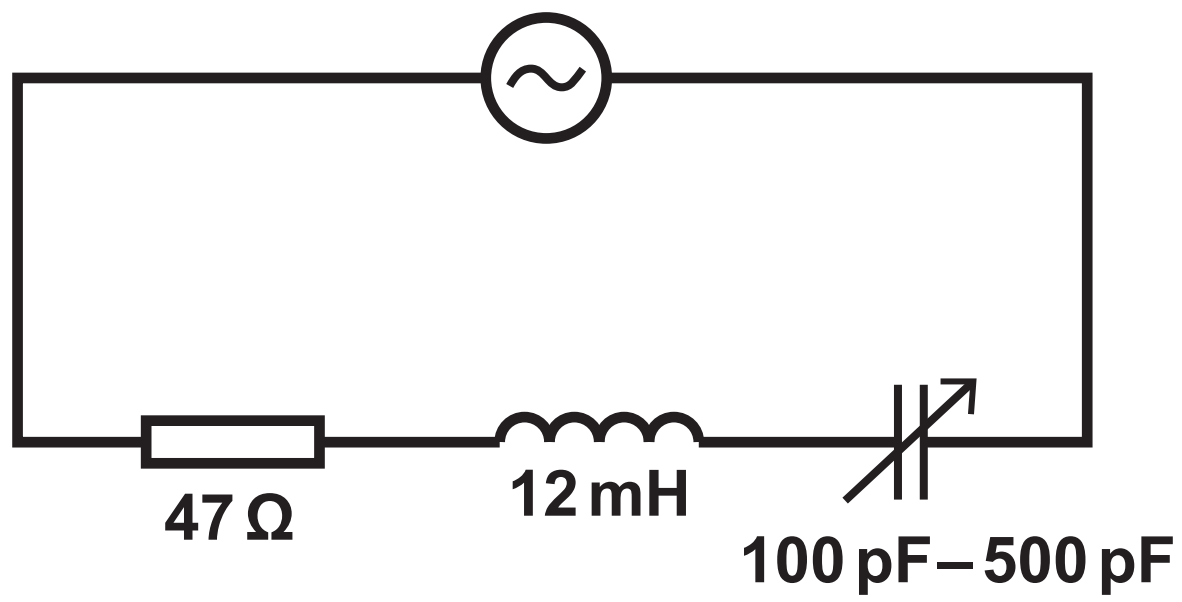
Question 10 (b)

view from above



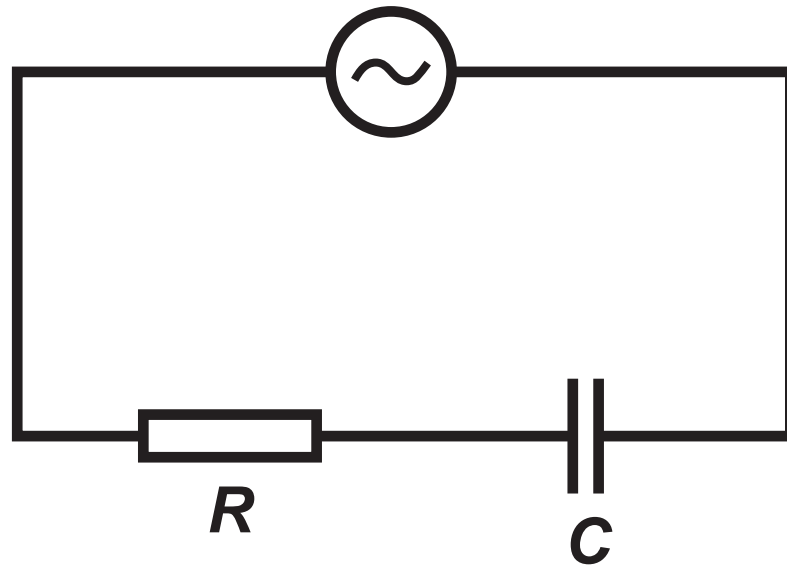
Question 11

variable frequency a.c. supply
 $V_{\text{rms}} = 230 \text{ V}$

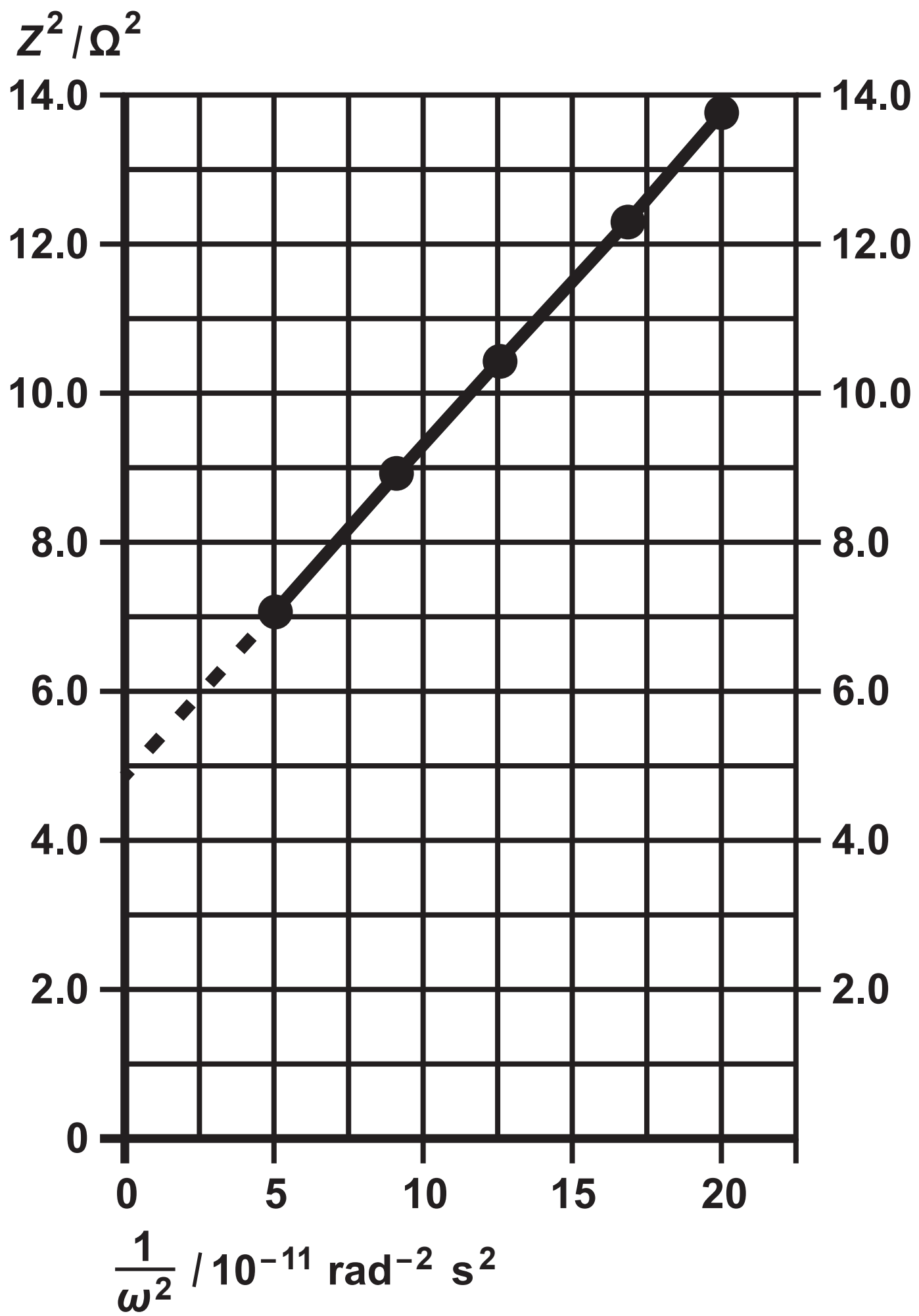


Question 11 (b)

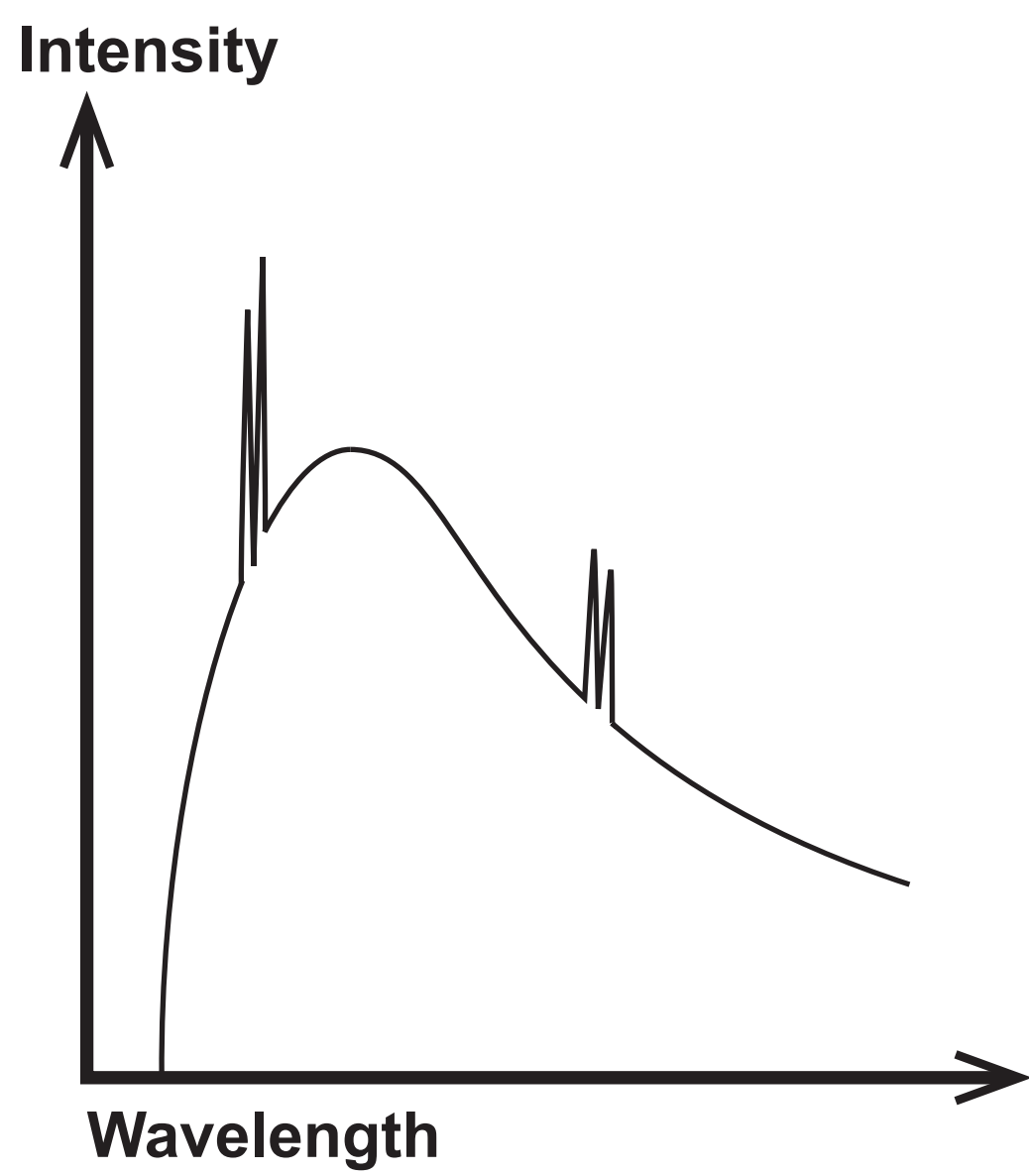
variable frequency a.c. supply



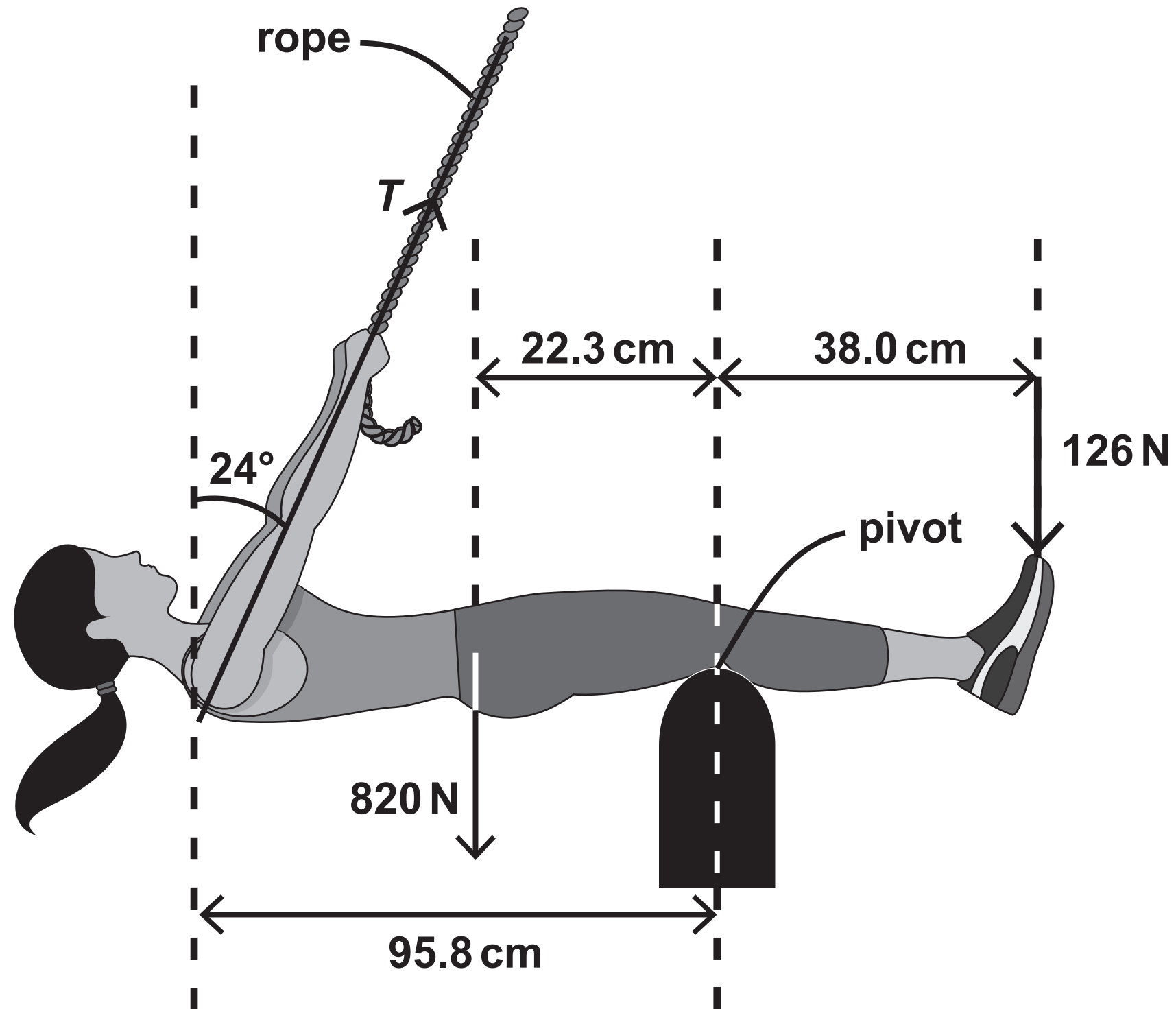
Question 11 (b) (iii)



Question 12 (a) (ii)

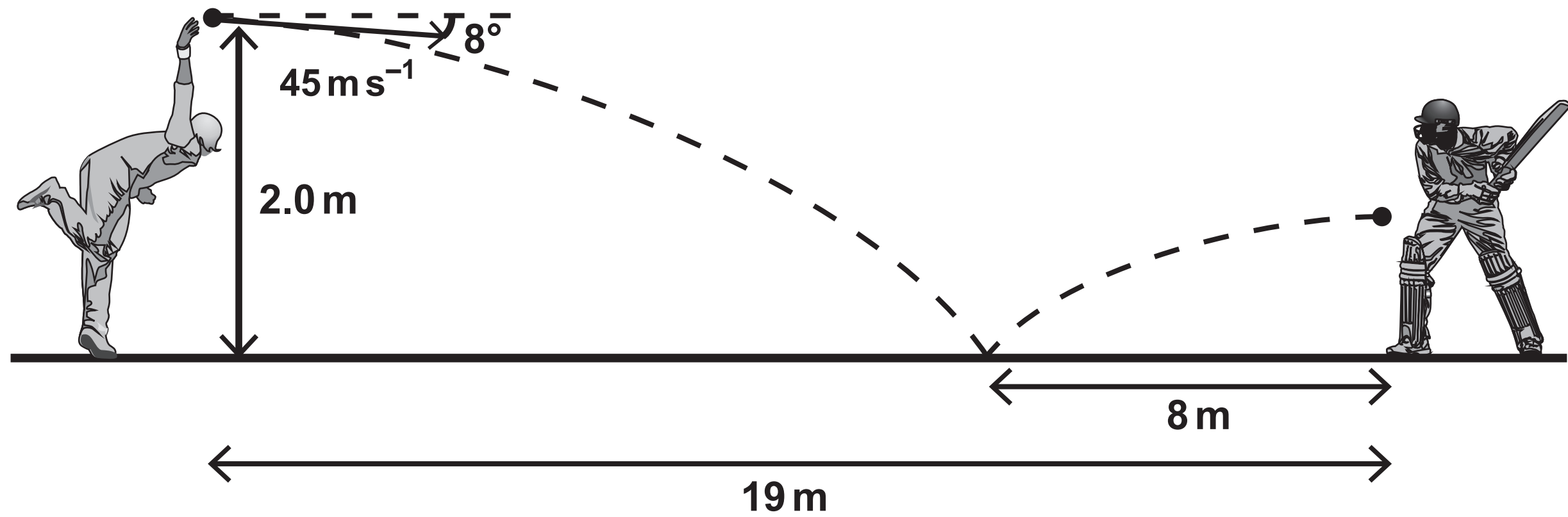


Question 13 (a)

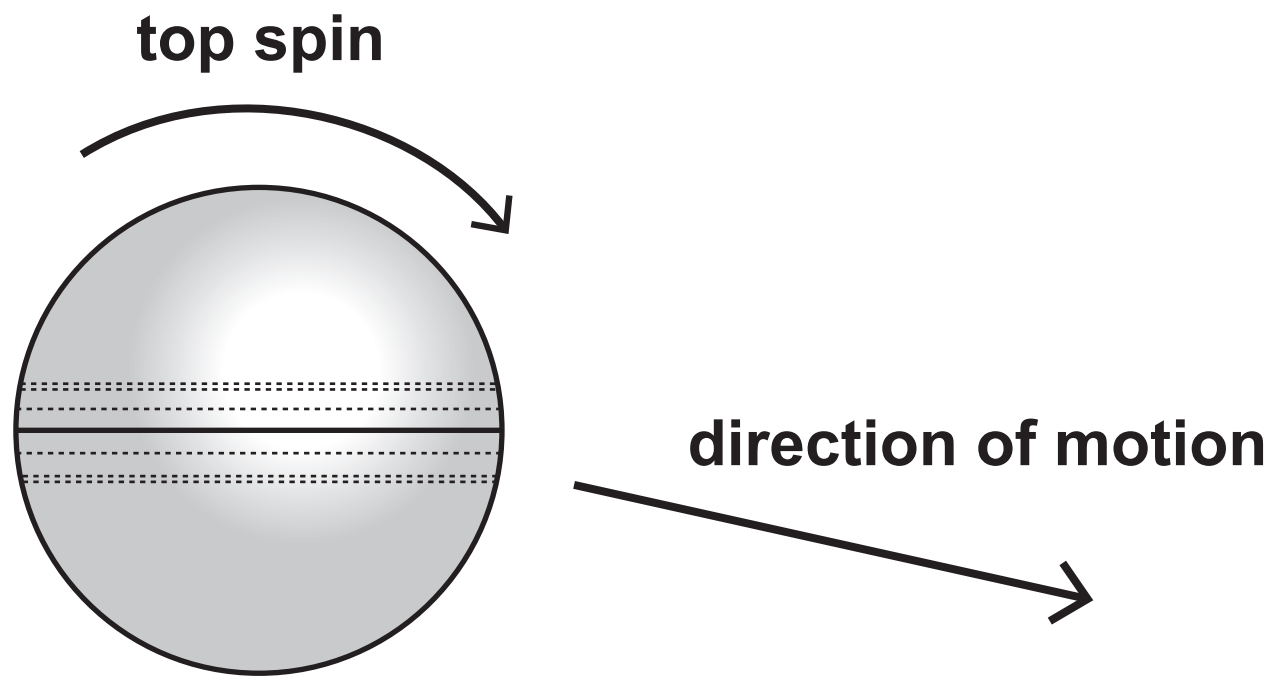


Question 13 (d) (i)

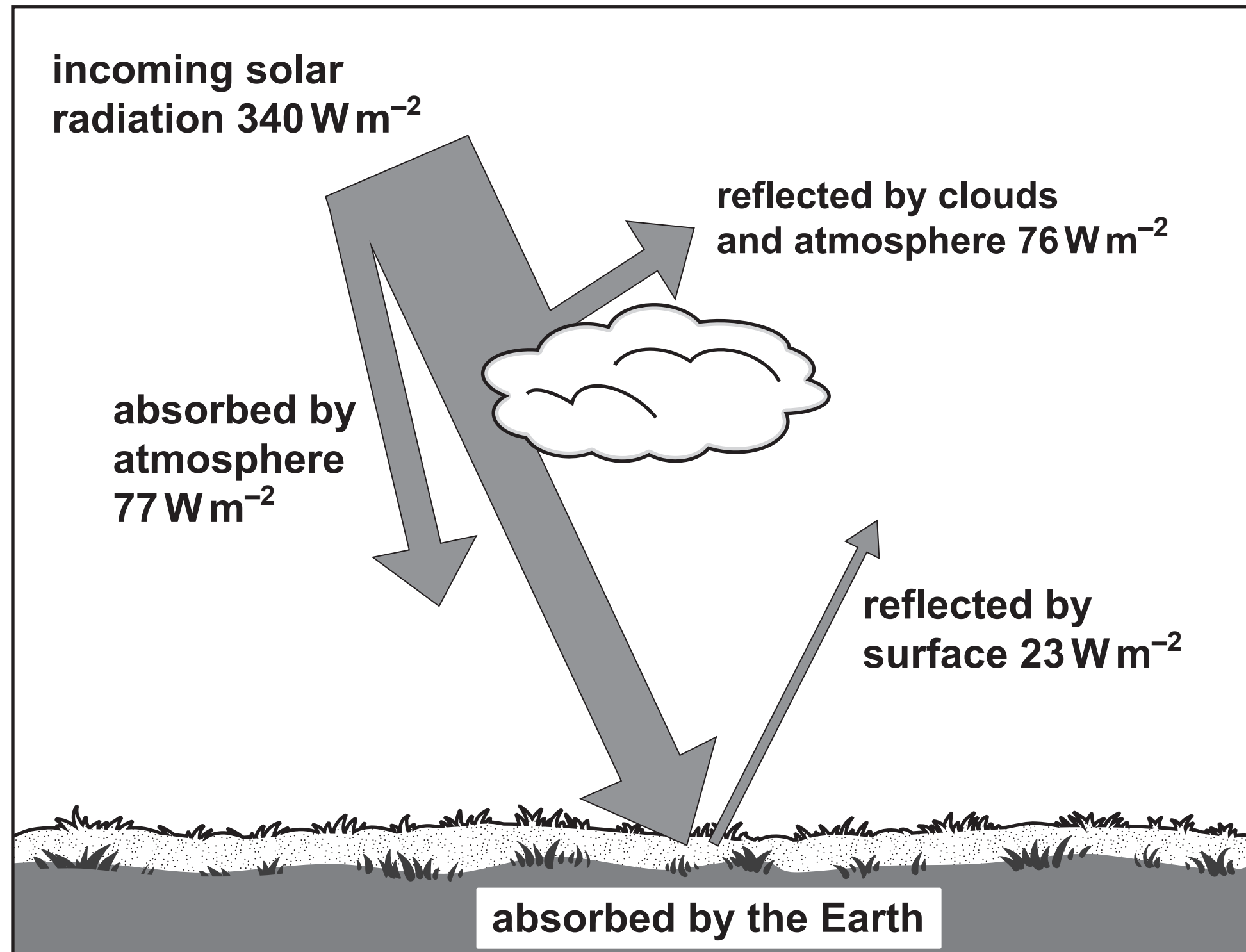
Diagram NOT drawn to scale



Question 13 (d) (ii)

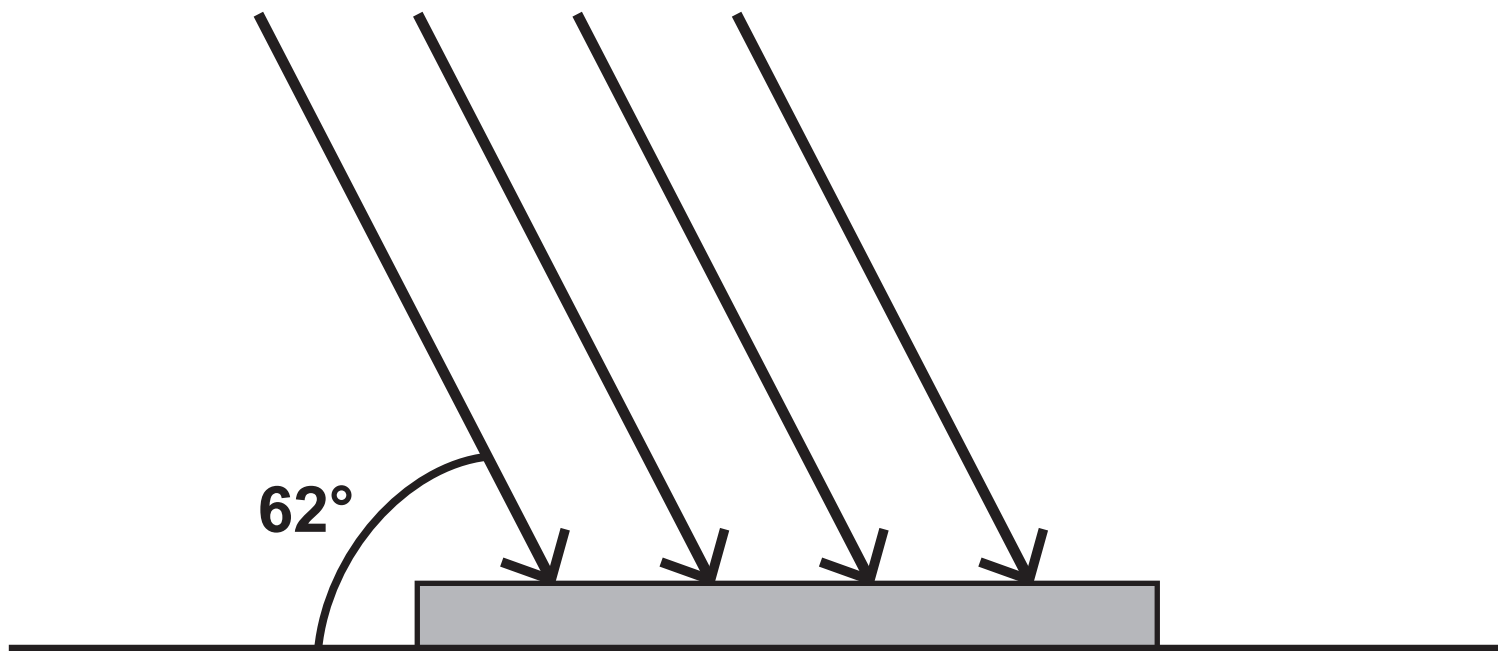


Question 14 (a)



Question 14 (b)

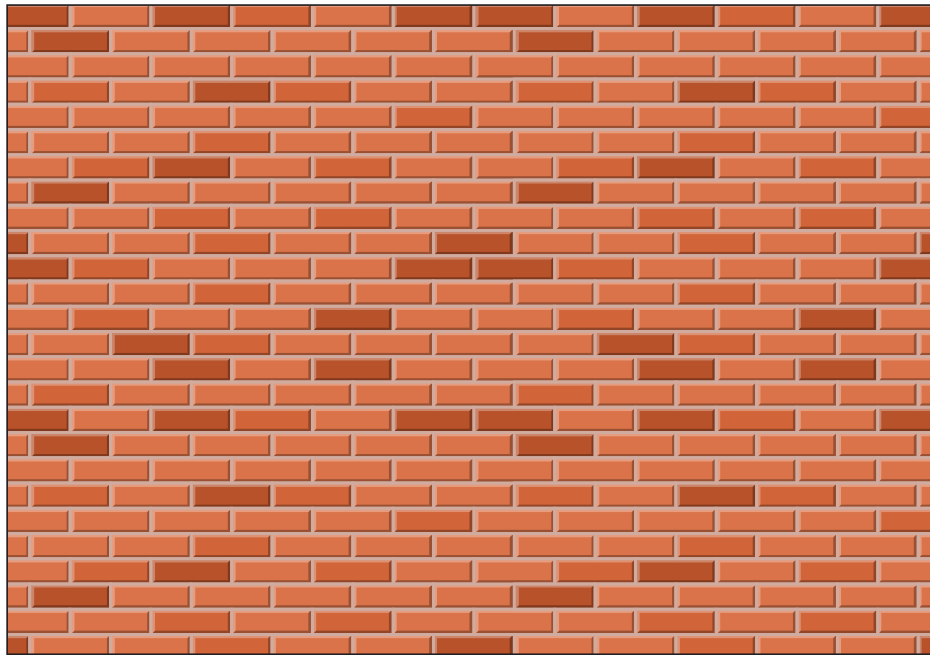
Diagram not drawn to scale



Question 14 (c) (ii)

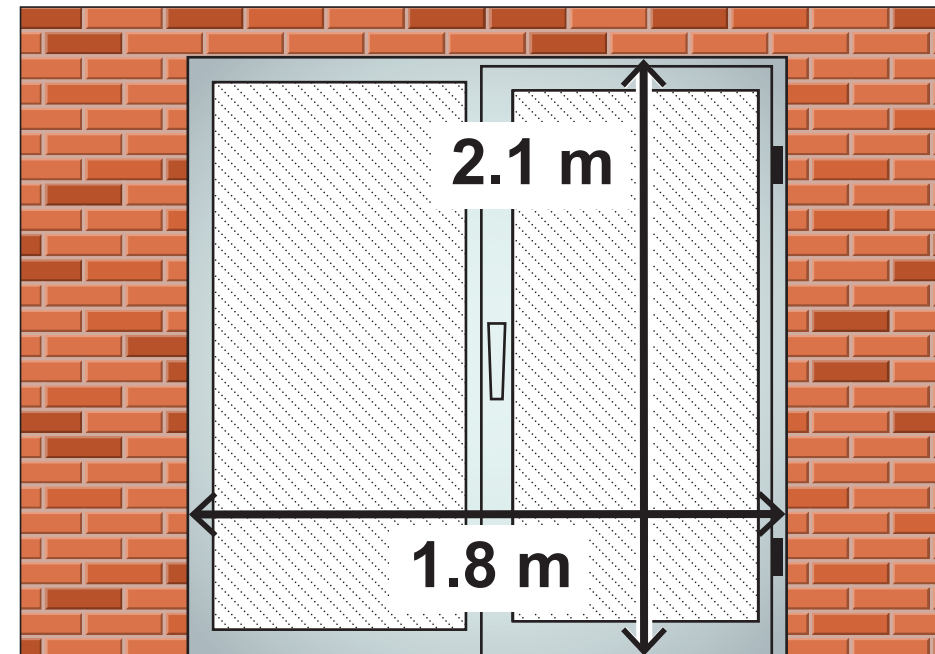
Diagrams not drawn to scale

BEFORE



Uninsulated external wall

AFTER



**Insulated external wall
with patio doors**

Question 14 (c) (ii)

