



GCE A LEVEL



A420U30-1

THURSDAY, 16 JUNE 2022 – 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.	13	
	2.	9	
	3.	8	
	4.	14	
	5.	13	
	6.	8	
	7.	17	
	8.	13	
	9.	5	
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.

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.

(Turn over)

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 on this section.

Section B: 20 marks; Options.

Answer ONE OPTION ONLY. You are advised to spend about 25 minutes 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 7 (b).

SECTION A**ANSWER ALL QUESTIONS**

- 1. (a) Look at the diagram for Question 1 (a) in the separate Diagram Booklet.**
The instantaneous displacement – distance graph of a progressive wave is shown.

(i) State the amplitude of the wave.

[1 mark]

(ii) Calculate the wavelength of the wave as precisely as you can from the graph.

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

- 1. (a) (iii) Use the graph to explain how the phase of the wave varies with distance. In your explanation you should include the terms “in phase” and “in anti – phase”.**

[illegible]

[4 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (b) Look at the diagram for Question 1 (b) in the separate Diagram Booklet.**

The diagram shows the displacement – time graph for a point on the wave in the diagram for part (a).

- (i) Calculate the speed of the wave as precisely as you can.**

[4 marks]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

- 1. (b) (ii) Explain the value of the displacement when the time is 8.7 ms.**

[2 marks]

(Total for Question 1 = 13 marks)

(Turn over)

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

Anushka sets up an experiment to demonstrate stationary waves using a microwave source, detector and reflector, as shown in the diagram.

The microwave detector is moved from left to right and the positions of nodes and anti – nodes are recorded.

- (a) Explain how a stationary wave is produced between the microwave source and the aluminium sheet.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

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

The positions of nodes (N) and anti – nodes (A) are recorded on a piece of paper using a pencil and can be seen in the diagram.

- (i) Calculate the WAVELENGTH AND FREQUENCY of the microwaves.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 2 (b) continued

- 2. (b) (ii) The data in part (b) (i) should lead to a value of wavelength with an uncertainty of approximately 2%. Explain a very simple modification to the method that would halve the percentage uncertainty.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 continued

2. (c) Anushka suggests that replacing the microwave source with a loudspeaker oscillating at **12.25 kHz** and using a microphone as a detector will produce nodes with the same separation. Determine whether, or not, Anushka is correct.

(Speed of sound in air = **343 m s⁻¹**.)

[2 marks]

(Total for Question 2 = 9 marks)

(Turn over)

- 3. Look at the diagram for Question 3 in the separate Diagram Booklet.**

Charlie investigates the two – source interference of microwaves using the set – up, as shown in the diagram.

- (a) Describe how the detected microwave intensity varies as she moves the detector along the dotted path and explain what causes this variation in intensity.**

[5 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (b) Look at the diagram for Question 3 (b) in the separate Diagram Booklet.**

The diagram shows Charlie's data.

Calculate the wavelength of the microwaves from Charlie's data.

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (c) Look at the diagram for Question 3 (c) in the separate Diagram Booklet.**

Reggie has two microwave sources and believes he can reproduce Charlie's results with the set – up, as shown in the diagram.

Each microwave source has its own internal signal generator that will be different from the other. Charlie tells Reggie that his set – up won't work because of this.

Discuss briefly whether Charlie is correct.

[1 mark]

(Total for Question 3 = 8 marks)

(Turn over)

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

A 4 – level laser system has the energy levels, as shown in the diagram.

- (a) (i) Explain briefly why energy level E_2 should have a long lifetime.

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (a) continued

4. (a) (ii) The output wavelength of the laser is **632.8 nm**.

Calculate the energy of level E_2 .

[3 marks]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (b) Look at the diagram for Question 4 (b) in the separate Diagram Booklet.**

Sean uses a diffraction grating to check the wavelength of the laser.

His results are shown in the diagram for the $n = 1$ lines.

- (i) Evaluate whether Sean's data agree with the given wavelength of 632.8 nm.**

[4 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

4. (b) (ii) Look at the diagram for Question 4 (b) (ii) in the separate Diagram Booklet.

Sean then extends his experiment to measure the refractive index of a rectangular block of glass of width **20.0 cm** using the same apparatus (see the diagram).

- I. Explain why the distance between the $n = 1$ lines has decreased.

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) (ii) continued

- 4. (b) (ii) II. Calculate the refractive index of the block of glass.**

[3 marks]

(Total for Question 4 = 14 marks)

(Turn over)

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

A small rocket is placed in space and is propelled using a single pulse of laser light, as shown in the diagram.

When the pulse of light reaches the rocket, it is reflected back by the mirror on the rocket. Before the pulse returns to the laser, a mirror is placed in front of the laser and the pulse of light is reflected back to the rocket. This process repeats over and over for the rocket to accelerate.

continued on the next page . . .

Question 5 continued

- 5. (a) Explain briefly how the laser light can provide a forward momentum for the rocket.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

5. (b) (i) The wavelength of the laser is **403 nm** and the total energy of the laser pulse is **1.27 kJ**. Show that the number of photons in the pulse is approximately **2.6×10^{21}** .

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (b) continued

5. (b) (ii) Hence, show that the momentum transferred to the rocket each time the pulse is reflected is approximately $8 \times 10^{-6} \text{ kg m s}^{-1}$.

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (b) continued

- 5. (b) (iii) The rocket has a mass of 0.029 kg. Assuming that the same momentum is transferred to the rocket each time it reflects the pulse, calculate the number of reflections required for the kinetic energy of the rocket to exceed the energy of the pulse.**

[4 marks]**continued on the next page . . .****(Turn over)**

Question 5 (b) continued

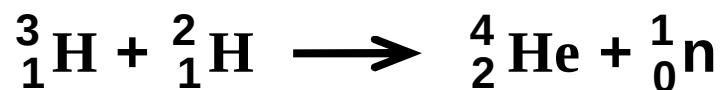
- 5. (b) (iv) By discussing kinetic energy and light energy, determine whether this rocket disobeys a fundamental law of physics.**

[3 marks]

(Total for Question 5 = 13 marks)

(Turn over)

6. (a) Calculate the energy released in the following hydrogen fusion reaction.



Mass of ${}^3_1\text{H} = 3.01605 \text{ u}$,

Mass of ${}^4_2\text{He} = 4.00260 \text{ u}$,

Mass of ${}^2_1\text{H} = 2.01410 \text{ u}$,

Mass of ${}^1_0\text{n} = 1.00866 \text{ u}$,

1 u = 931 MeV

[3 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (b) Look at the diagram for Question 6 (b) in the separate Diagram Booklet.**

The diagram shows a binding energy per nucleon graph.

Use the binding energy per nucleon graph to explain why this reaction releases a large amount of energy.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (c) For many years, research has been carried out on this hydrogen fusion reaction. A fusion reactor project called ITER (International Thermonuclear Experimental Reactor) has cost around £20 billion and has produced no electricity.**

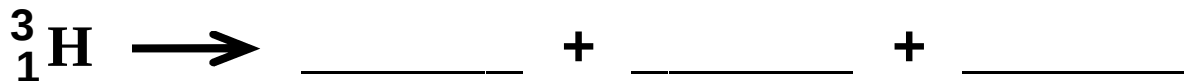
If the ITER project is successful, the next fusion project will cost another £20 billion and might produce a demonstration fusion reactor by the year 2050. Many people believe this to be a complete waste of money and that this money would be better spent harnessing existing cheap solar power.

Discuss whether spending money on fusion power or solar power is the better solution.

[3 marks]

(Total for Question 6 = 8 marks)

7. (a) (i) A ${}^3_1\text{H}$ nucleus is unstable and decays by emission of a β^- particle to helium.
Complete the decay equation.



[3 marks]

- (ii) The molecules of a gas each consist of two ${}^3_1\text{H}$ atoms. The gas has a volume of $17.2 \times 10^{-3} \text{ m}^3$, a temperature of 293 K and a pressure of 227 kPa.

Show that the number of ${}^3_1\text{H}$ nuclei is approximately 2×10^{24} .

(Turn over)

[3 marks]

7. (a) (iii) The ${}^3_1\text{H}$ nucleus has a half – life of 12.32 years. Calculate the initial activity of the ${}^3_1\text{H}$ gas.

[2 marks]

continued on the next page . . .

(Turn over)

Question 7 (a) continued

- 7. (a) (iv) Calculate the time taken for the activity to drop to **10%** of its initial activity.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 7 continued

7. (b) Pions are also unstable particles and can decay according to the following equations.

$$\pi^+ \longrightarrow e^+ + \nu_e$$

$$\pi^0 \longrightarrow \gamma + \gamma$$

Discuss both these decays in terms of conservation laws and forces.

(Total for Question 7 = 17 marks)

(Turn over)

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

Dafydd carries out an experiment to investigate the variation of magnetic field with distance for a long, current – carrying wire. He uses the Hall probe in his mobile phone to measure the magnetic flux density.

- (a) He varies the distance, a , from the wire to the edge of the phone and measures the magnetic flux density each time. The current is kept constant.**

Look at the table for Question 8 (a) in the separate Diagram Booklet. His results are shown in the table.

continued on the next page . . .

Question 8 (a) continued

The equation for the magnetic flux density is:

$$B = \frac{\mu_0 I}{2\pi a}$$

Which, rearranged for the current is:

$$I = \frac{2\pi a B}{\mu_0}$$

Use the $a = 10.0$ cm data to calculate a value for the current.

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

- 8. (b) Look at the diagram for Question 8 (b) in the separate Diagram Booklet.**

The data from the table in part (a) is plotted on the graph shown.

- (i) On the graph, DRAW A SINGLE LINE OF BEST FIT.**

[1 mark]

- (ii) Use the graph to determine the distance from the edge of the phone to the centre of the Hall probe (see the set – up in the diagram for Question 8).**

[2 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

8. (c) Determine the current in the wire.

[illegible]

[4 marks]

continued on the next page . . .

(Turn over)

Question 8 continued

- 8. (d) Dafydd measured the current in the wire as (10.5 ± 0.5) A.**

Evaluate the quality of the data obtained in this experiment.

[illegible]

[4 marks]

(Total for Question 8 = 13 marks)

9. Look at Diagram 1 for Question 9 in the separate Diagram Booklet. The diagram shows a strong magnet attached to a spring. The magnet oscillates vertically through a metal hoop.

Look at the Diagram 2 for Question 9 in the separate Diagram Booklet.

The diagram shows a graph of current in the metal hoop against time.

- (a) A periodic induced **emf** is expected because of the periodic change of flux in the metal hoop. Explain briefly why the oscillations are damped.

[3 marks]

9. (b) The resistance of the metal hoop is $0.18 \, \Omega$. Explain what the value of the rate of change of flux in the metal hoop is at time $t = 0$.

[2 marks]

(Total for Question 9 = 5 marks)

(Turn over)

SECTION B: OPTIONAL TOPICS

Option A – ALTERNATING CURRENTS _____

Option B – MEDICAL PHYSICS _____

Option C – THE PHYSICS OF SPORT _____

Option D – ENERGY AND THE ENVIRONMENT _____

Answer the question on ONE TOPIC ONLY.

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

YOU ARE ADVISED TO SPEND ABOUT 25 MINUTES ON THIS SECTION (plus your additional time allowance).

Option A – ALTERNATING CURRENTS

- 10. (a) (i) Describe how, if at all, the reactance of an inductor and the resistance of a resistor vary with frequency.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

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

The diagram shows a potential divider circuit. In the circuit, the output pd (V_{out}) is taken across the inductor.

I. Calculate the output pd when the frequency is 5.0×10^4 Hz.

[3 marks]

(Turn over)

Question 10 (a) (ii) continued

- 10. (a) (ii) II. State what happens to the output
pd when the frequency is
increased above 5.0×10^4 Hz.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

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

The diagram shows another potential divider circuit. In this circuit the output pd (V_{out}) is taken across the capacitor.

- I. Calculate the reactance of the capacitor at 5.0×10^4 Hz.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 10 (a) (iii) continued

**10. (a) (iii) II. Explain why the output pd
decreases with frequency.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 10 (a) continued

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

Hence, explain briefly why this circuit has a Q factor slightly greater than 1 and why 5.0×10^4 Hz is its resonant frequency.

[2 marks]

continued on the next page...

(Turn over)

Question 10 (a) continued

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

The diagram shows a circuit and a blank grid of current against frequency.

On the grid, sketch a graph of current against frequency for the circuit shown (only one point needs to be calculated).

Space for calculation:

[4 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.**

Harry is asked by his teacher to sketch an expected oscilloscope trace for a sinusoidal power supply of rms pd 20.0 mV and frequency 0.200 MHz. He is also expected to suggest sensible values of the y – sensitivity (Variable VOLTS/DIV) and the time base (SEC/DIV). HIS ANSWER IS SHOWN IN THE DIAGRAM. Determine to what extent he has answered correctly.

[5 marks]

(Total for Option A = 20 marks)

(Turn over)

Option B – MEDICAL PHYSICS

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

The diagram shows a typical X – ray emission spectrum for an X – ray tube with a tungsten target.

- (i) Determine the operating voltage of the X – ray tube.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 (a) continued

- 11. (a) (ii) DRAW, ON THE DIAGRAM FOR QUESTION 11 (a), the emission spectrum for an X – ray tube operating at a lower operating voltage AND using a different metal target.**

[2 marks]

continued on the next page . . .

Question 11 (a) continued

11. (a) (iii) When a beam of X – rays passes through bone, the X – rays are absorbed and the beam becomes attenuated. The thickness of bone needed to reduce the original intensity by 50% is known as the half – value thickness, $x_{\frac{1}{2}}$.

Show that:

$$x_{\frac{1}{2}} = \frac{\ln 2}{\mu}$$

where μ is the attenuation coefficient.

[2 marks]

(Turn over)

Question 11 (a) continued

- 11. (a) (iv) A beam of X – rays is used to detect a fracture in a bone. If the half – value thickness for these X – rays is 1.4 cm, calculate the thickness of bone that reduces the intensity to 65% of its original value.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 11 continued

- 11. (b) (i) Explain briefly the role played by radio waves in the process of MRI scans.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 (b) continued

- 11. (b) (ii) An MRI scanner uses radio waves of wavelength 5.9 m. Calculate the magnetic field needed for the MRI to work effectively.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 continued

- 11. (c) A radionuclide such as iodine – 131 or iodine – 123 can be used to investigate kidney function. Give TWO important properties of any radionuclide that is used as a tracer.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 11 continued

- 11. (d) Doctors are concerned about a head injury sustained by a rugby player and, in particular, if there is a bleed in the brain. They have the choice of the following forms of imaging techniques.**

X – RAY

MRI

ULTRASOUND B – SCAN

RADIOACTIVE TRACERS

CT SCAN

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

(Total for Option B = 20 marks)

Option C – THE PHYSICS OF SPORTS

- 12. (a) Look at the photograph for Question 12 (a) in the separate Diagram Booklet.**

The photograph shows a hockey player in action.

Explain why the hockey player is in a stable position.

[2 marks]

continued on the next page . . .

(Turn over)

Question 12 continued

- 12. (b)** The table below gives values of the coefficient of restitution between a hockey ball and three different types of hockey sticks.

Stick	Coefficient of restitution
A	0.68
B	0.72
C	0.74

Andrea decides to use stick C as it will enable the ball to gain higher speeds. Evaluate whether Andrea is correct in her choice of a hockey stick.

[2 marks]

(Turn over)

Question 12 continued

- 12. (c) The remaining questions are about a hockey ball.**

Mass of hockey ball = 163 g

Diameter of hockey ball = 71.3 mm

- (i) Determine the torque that a player must apply to a hockey ball for the ball to reach a spin rate of 752 revolutions per minute from rest in a time of 0.212 ms. The moment of inertia of a hockey ball = $\frac{2}{5} mr^2$.**
-
-
-
-
-
-
-

[4 marks]

continued on the next page . . .

(Turn over)

Question 12 (c) continued

- 12. (c) (ii) Determine the LINEAR AND ROTATIONAL kinetic energies acquired by the ball if it also moves with a linear speed of 42 m s^{-1} .**

[3 marks]

continued on the next page . . .

(Turn over)

Question 12 (c) continued

- 12. (c) (iii) A goalkeeper saves a shot with their leg pads. The initial speed of the ball is 42 m s^{-1} just before the goalkeeper saves the shot. The ball is in contact with the leg pads for 5.2 ms and REBOUNDS IN THE OPPOSITE DIRECTION with a speed of 27 m s^{-1} .**

Evaluate whether the goalkeeper's leg pads are advisable for protection.

[3 marks]

(Turn over)

Question 12 (c) continued

- 12. (c) (iv) Look at the diagram for Question 12 (c) (iv) in the separate Diagram Booklet.**

During a hockey match, Sandeep takes a shot and the ball is moving to the right. The diagram shows the velocity of the air relative to the ball. During its flight, the velocity of the air above the ball is greater than below it, creating lift.

- I. Calculate the lift force acting on the ball and show that this is considerably smaller than the weight of the ball.**

[4 marks]

continued on the next page . . .

(Turn over)

Question 12 (c) (iv) continued

- 12. (c) (iv) II. As the ball travels through the air, the speed of the ball decreases from 32 m s^{-1} to 16 m s^{-1} .**

Determine by what factor the magnitude of the drag force acting on the ball changes.

[2 marks]

(Total for Option C = 20 marks)

(Turn over)

Option D – ENERGY AND THE ENVIRONMENT

- 13. (a) (i) The solar constant can be defined as the intensity of the electromagnetic radiation from the Sun, just outside the Earth's atmosphere.**

State what is meant by intensity and give a suitable unit.

[1 mark]

continued on the next page . . .

(Turn over)

Question 13 (a) continued

- 13. (a) (ii) Assuming the Sun behaves as a black body, show that a value for this intensity, I , can be calculated using the equation below:**

$$I = \frac{r^2 \sigma W^4}{R^2 \lambda^4}$$

**Where r is the radius of the Sun,
 R is the mean Earth – Sun separation
and λ is the wavelength of maximum
intensity emitted by the Sun.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 (a) continued

- 13. (a) (iii) Calculate the value of the solar constant given that**

$$r = 6.96 \times 10^5 \text{ km},$$

$$R = 150 \times 10^6 \text{ km and}$$

$$\lambda = 500 \text{ nm}.$$

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

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

The diagram shows how a pumped storage hydroelectric power station can provide electrical power in times of high demand.

- (i) The station consists of a generator that can also act as a pump.**
- During times of low electrical power demand, 40 m^3 of water per second is pumped up to the high level reservoir. The height difference between the high level reservoir and station is 390 m . Calculate the mean power required for this process.**

(Density of water = $1.0 \times 10^3 \text{ kg m}^{-3}$.)

(Turn over)

[2 marks]

- 13. (b) (ii) Discuss the impact that pumped storage hydroelectric power stations have on greenhouse gas emissions.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

- 13. (c)** In fusion reactions, the triple product, $nT\tau_E$ is a combination of the temperature, T , particle density, n , and confinement time, τ_E of the fuel.

- (i)** Explain what is meant by the confinement time of the fuel.

[1 mark]

continued on the next page . . .

(Turn over)

Question 13 (c) continued

- 13. (c) (ii) A nuclear fusion power plant aims to produce a fusion triple product of $8.0 \times 10^{22} \text{ m}^{-3} \text{ s keV}$ at a temperature of $1.1 \times 10^8 \text{ K}$.**

- I. Show that this temperature is equivalent to a particle energy of approximately 10 keV.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 (c) (ii) continued

- 13. (c) (ii) II. Hence, determine the value of τ_E required if the particle density, n , is $2.0 \times 10^{21} \text{ m}^{-3}$.**

[2 marks]

continued on the next page . . .

(Turn over)

Question 13 continued

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

The diagram shows two layers of equal thickness that form the external wall of a building, as shown.

The thermal conductivity of the inner layer of the external wall is $0.10 \text{ W m}^{-1} \text{ K}^{-1}$ and that of the outer layer is $0.50 \text{ W m}^{-1} \text{ K}^{-1}$.

Tom states that the temperature at the boundary between the two layers is 7.5°C and that the rate of heat flow per unit area through the wall is 90 W m^{-2} . Determine whether Tom's statement is correct.

[5 marks]

(Total for Option D = 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.

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

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GCE A LEVEL



A420U30-1

THURSDAY, 16 JUNE 2022 – 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

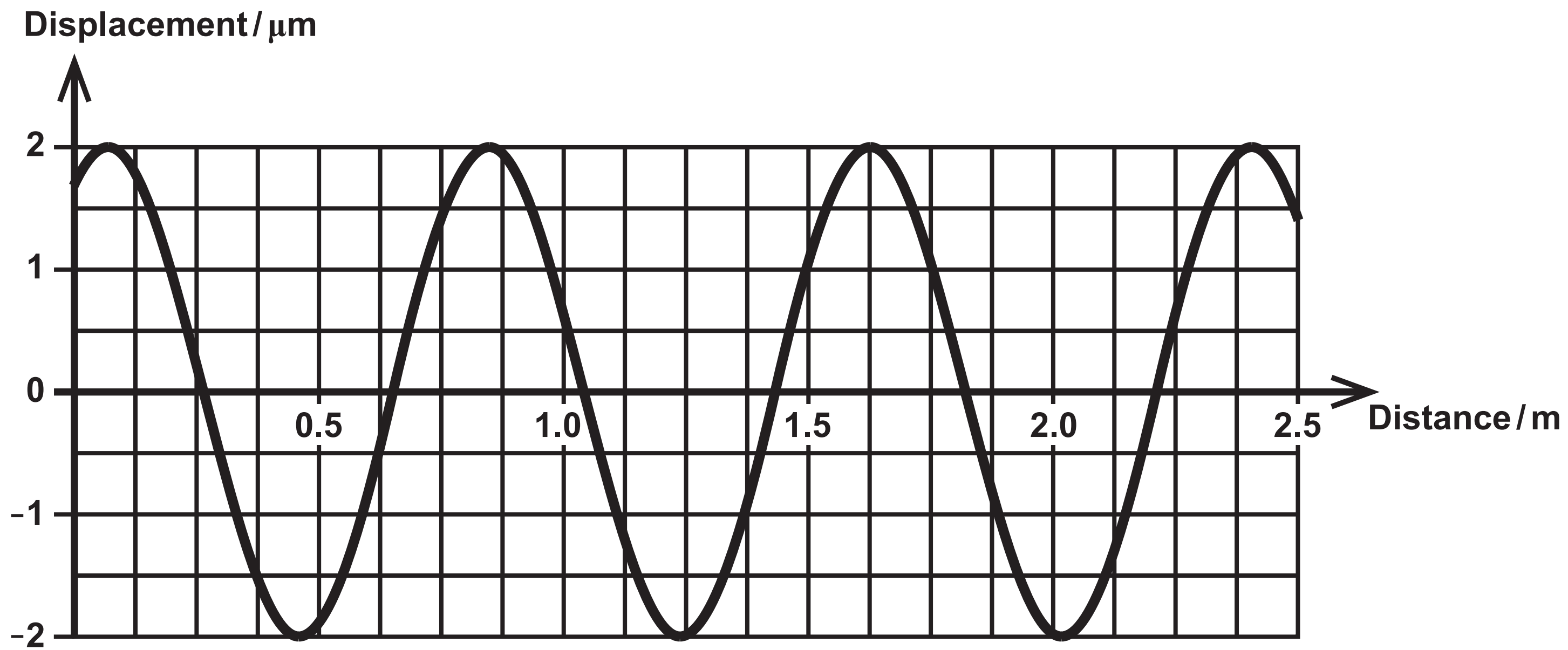
Surname: _____

First name(s): _____

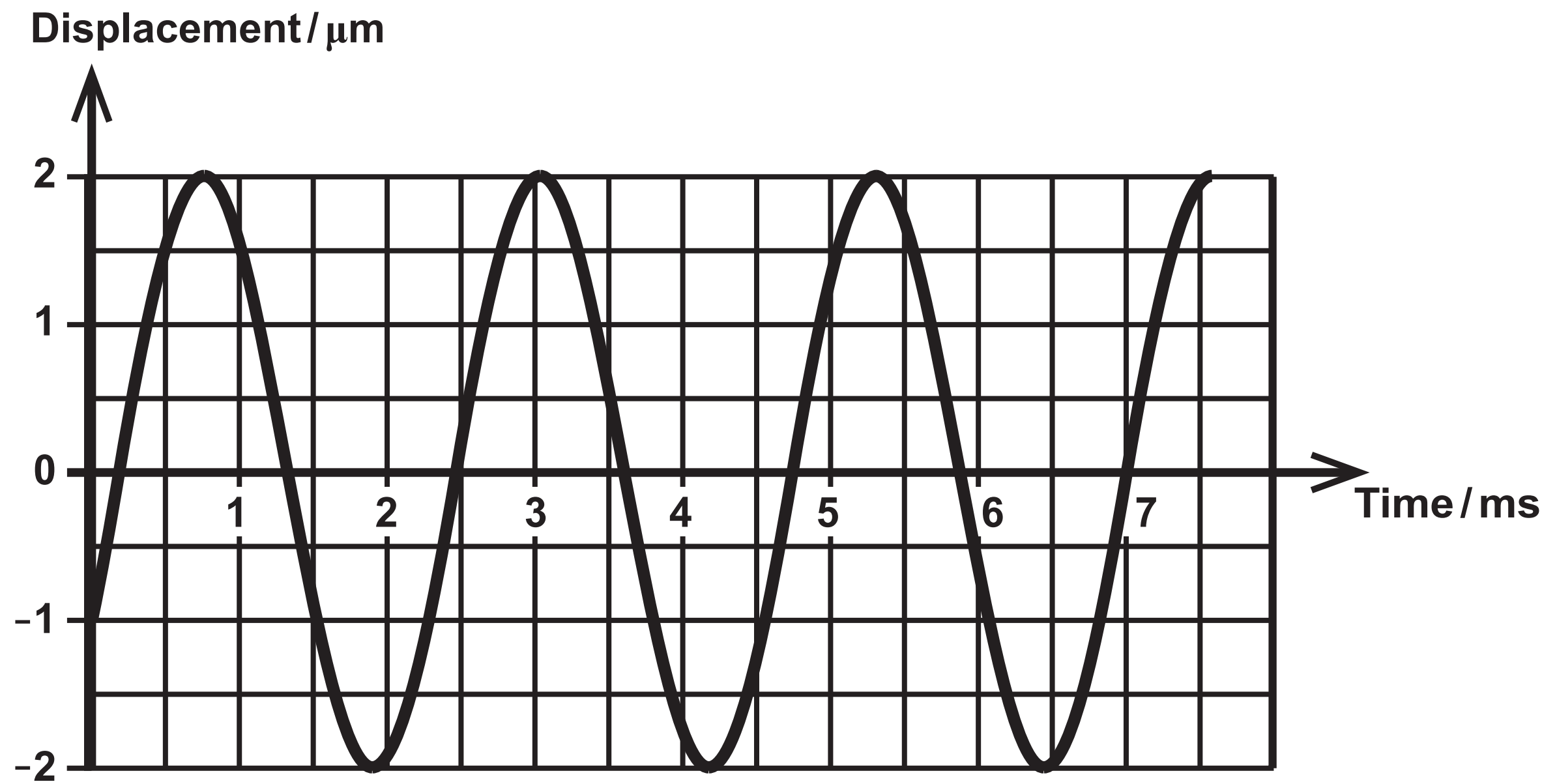
Centre Number: _____

Candidate Number: 2 _____

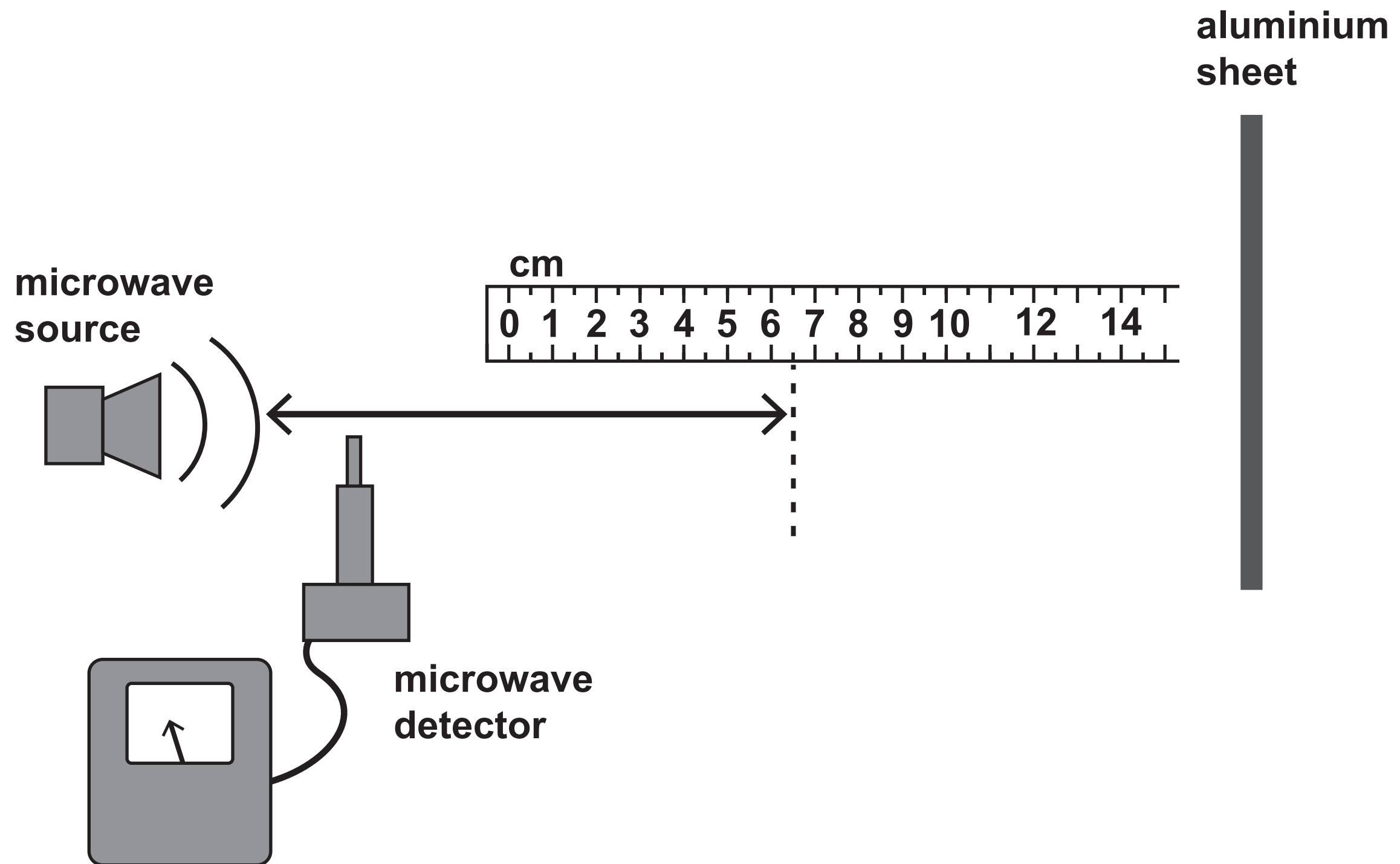
Question 1 (a)



Question 1 (b)

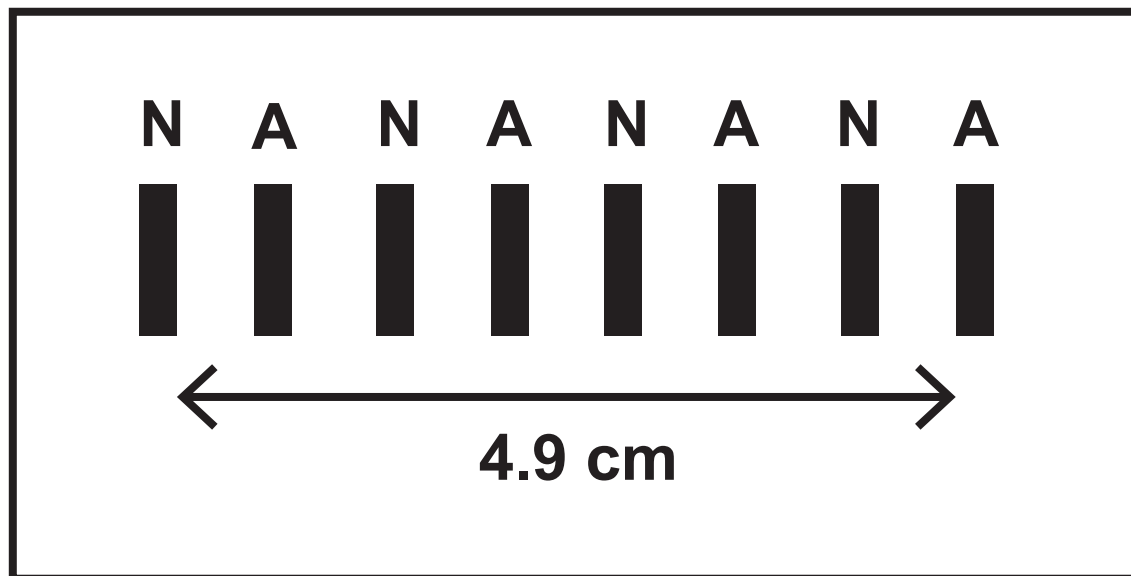


Question 2

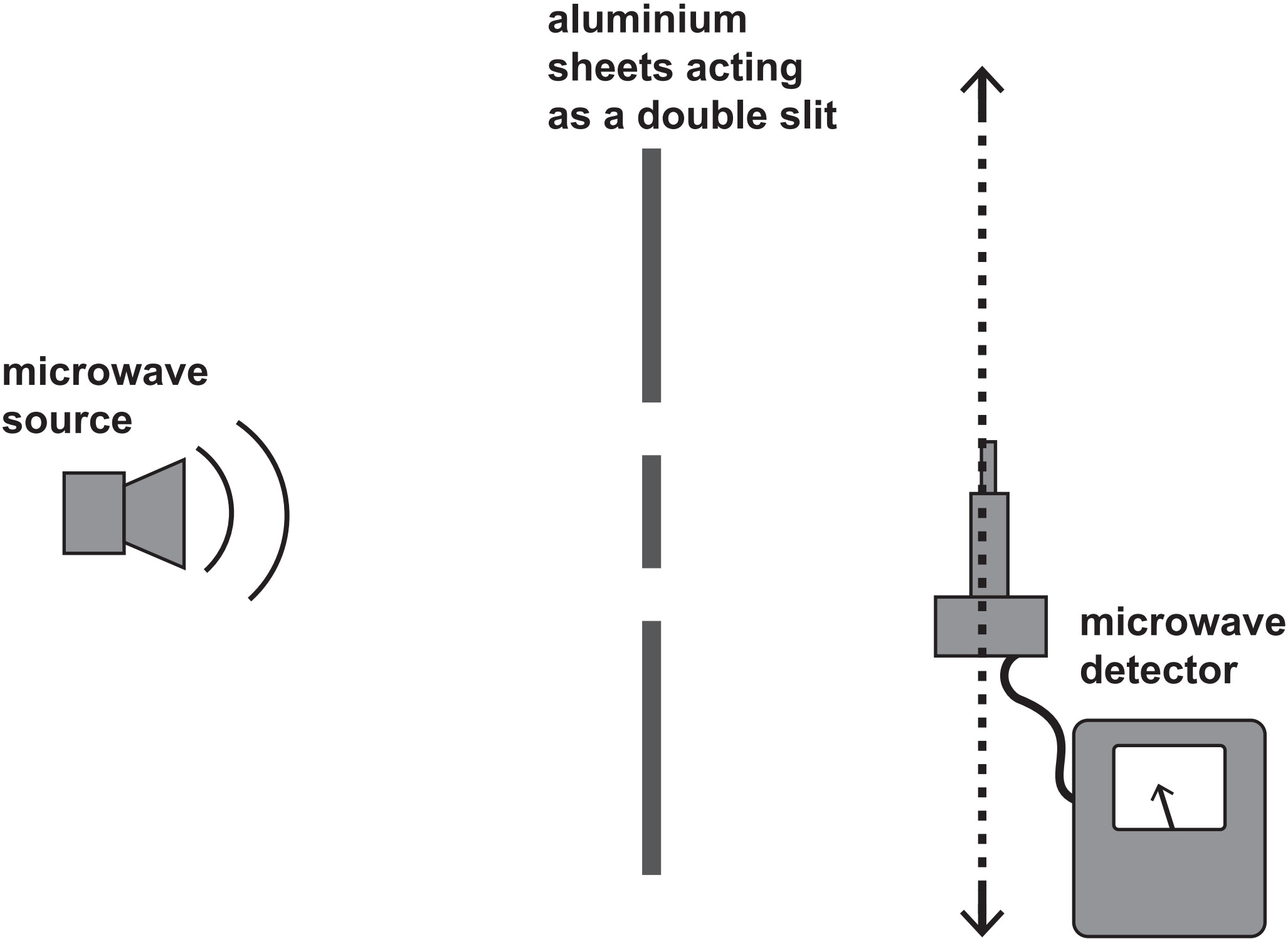


Question 2 (b)

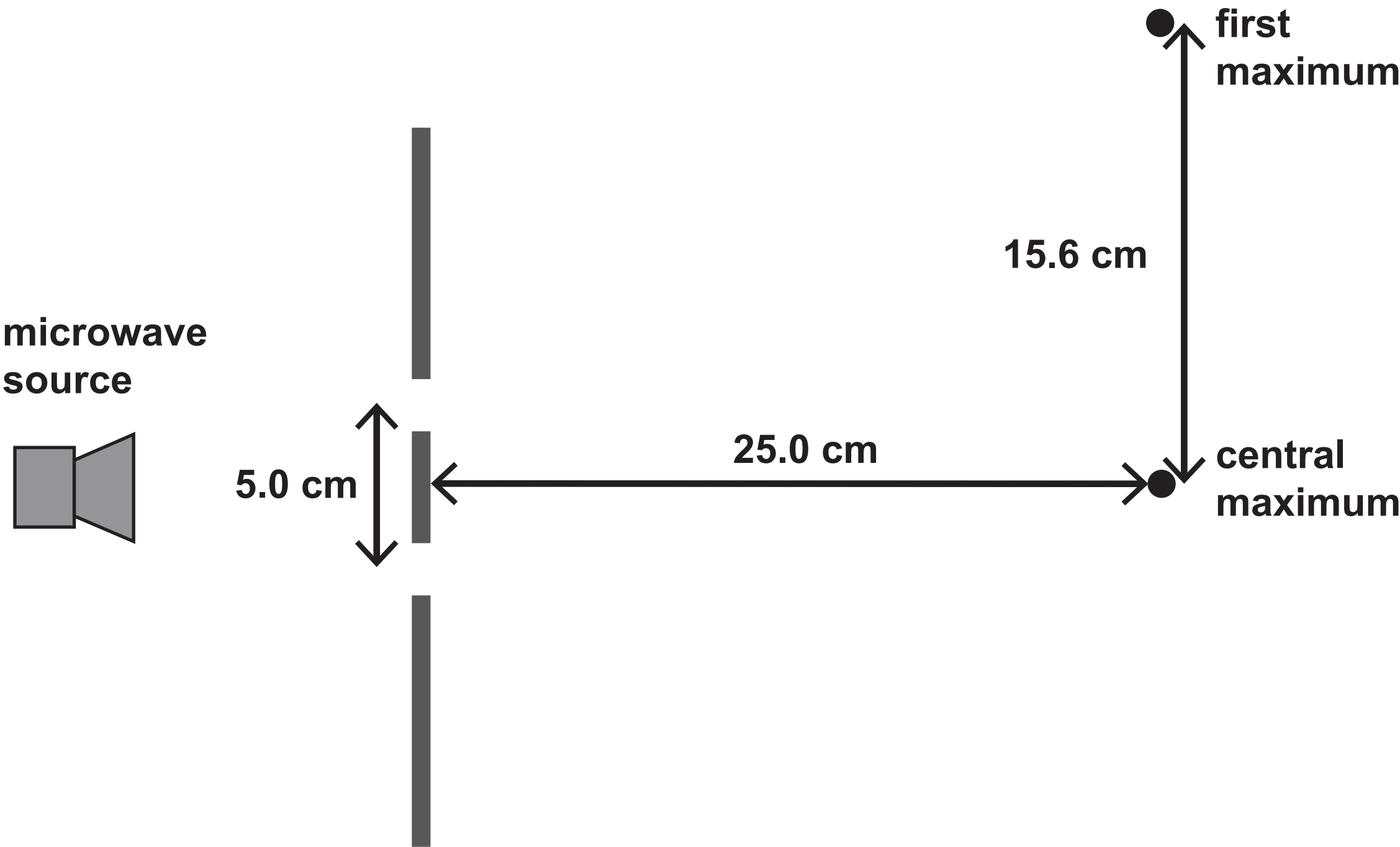
Diagram NOT drawn to scale



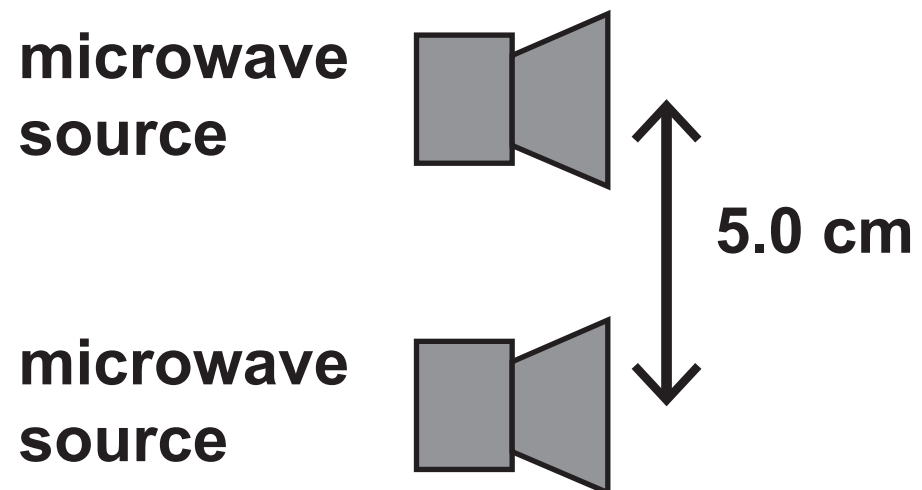
Question 3



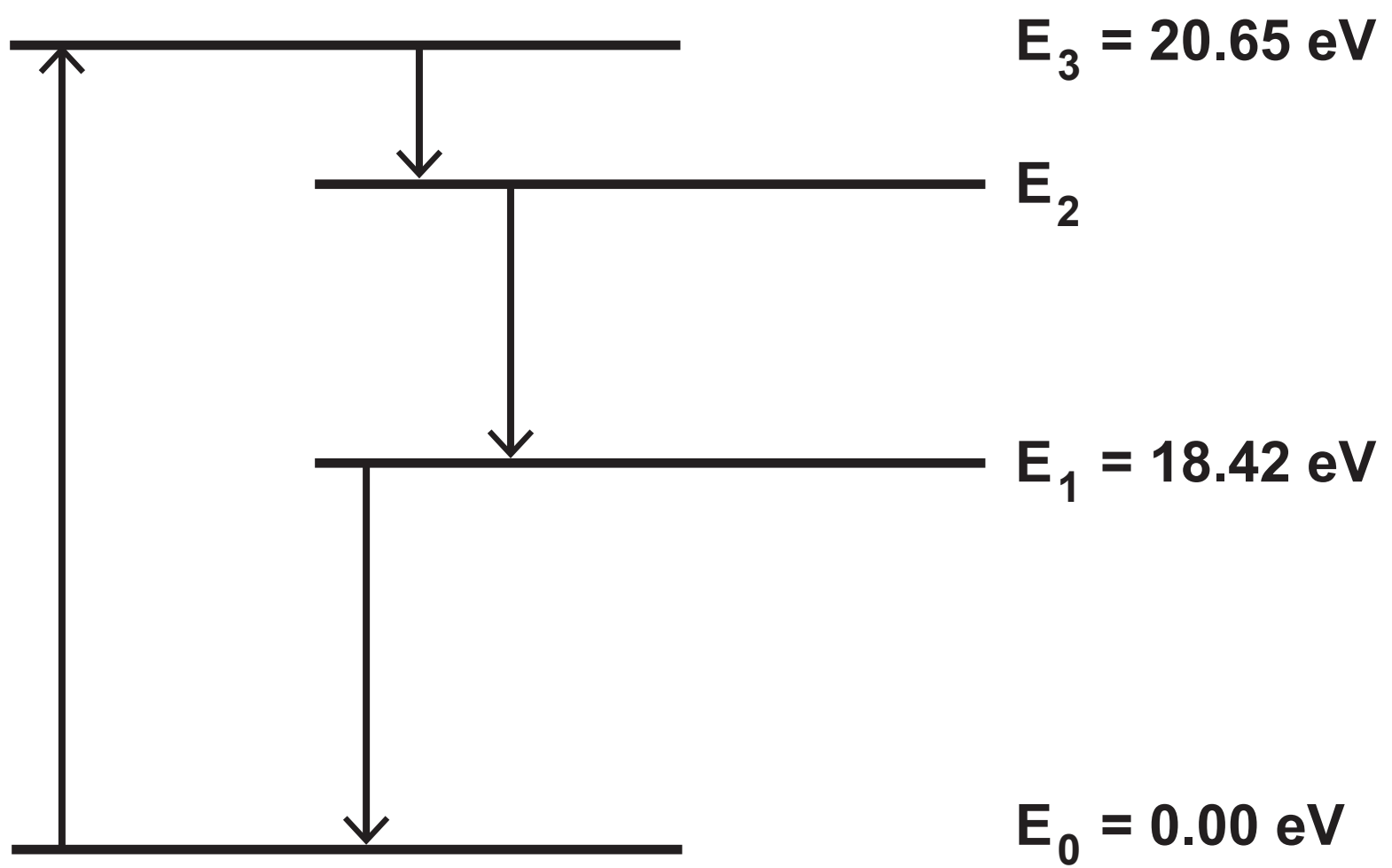
Question 3 (b)



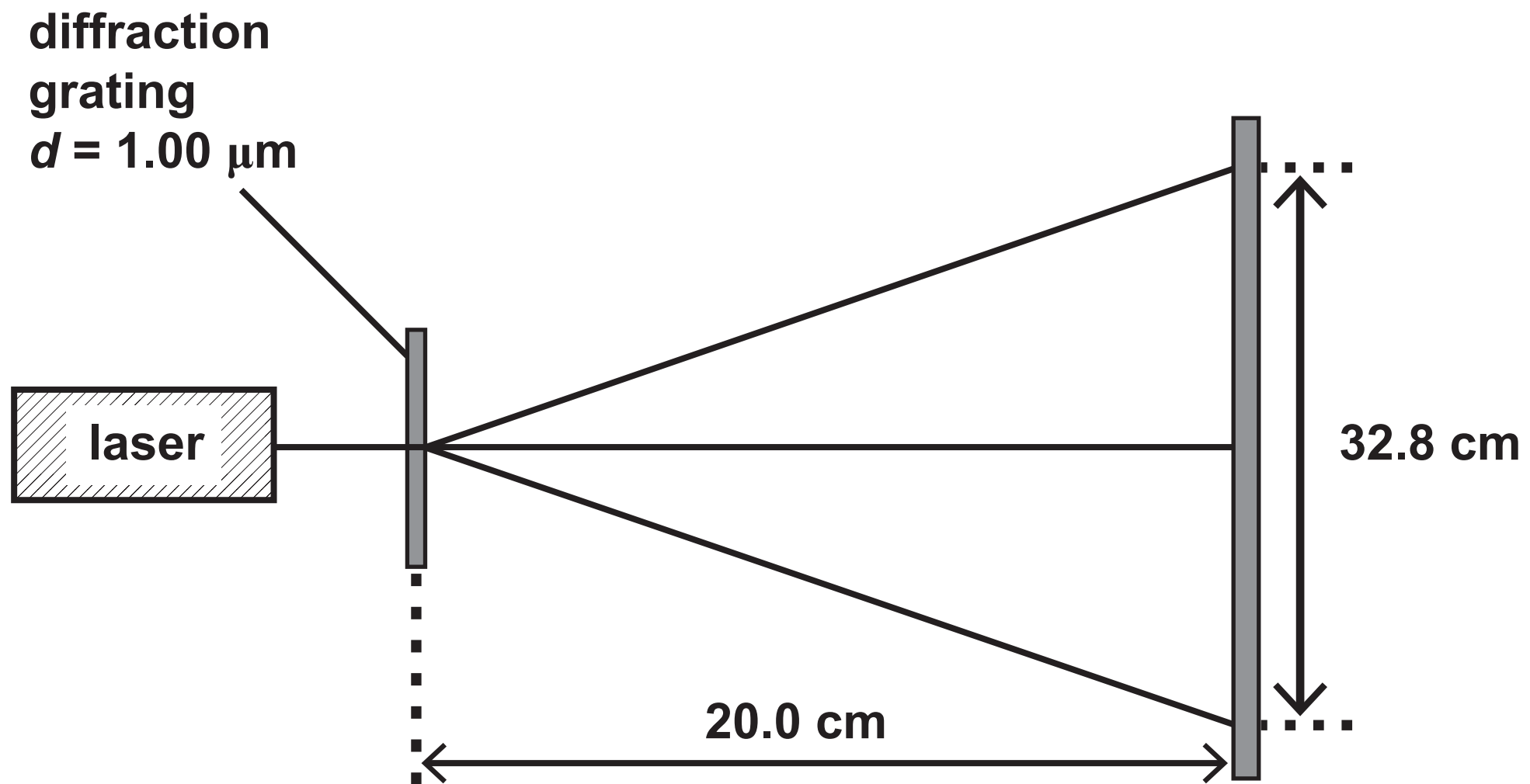
Question 3 (c)



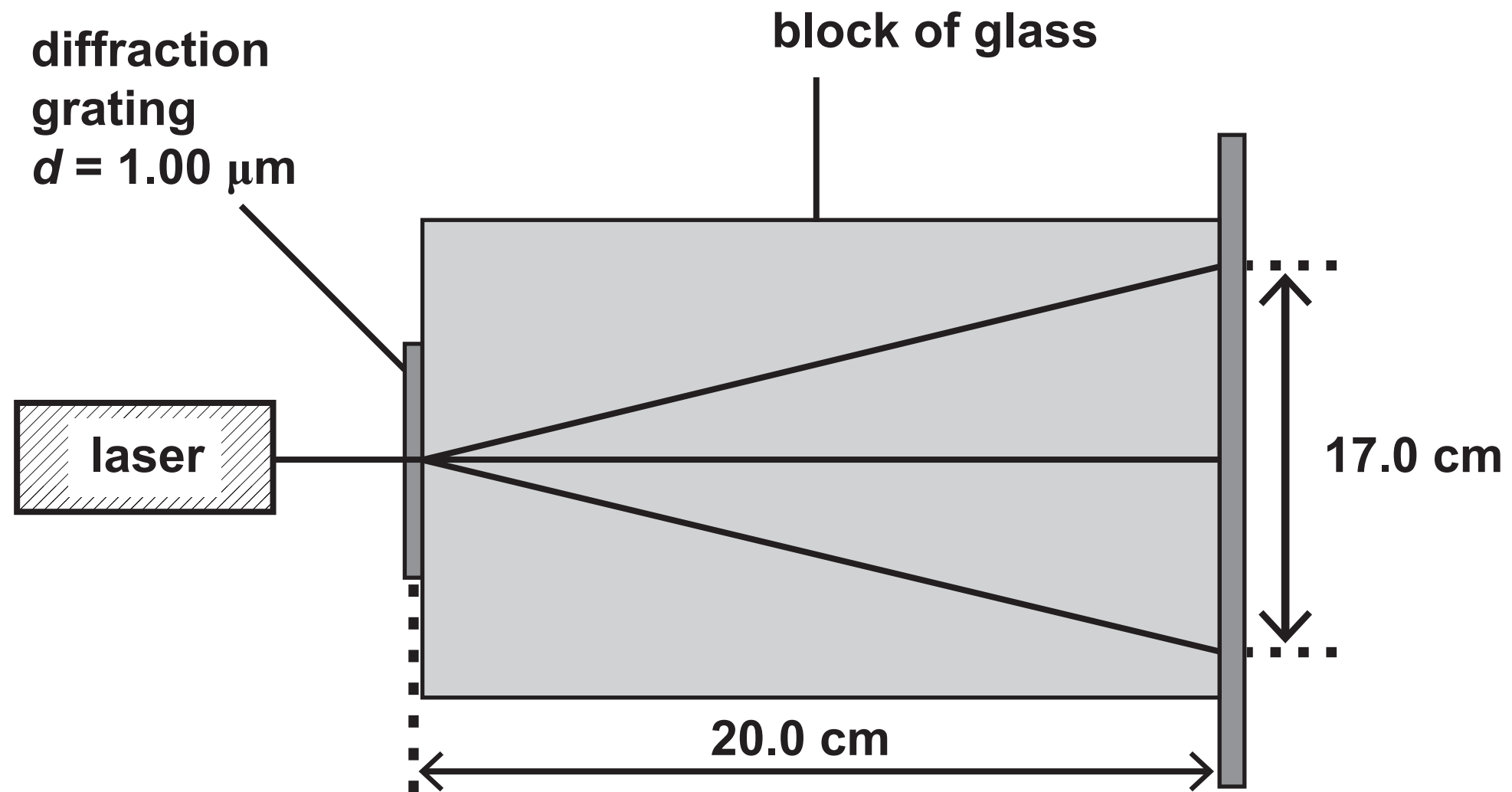
Question 4



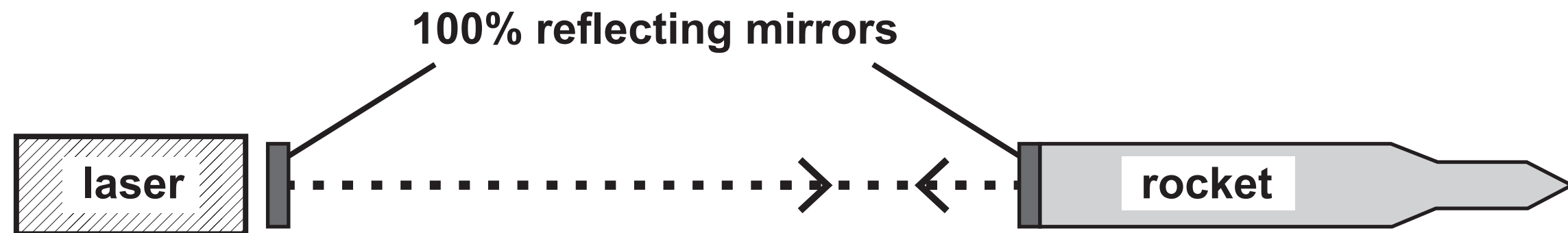
Question 4 (b)



Question 4 (b) (ii)

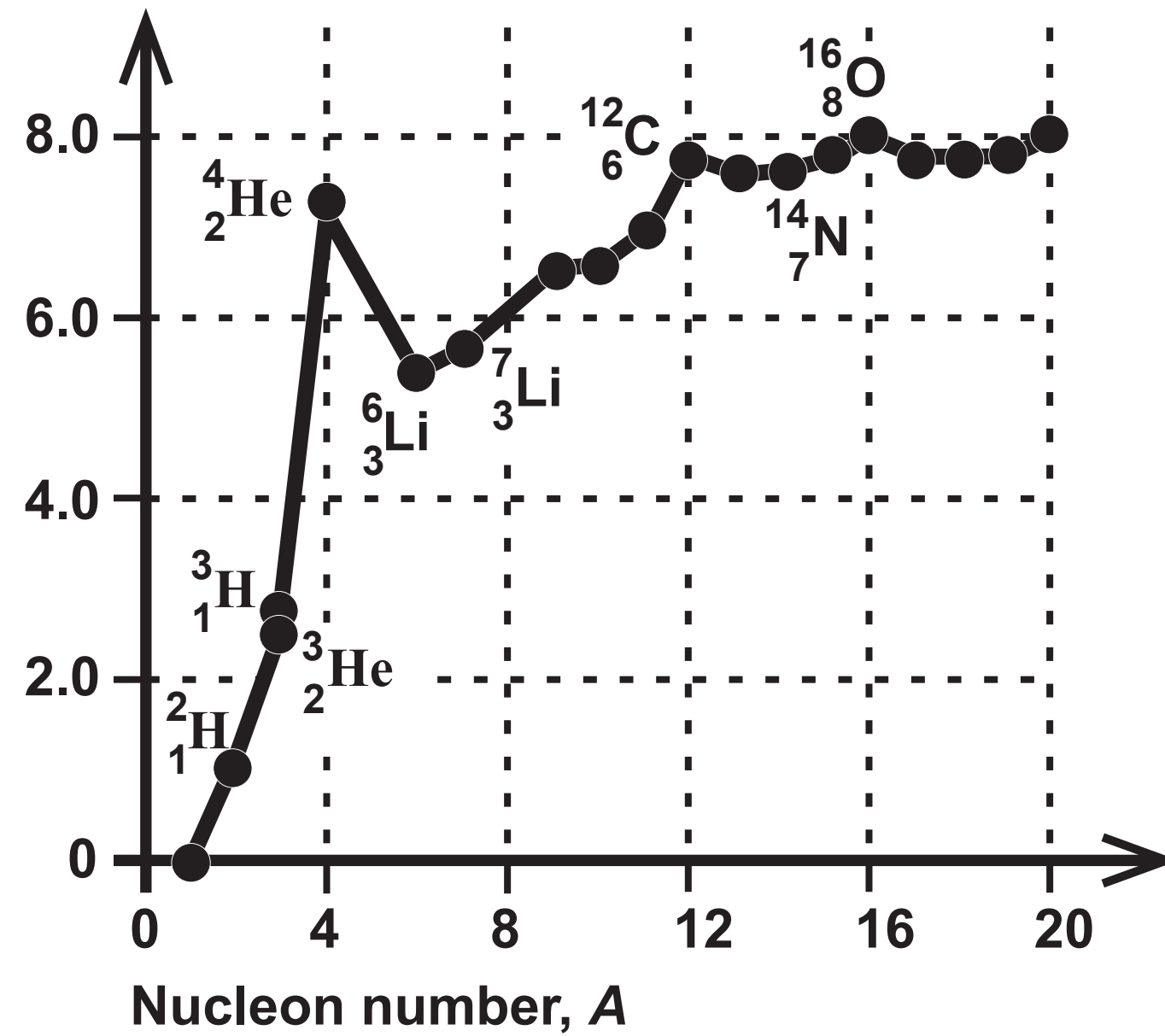


Question 5

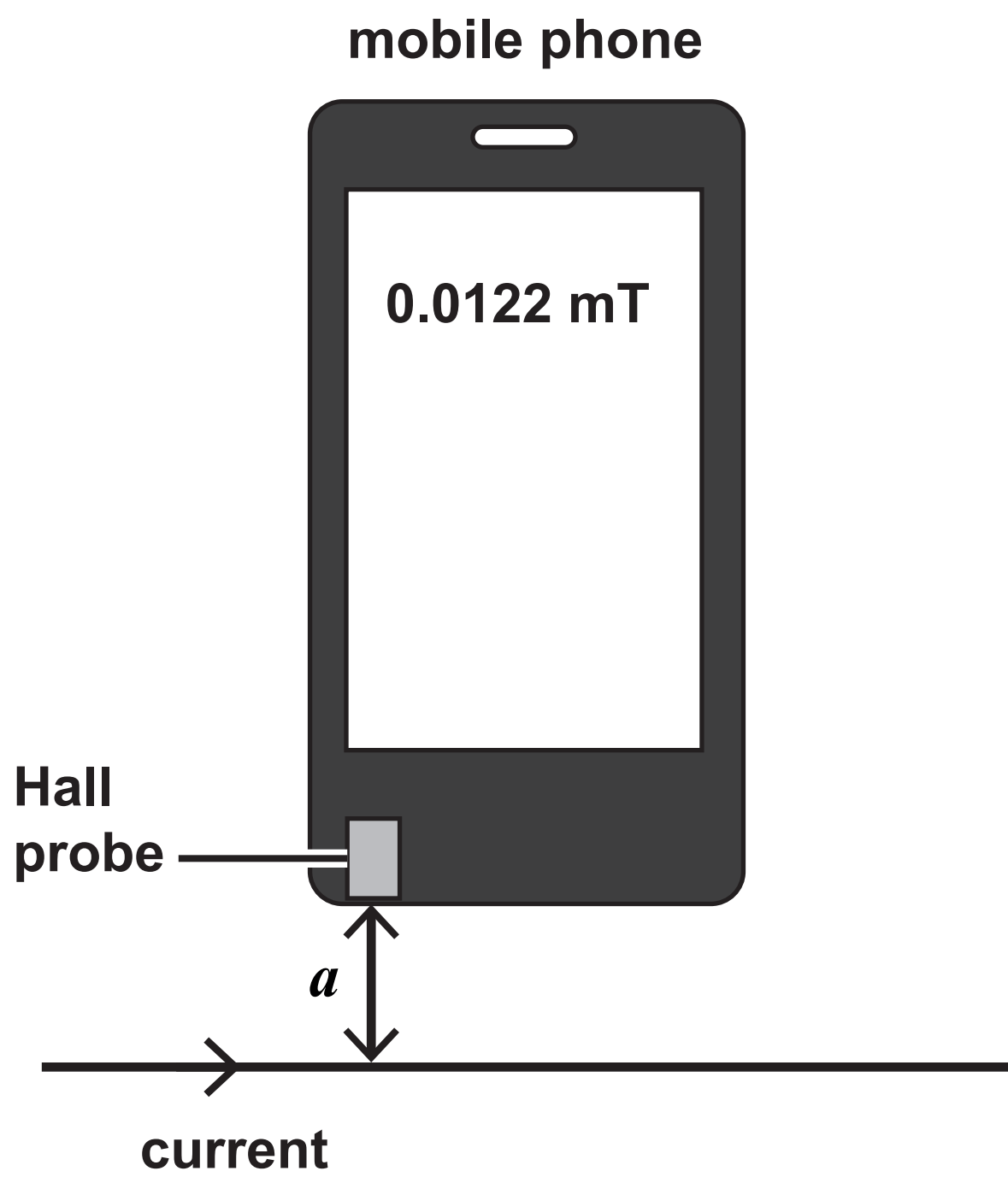


Question 6 (b)

Binding energy
per nucleon / MeV



Question 8

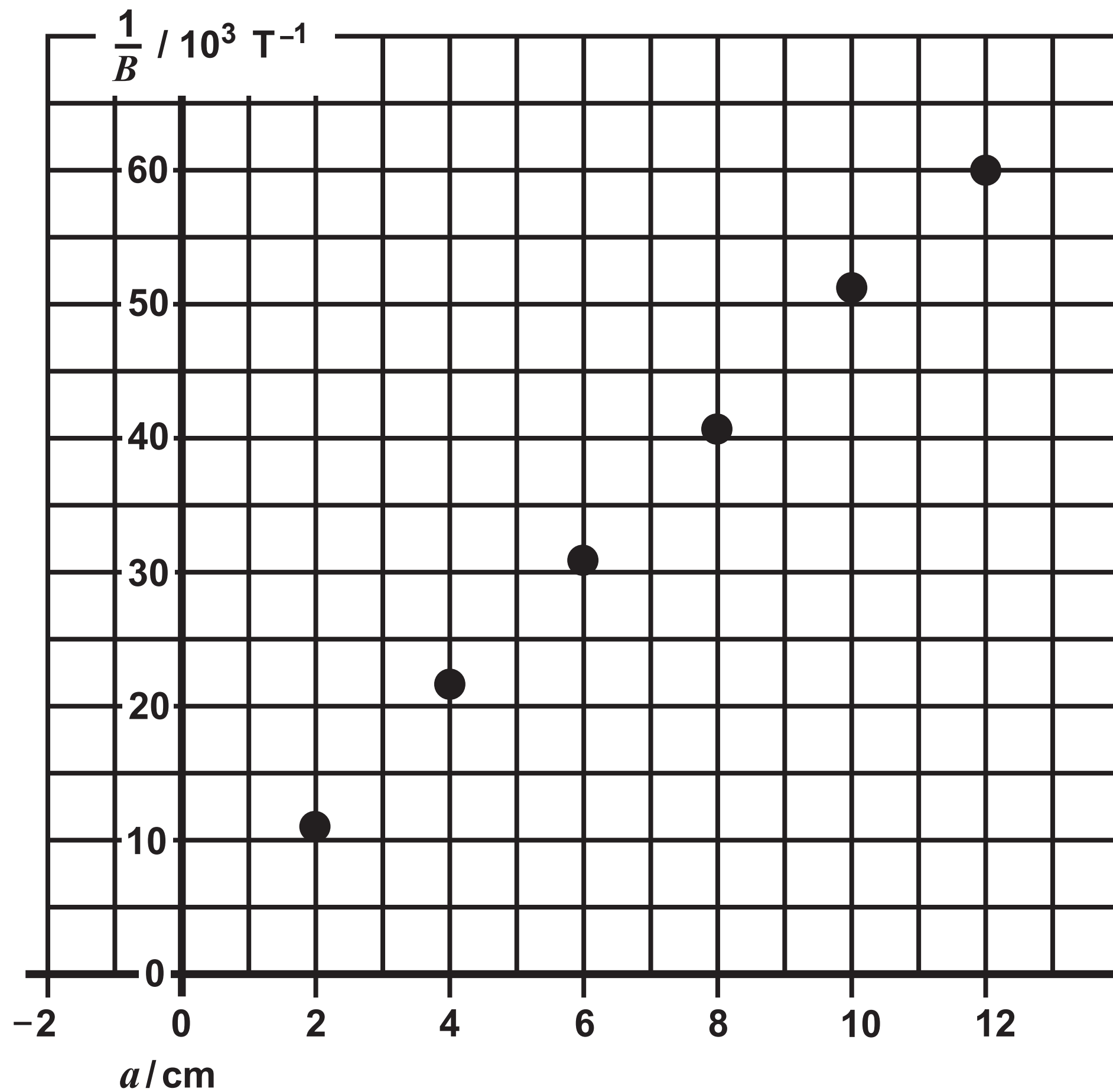


Question 8 (a)

Table

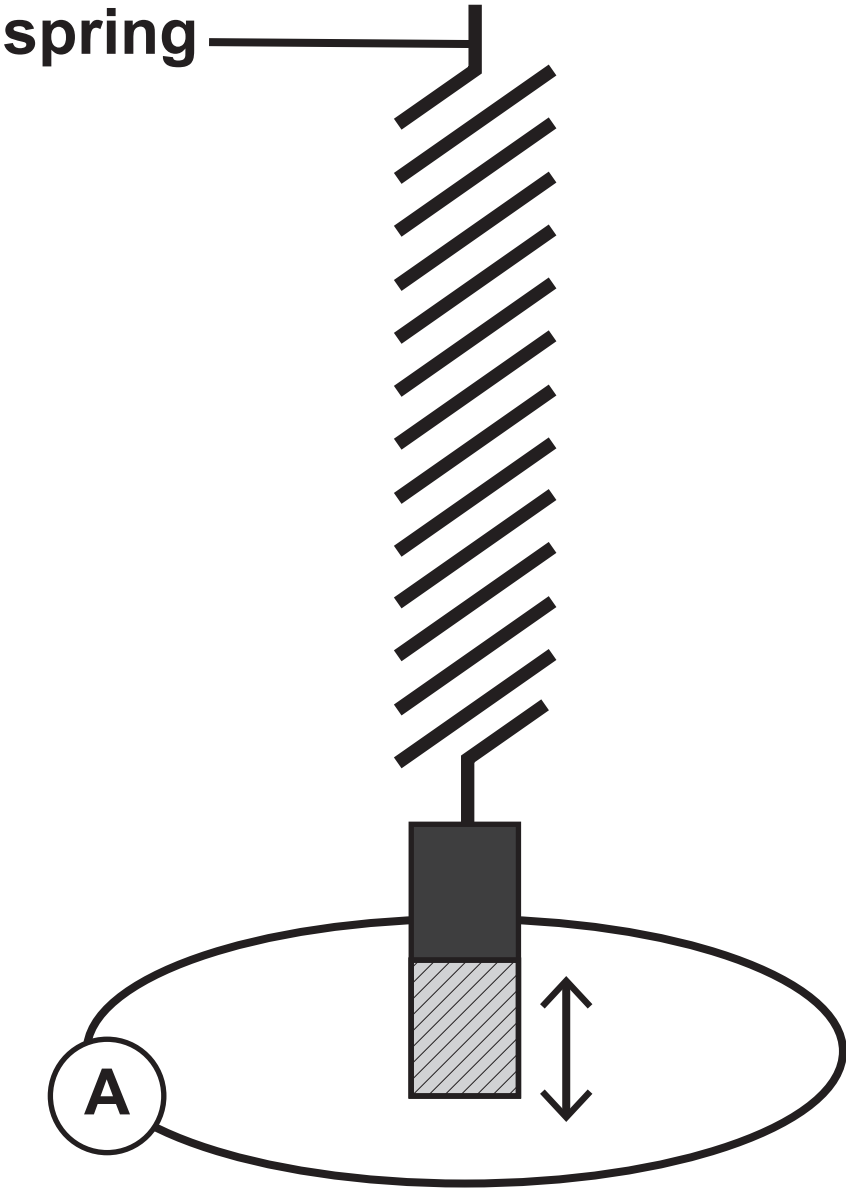
Distance, a / cm	Magnetic flux density, B / mT	$\frac{1}{B} / 10^3 \text{ T}^{-1}$
2.0	0.0907	11.0
4.0	0.0470	21.3
6.0	0.0325	30.8
8.0	0.0246	40.7
10.0	0.0195	51.3
12.0	0.0167	59.9

Question 8 (b)



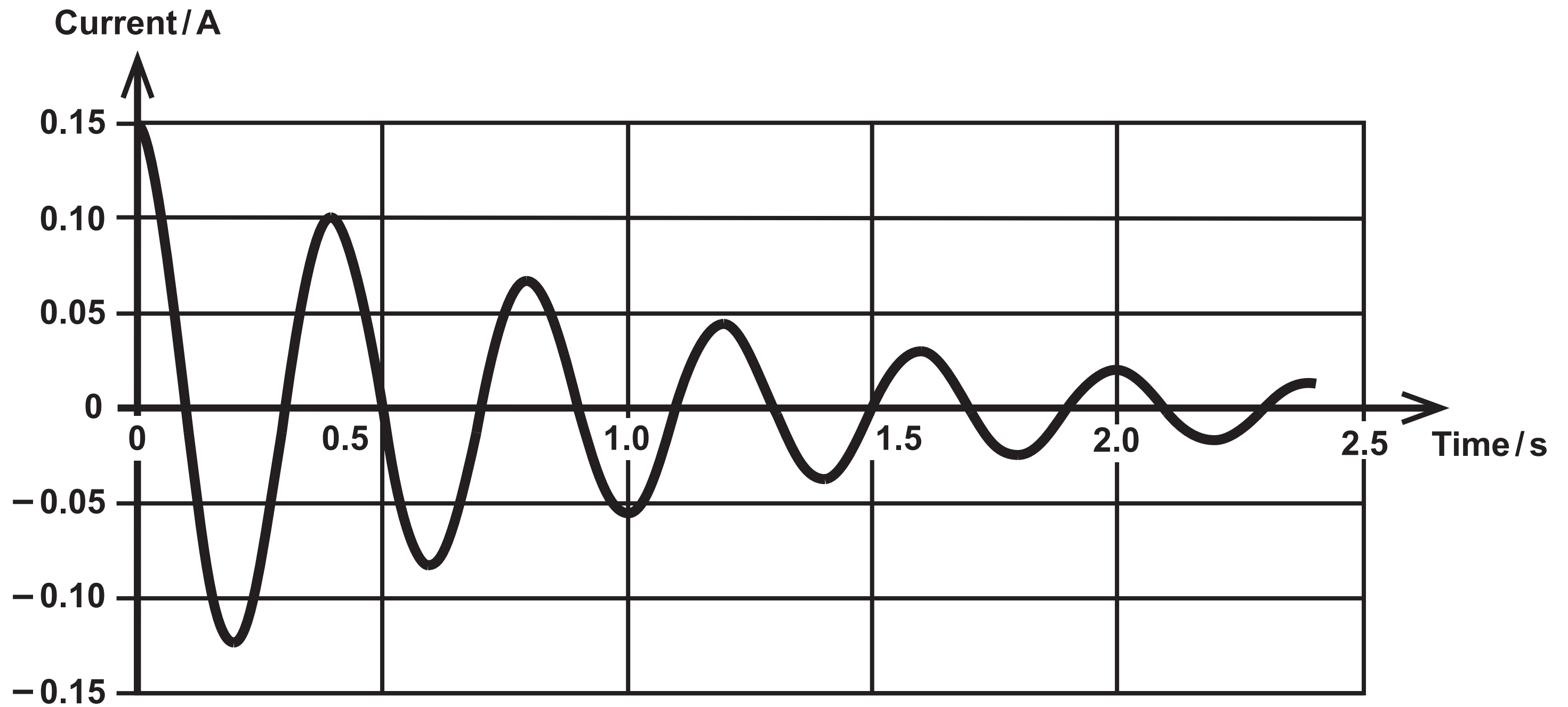
Question 9

Diagram 1

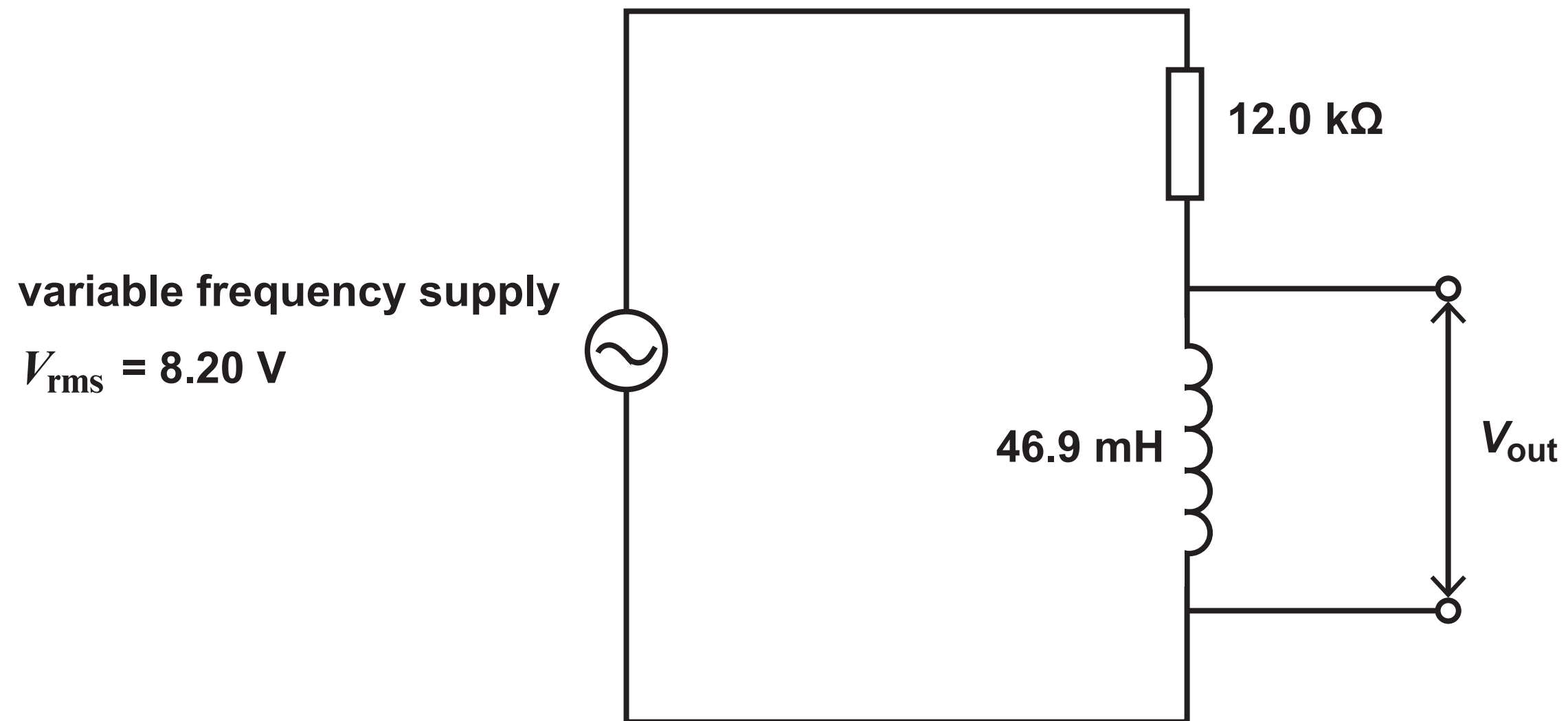


Question 9

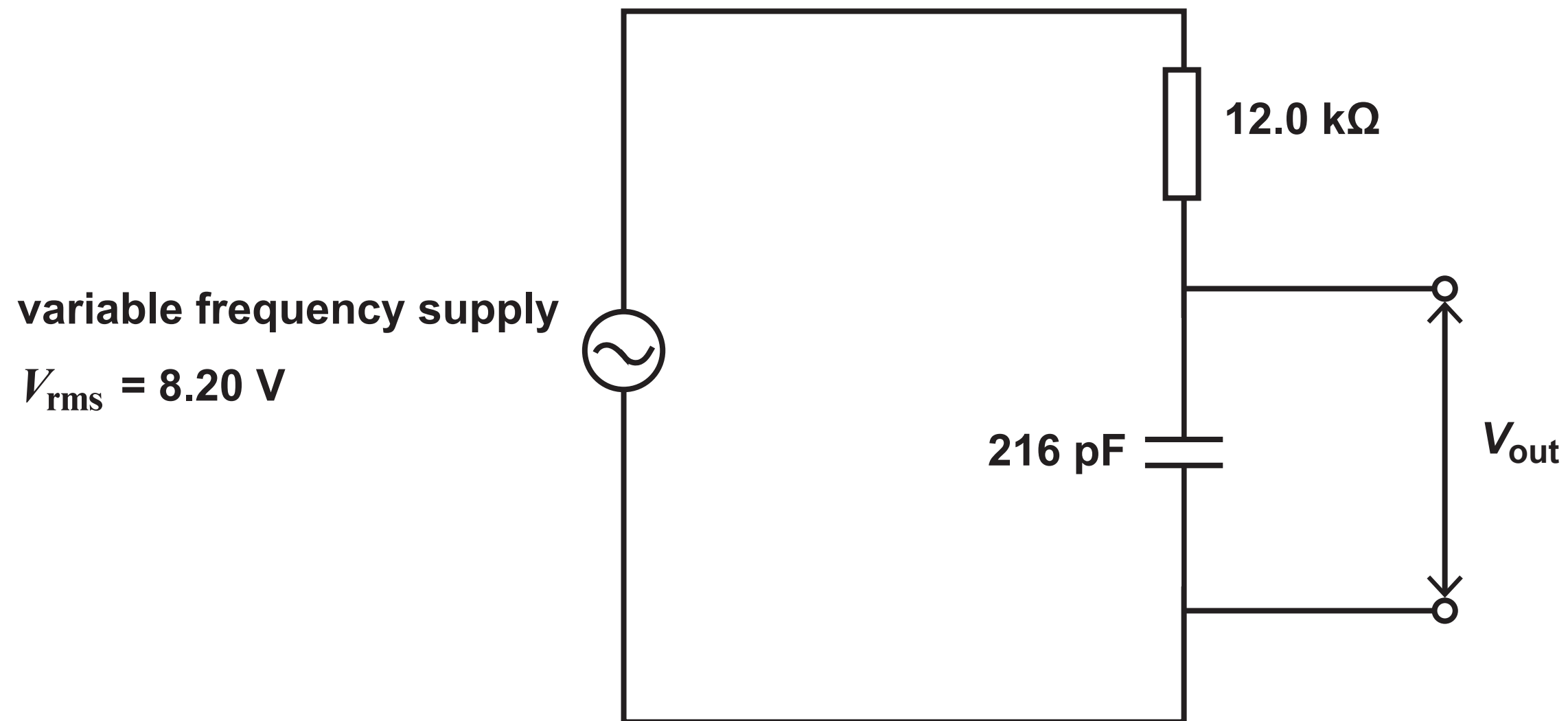
Diagram 2



Question 10 (a) (ii)



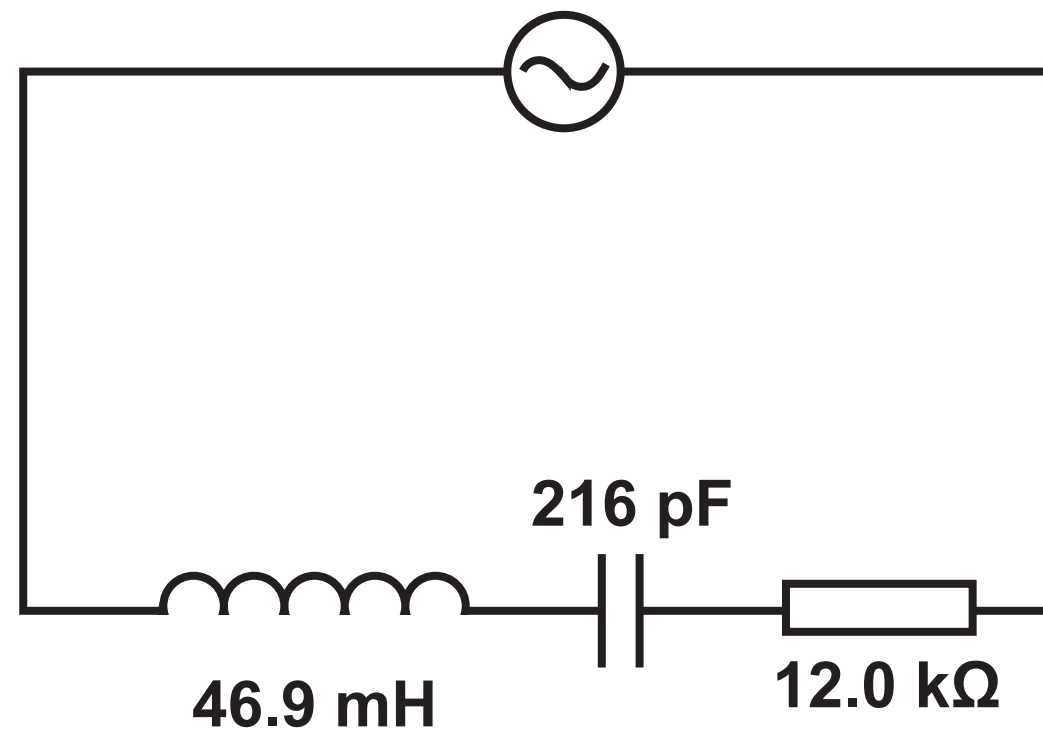
Question 10 (a) (iii)



Question 10 (a) (iv)

variable frequency supply

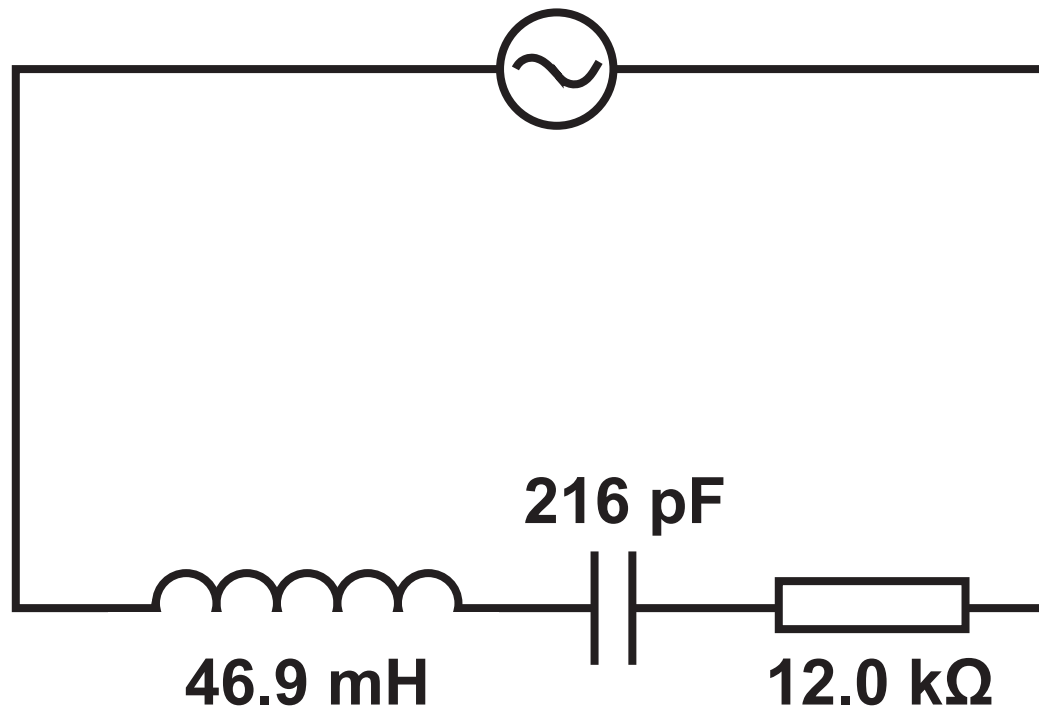
$$V_{\text{rms}} = 8.20 \text{ V}$$



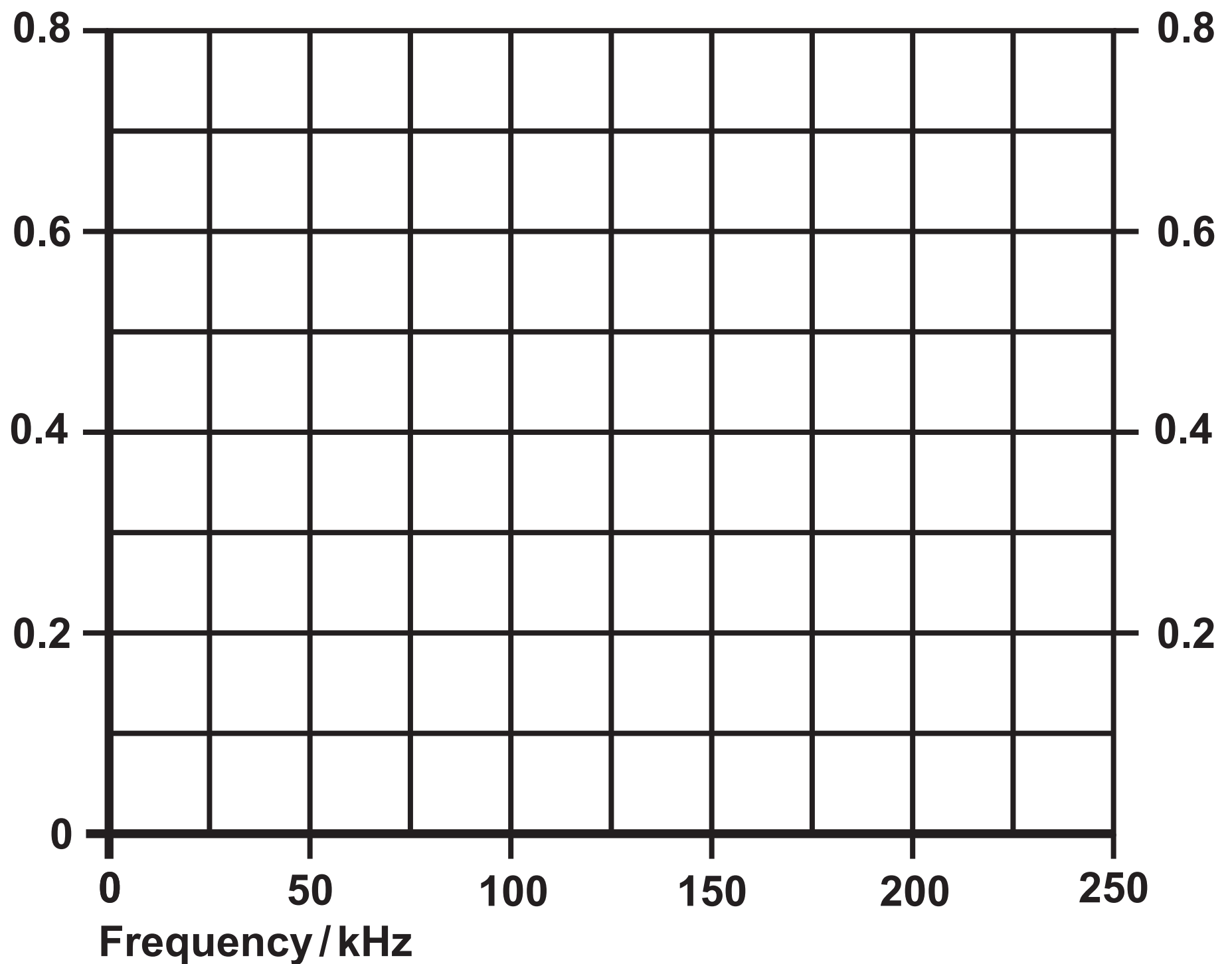
Question 10 (a) (v)

variable frequency supply

$$V_{\text{rms}} = 8.20 \text{ V}$$

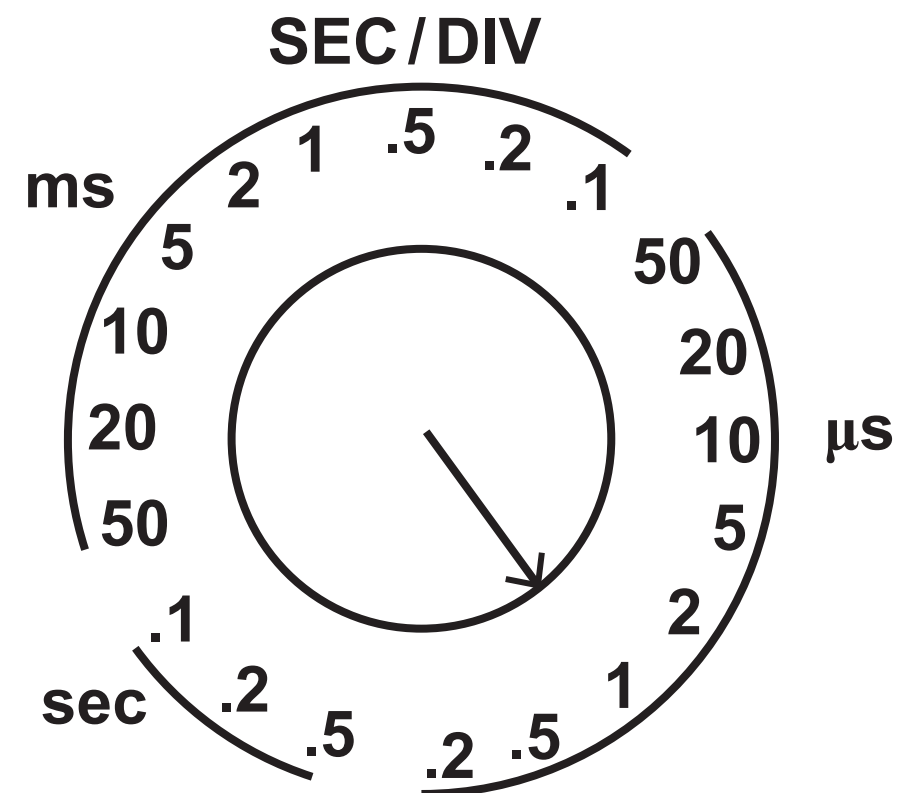
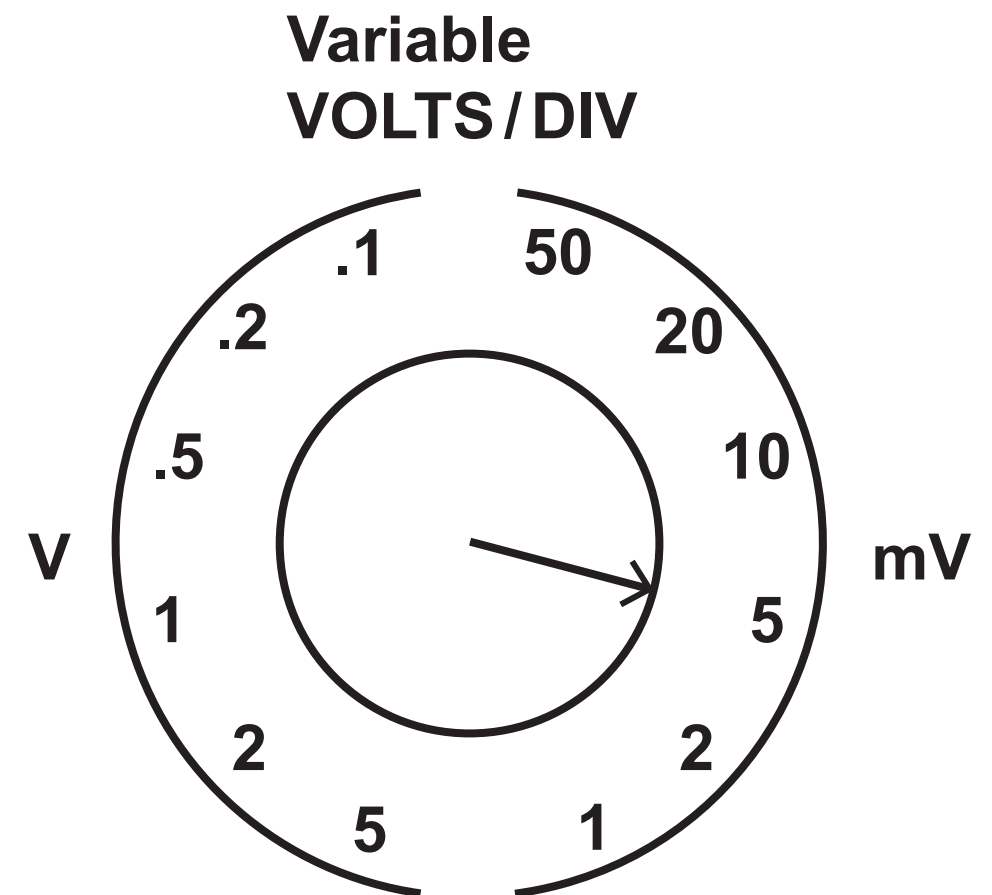
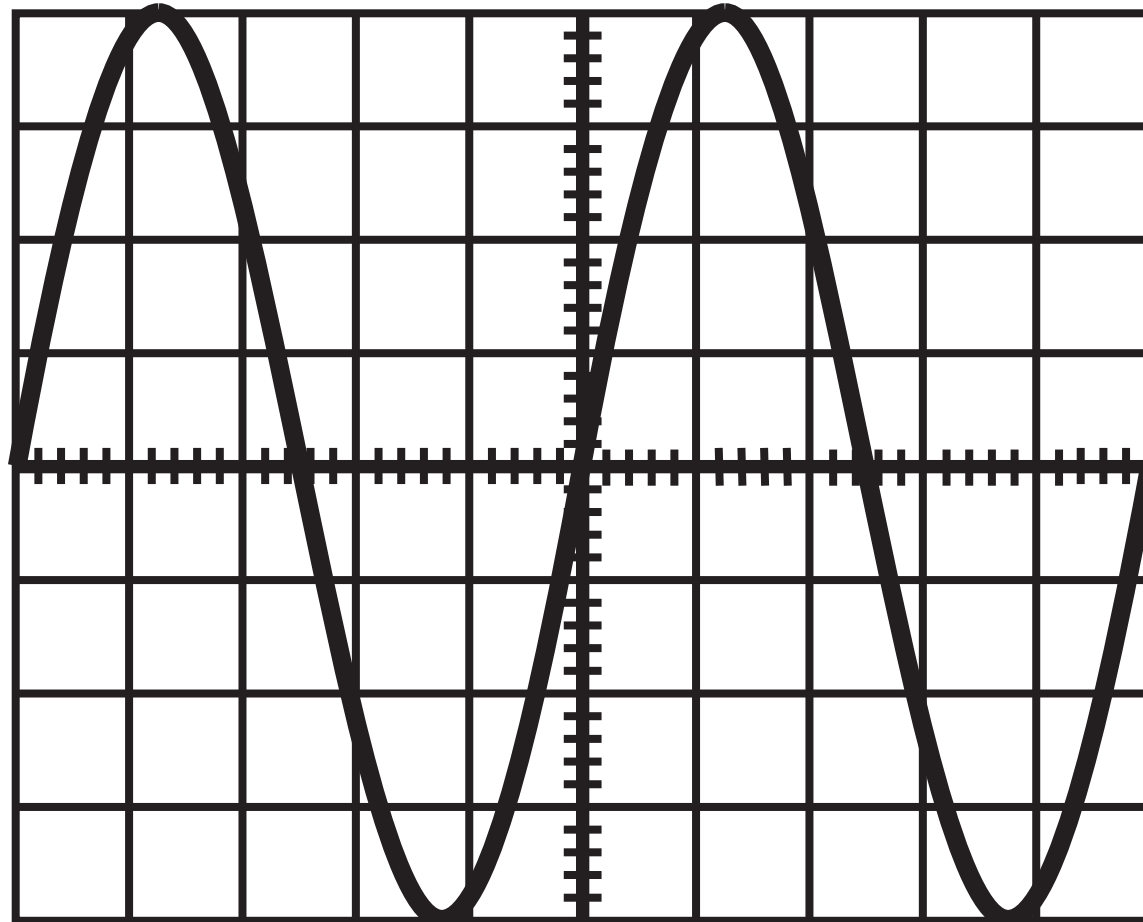


Current / mA

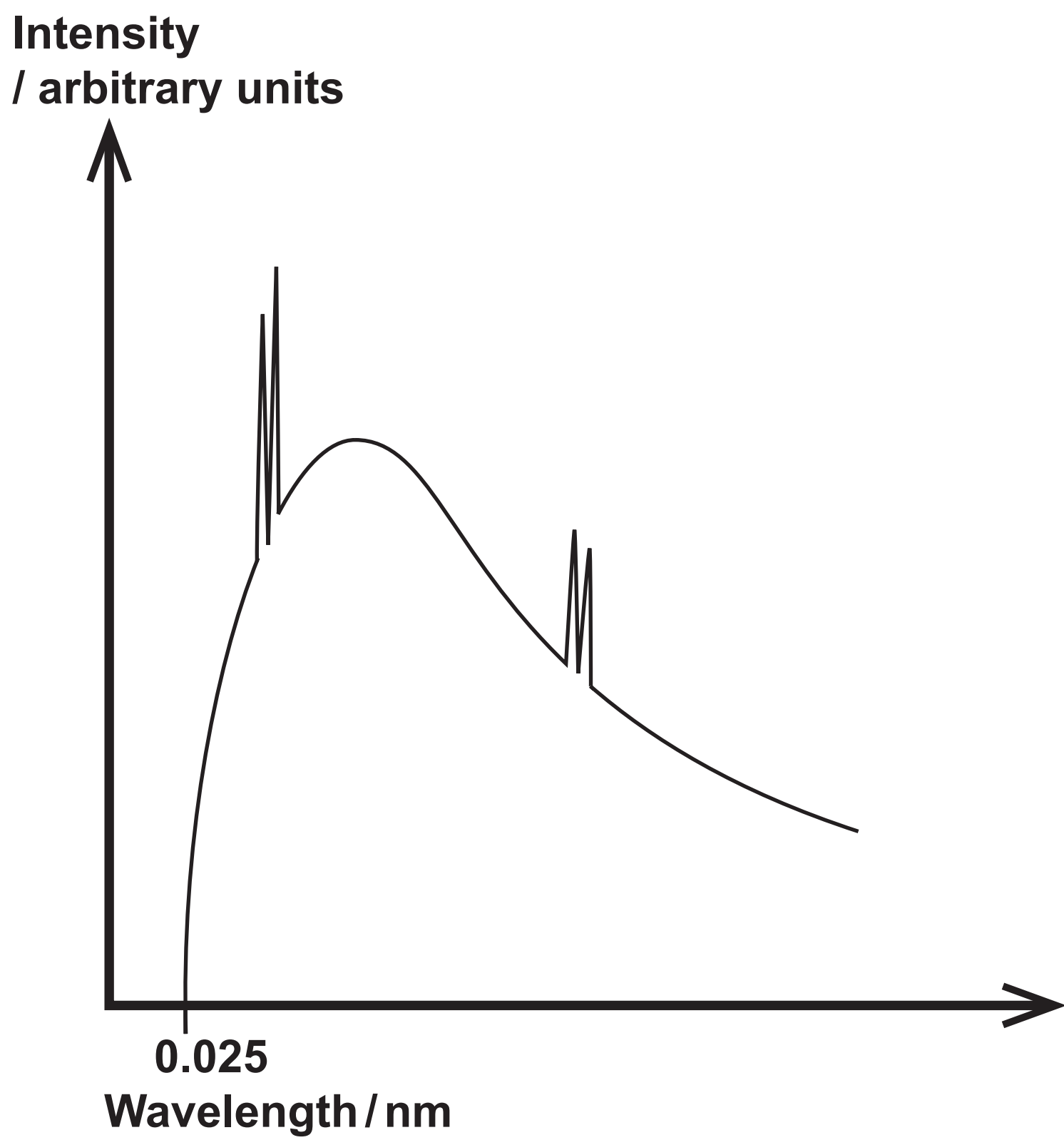


Question 10 (b)

Harry's answer



Question 11 (a)

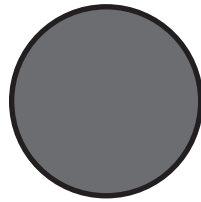


Question 12 (a)



Question 12 (c) (iv)

velocity of air = 22 m s^{-1}

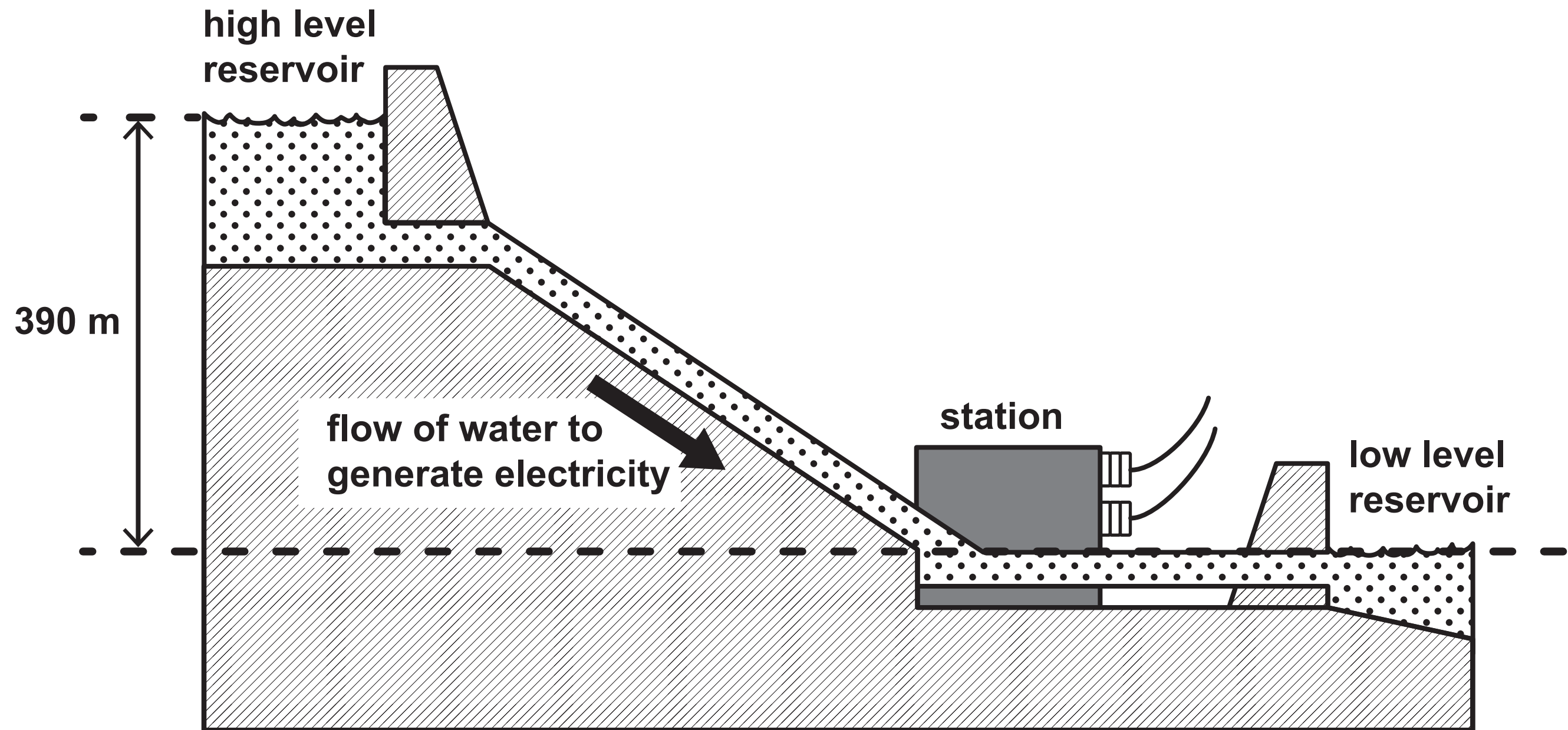


density of air = 1.28 kg m^{-3}



velocity of air = 20 m s^{-1}

Question 13 (b)



Question 13 (d)

