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RECOGNISING ACHIEVEMENT

Wednesday 5 June 2013 – Morning

AS GCE PHYSICS A

G482/01 Electrons, Waves and Photons

G411720613

Candidates answer on the Question Paper.

OCR supplied materials:
- Data, Formulae and Relationships Booklet (sent with general stationery)

Other materials required:
- Electronic calculator

Duration: 1 hour 45 minutes

G 4 8 2 0 1

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, your should use the lined pages at the end of the booklet. The question numbers must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
-  Where you see this icon you will be awarded marks for the quality of written communication in your answer.

  This means for example you should:
  - ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear;
  - organise information clearly and coherently, using specialist vocabulary when appropriate.
- This document consists of **20** pages. Any blank pages are indicated.

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Answer **all** the questions.

1 Fig. 1.1 shows the $I-V$ characteristic of a slice of semiconducting material.

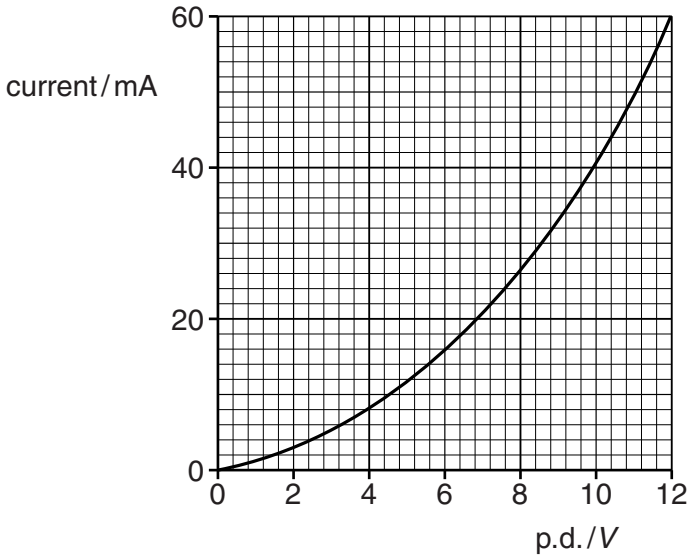


Fig. 1.1

(a) (i) Define *resistance*.

.....

..... **[1]**

(ii) Show that the resistance of the slice is about 250 Ω when there is a current of 40 mA in it.

[2]

(b) The dimensions of the slice are shown in Fig. 1.2.

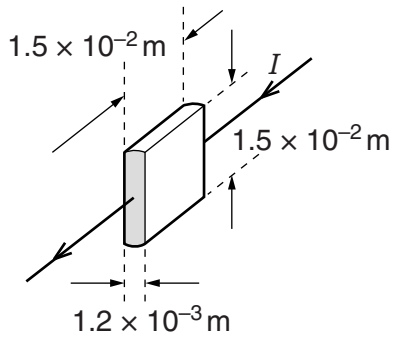


Fig. 1.2

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Calculate the resistivity ρ of the semiconducting material when there is a current I of 40 mA in the slice.

ρ = ... Ω m **[3]**

(c) Explain how the $I-V$ characteristic shows that the resistivity of the semiconducting material decreases with increasing temperature.



In your answer you should explain how you are aware that the temperature of the slice changes.

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..... **[4]**

[Total: 10]

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2 **(a)** The battery in an electric car has an e.m.f. of 24 V. It can provide a current of 200 A to the motor for a period of 4.0 hours.

(i) Define the term *electromotive force* (e.m.f.) for the battery.

.....

.....

..... **[2]**

(ii) Show that the total charge Q that can be delivered by the battery is about 3×10^6 C.

[2]

(iii) Calculate the total energy E that can be supplied by the battery at a constant e.m.f. of 24 V.

E = ... J **[2]**

(b) The charger for the battery has a 30 V output supplying a current I. The total resistance of the circuit is indicated by one resistor **R** in Fig. 2.1. The positive terminal of the battery is connected to **X**.

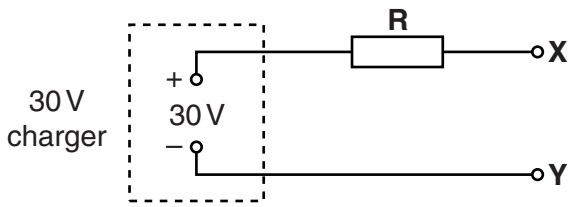


Fig. 2.1

(i) Complete the circuit by drawing the correct symbol for the battery between **X** and **Y** on Fig. 2.1. The battery has negligible internal resistance. **[1]**

(ii) The potential difference across the battery remains at 24 V. The current I provided by the battery charger is constant at 120 A. Show that the value of the resistance of **R** is 0.050 Ω.

[2]

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(iii) Calculate the power lost in **R** as the battery is charging.

power lost = ... W **[2]**

(iv) The efficiency of the charging process is given by the equation

$$\text{efficiency} = \frac{\text{input power from charger} - \text{power loss in } \mathbf{R}}{\text{input power from charger}}.$$

Calculate its value as a percentage.

efficiency = ... % **[3]**

(c) (i) Show that it takes about 7 hours to charge a completely flat battery.

[2]

(ii) Calculate the cost of charging the battery at 26p per kWh.

cost = ... p **[1]**

[Total: 17]

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3 **(a)** Kirchhoff's laws can be used to analyse any electrical circuit. State each of Kirchhoff's laws and the physical quantity associated with each law that is conserved in the circuit.

(i) Kirchhoff's first law

.....

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..... **[2]**

(ii) Kirchhoff's second law

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..... **[2]**

(b) The circuit in Fig. 3.1 consists of a battery of e.m.f. 45 V and negligible internal resistance and three resistors.

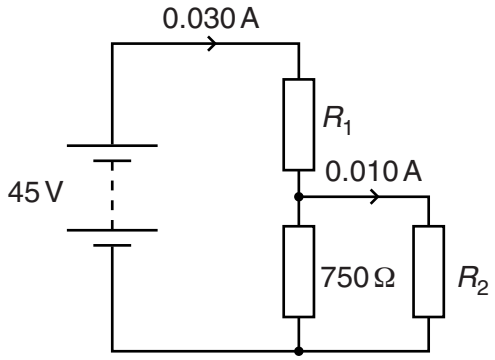


Fig. 3.1

The resistors have resistances R_1, R_2 and 750 Ω. The current in the resistor of resistance R_1 is 0.030 A. The current in the resistor of resistance R_2 is 0.010 A.

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Calculate

(i) the current I in the 750 Ω resistor

I = ... A **[1]**

(ii) the p.d. V across the 750 Ω resistor

V = ...V **[1]**

(iii) the resistances R_1 and R_2.

R_1 = ... Ω

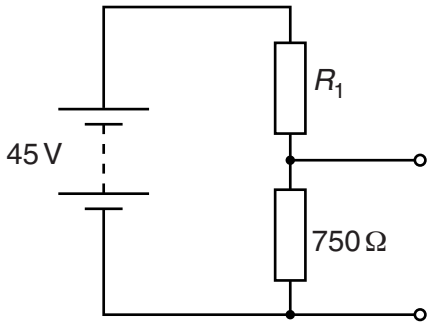
R_2 = ... Ω
[2]

Question 3 is continued on page 8

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(c) The resistor of resistance R_2 is replaced in Fig. 3.1 by a light dependent resistor (LDR).

(i) Draw the circuit symbol for an LDR on Fig. 3.2 to complete this new circuit.



[1]

Fig. 3.2

(ii) The resistance of the LDR falls from about 1.5 kΩ to about 400 Ω as the light intensity increases. State and explain, without calculation, how the potential difference across the 750 Ω resistor varies as the intensity of the light incident on the LDR increases.

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..... **[3]**

(iii) It is suggested that the LDR in the circuit of Fig. 3.2 is used to monitor changes in the light intensity.

1 Draw a suitable electrical meter in the LDR branch of the circuit on Fig. 3.2 to measure these changes.

2 State the electrical meter that you have chosen and suggest a sensible maximum scale reading.

.....

.....

.....

[3]

[Total: 15]

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Question 4 begins on page 10

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4 **(a)** **(i)** Explain what is meant by a *progressive wave*.

.....

.....

.....

..... **[2]**

(ii) State **two** differences between a *progressive* and a *stationary* wave.

1 .....

.....

2 .....

.....

[2]

(b) Fig. 4.1 shows, at time $t = 0$, the shape of a section of stretched cord along which a transverse wave is **travelling** from left to right. **W**, **X**, **Y** and **Z** are four marked points on the cord.

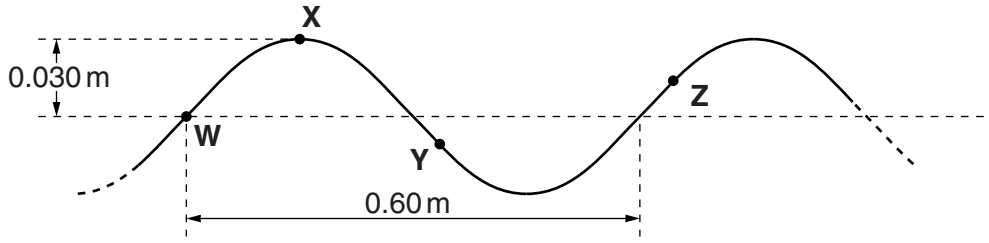


Fig. 4.1

A mechanical oscillator is causing the wave by oscillating the end of the cord at a steady frequency of 5.0 Hz. The wave has a wavelength of 0.60 m and amplitude of 0.030 m.

(i) On the axes of Fig. 4.2 sketch the graph of the displacement of point **X** over the period $t = 0$ to 0.40 s. Add suitable scales to the axes. **[4]**

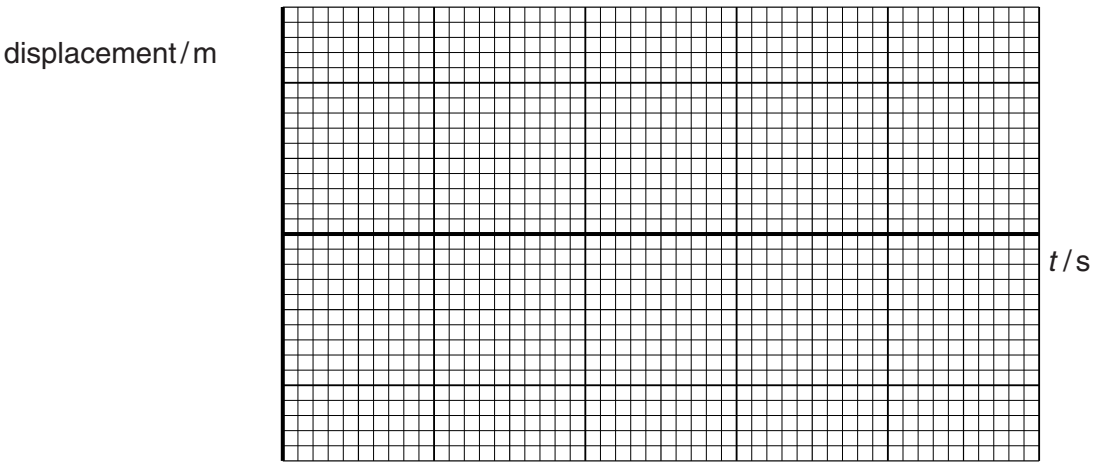


Fig. 4.2

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(ii) State which of the points **W**, **X**, **Y** and **Z** at $t = 0$

1 is instantaneously at rest .....

2 has the greatest speed .....

3 are moving 90° out of phase with each other. .....

[3]

(iii) On Fig. 4.1 draw arrows to show the directions in which the points **Y** and **Z** are moving. **[2]**

(c) The speed v of the wave on the stretched cord is given by the formula

$$v = k\sqrt{T}$$

where T is the tension in the cord and k is a constant.

Calculate the wavelength λ of the wave after the tension in the cord has been **quadrupled** (×4) but the frequency of oscillation is unchanged.

λ = ... m **[2]**

(d) The speed of point **W** on the cord at $t = 0$ is $0.94\,\text{m s}^{-1}$. With the cord at its original tension, the frequency of oscillation is now **doubled** to 10 Hz. The amplitude is kept at 0.030 m. Calculate the new speed of point **W** at $t = 0$. Explain your reasoning.

speed = ... m s^{-1} **[2]**

[Total: 17]

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5 This question is about the superposition of electromagnetic waves.

(a) (i) State the *principle of superposition of waves*.

.....

.....

..... **[2]**

(ii) State **one** property of electromagnetic waves that distinguishes them from **all** other waves.

.....

..... **[1]**

(iii) State why electromagnetic waves can be polarised but sound waves cannot be polarised.

.....

..... **[1]**

(b) In Fig. 5.1 $\mathbf{T_1}$ and $\mathbf{T_2}$ are two adjacent transmitters 1.0 m apart with a receiving aerial **R** halfway between them. The transmitters are set up to emit coherent electromagnetic waves of wavelength 3.0 cm.

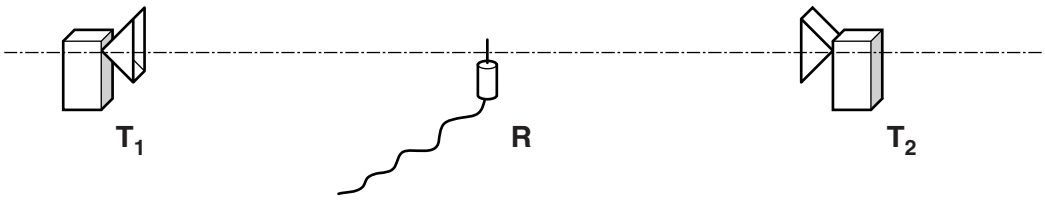


Fig. 5.1

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(i) The student finds that the signal at the receiver **R** falls from maximum to zero when **R** is moved 0.75 cm towards a transmitter. Explain this observation.

In your answer you should make clear how the signal can be zero and why the distance moved should be 0.75 cm.

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..... **[4]**

(ii) With **R** at the mid-point between $\mathbf{T_1}$ and $\mathbf{T_2}$, the student rotates $\mathbf{T_2}$ through 90° about an axis through $\mathbf{T_1}$ and $\mathbf{T_2}$. See Fig. 5.2.

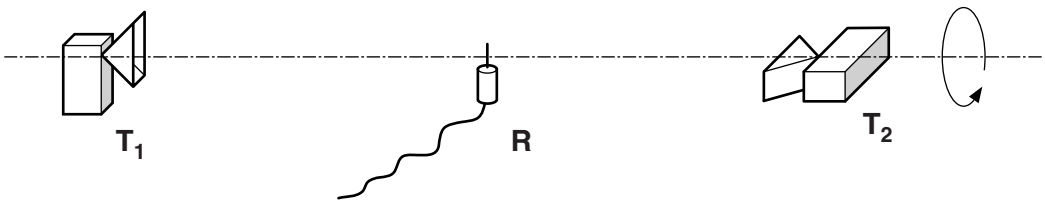


Fig. 5.2

The student finds that the amplitude of the signal at **R** falls to about one half. The detected signal now remains the same when **R** is moved 0.75 cm. Explain these observations.

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..... **[3]**

[Total: 11]

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6 **(a)** A 5.0 eV photon can cause the photoelectric effect from most metals.

(i) State what is meant by the *photoelectric effect*.

.....

..... **[1]**

(ii) State what is meant by an *electron volt* (eV).

.....

..... **[1]**

(iii) Calculate the value of 5.0 eV in SI units.

value = ... unit ..... **[1]**

(b) A photon of energy 8.0×10^{-19} J incident on a clean zinc surface can cause photoelectric emission. The maximum kinetic energy of an electron emitted from the surface is 1.1×10^{-19} J.

(i) **1** Define the term *work function* of a metal.

.....

..... **[1]**

2 Calculate the work function for zinc.

work function = ... unit ..... **[1]**

(ii) **1** Show that the maximum speed v of an electron emitted from the surface is about $5 \times 10^5\,\text{m s}^{-1}$.

[2]

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2 Calculate the de Broglie wavelength of an electron emitted from the surface at the maximum speed.

de Broglie wavelength = ... m **[3]**

(c) The spacing between atoms in a thin sheet of graphite is about 2.5×10^{-10} m.

(i) A beam of electrons in a vacuum can travel through a thin sheet of graphite placed perpendicular to the beam to produce a pattern of **rings** on a fluorescent screen beyond the graphite sheet. Explain why this pattern is produced.

.....

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..... **[3]**

(ii) Explain whether or not the electrons in **(b)(ii)** would be suitable for use in such an experiment.

.....

.....

..... **[1]**

[Total: 14]

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7 This question is about the Young double slit experiment. See Fig. 7.1. The fringe pattern seen on the screen is shown to the right.

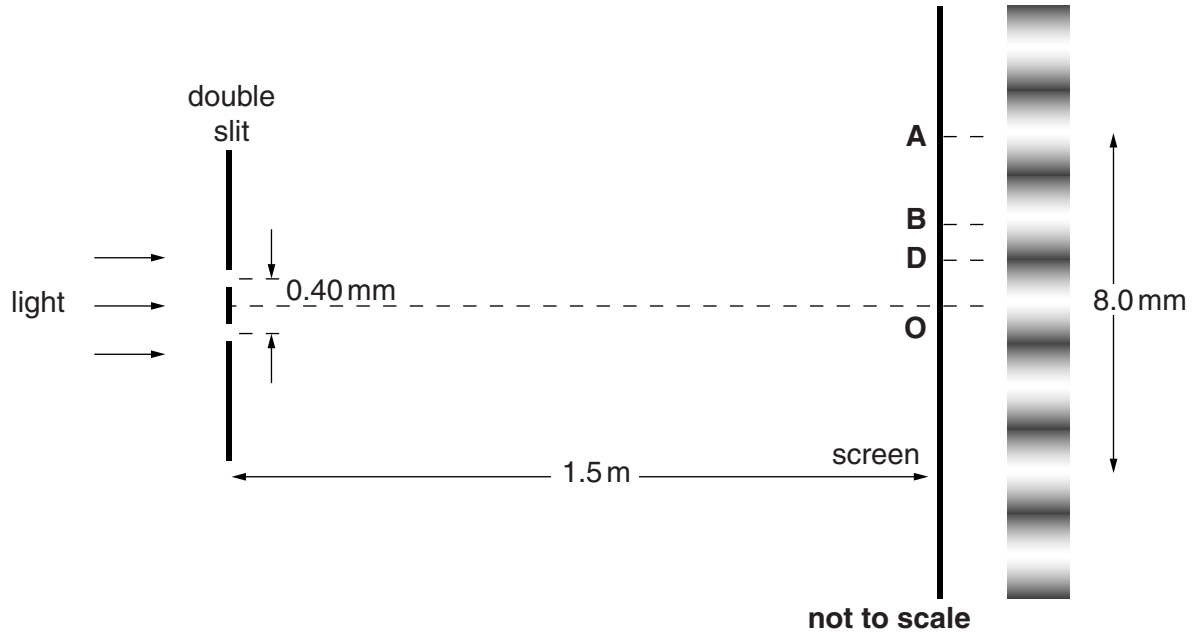


Fig. 7.1

Two parallel clear lines are scratched on a darkened glass slide 0.40 mm apart. When a beam of monochromatic visible light is shone through these slits, interference fringes are observed on a screen placed 1.5 m from the slide. The fringe at point **B** is bright and the fringe at point **D** is dark.

(a) Explain why this arrangement with two slits is used to produce visible fringes on the screen rather than two separate identical light sources.

.....

.....

..... **[2]**

(b) State the **phase difference** between the light waves from the two slits that meet on the screen in Fig. 7.1 at point

D .....

B ..... **[2]**

(c) **(i)** Use Fig. 7.1 to calculate the separation of adjacent bright fringes, the distance between **O** and **B**.

fringe separation = ... m **[1]**

(ii) Show that the wavelength λ of the monochromatic light is about 5×10^{-7} m.

[3]

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(d) Calculate the **path difference**, in nanometres, between the light waves from the two slits that meet on the screen in Fig. 7.1 at point **A**.

path difference = ... nm **[2]**

(e) The energy level diagram of Fig. 7.2 is for the atoms emitting photons in the light source. Electron transitions between the three levels shown produce three photons of different wavelength. The energy E of an electron bound to an atom is negative.

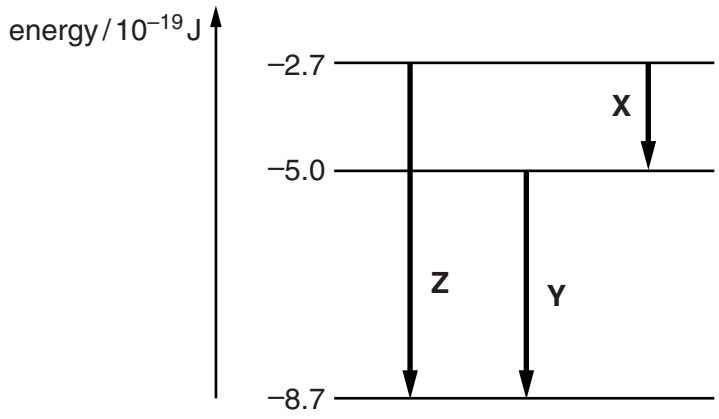


Fig. 7.2

(i) Use data from Fig. 7.2 to justify that the arrow labelled **Y** produces the photons of wavelength about 5×10^{-7} m used in the interference experiment.

[4]

(ii) Neither of the photons shown by the other transitions can be used for the experiment because they are not visible. State in which region of the electromagnetic spectrum each photon is produced, by the other transitions, **X** and **Z**.

X .....

Z ..... **[2]**

[Total: 16]

END OF QUESTION PAPER

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ADDITIONAL ANSWER PAGE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

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ADDITIONAL ANSWER SPACE

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