Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1322/01

PHYSICS
ASSESSMENT UNIT PH2:
WAVES AND PARTICLES

P.M. FRIDAY, 25 May 2012

1½ hours

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

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.

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.

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.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

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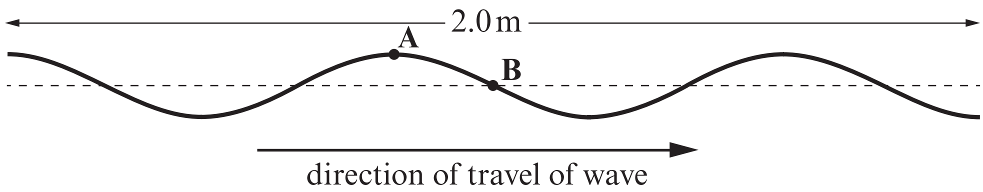
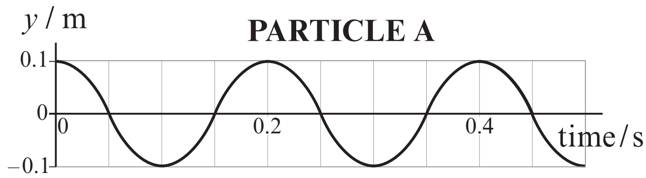
1. *(a)* A water wave is travelling from left to right along a canal. The diagram shows the wave at one instant.



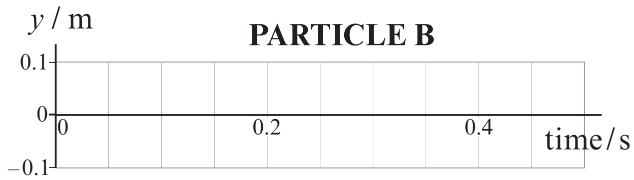
(i) (I) Show that the wavelength of the wave is 0.80 m. [1]

(II) How do the *amplitudes* compare for water particles **A** and **B**? [1]

(ii) A graph of displacement, y (vertical component) against time is given alongside for water particle **A**.



(I) Calculate the *frequency*. [1]



(II) Sketch the corresponding graph for particle **B** on the axes given. [2]

(iii) Calculate the *speed* of the wave. [1]

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(b) When the wave in the first diagram has travelled further, it reaches a length of the canal where the water is shallower. The wavelength in the shallow water is 0.60 m.

Calculate the speed of the wave in the shallow water, **giving your reasoning**. [2]

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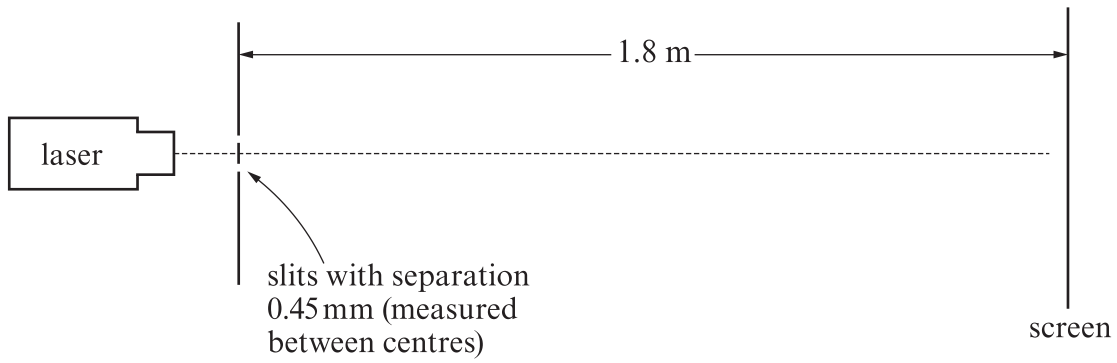
2. The apparatus shown is set up to produce a clear display on the screen of Young's fringes.



(a) The bright fringes result from constructive interference. Explain, in terms of *phase* and *path difference*, why there are bright fringes. You may add to the diagram above, or draw your own diagram(s) to assist your explanation. [2]

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(b) (i) The centres of the bright fringes are measured to be 2.4 mm apart. Calculate the wavelength of the light from the laser. [2]

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(ii) To obtain an accurate value of wavelength, it is better to use a diffraction grating than a double slit. Give **two** reasons for this. [2]

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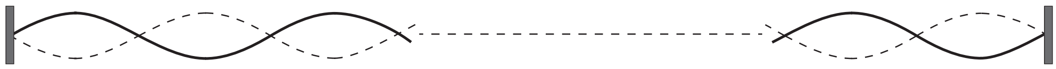
3. The cavity of a laser has reflecting ends a distance L apart. Assuming there is a node at each end, the possible wavelengths of stationary waves are given by the equation

$$\lambda = \frac{2L}{n} \quad \text{in which } n \text{ is a whole number.}$$

(a) Label relevant lengths on the diagram, and hence show how this equation arises. [The stationary wave is shown as if it were a stationary wave on a stretched string.] [2]



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(b) For a particular semiconductor laser, L = 0.2050 mm.

(i) Using the equation above, show that a stationary wave of wavelength 820.0 nm can exist in the cavity, but that a stationary wave of wavelength 821.0 nm cannot. [2]

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(ii) Find the next wavelength above 820.0 nm of stationary wave that could exist in the cavity. [2]

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(c) A stationary wave is equivalent to a superposition of progressive waves of equal amplitude travelling in opposite directions. Why is this condition not exactly met in a laser emitting a beam of light? [2]

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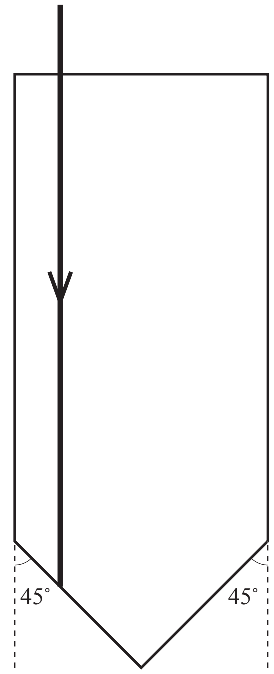
4. *(a)* A rod made of clear plastic of refractive index 1.55 is shaped as shown. The surrounding air has refractive index 1.00.



(i) Calculate the critical angle for light approaching a boundary between the plastic and the air. [2]

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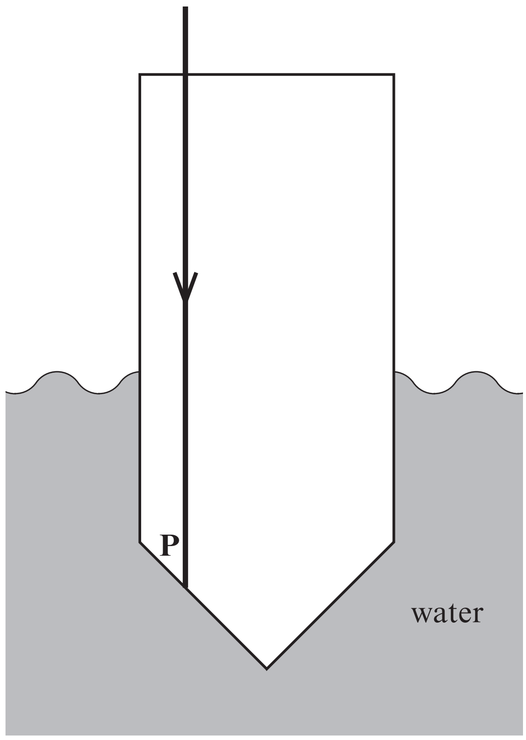
(ii) Hence complete the path of the beam in the diagram, showing its emergence into the air. [2]

(b) The bottom of the rod now dips into water, of refractive index 1.33.



(i) Calculate the angle of refraction of the beam into the water at **P**. [2]

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(ii) Sketch the refracted beam on the diagram. [1]

(iii) Suggest how this plastic rod might be used as part of a device to give a warning when the water level in a tank falls below a certain height. [1]

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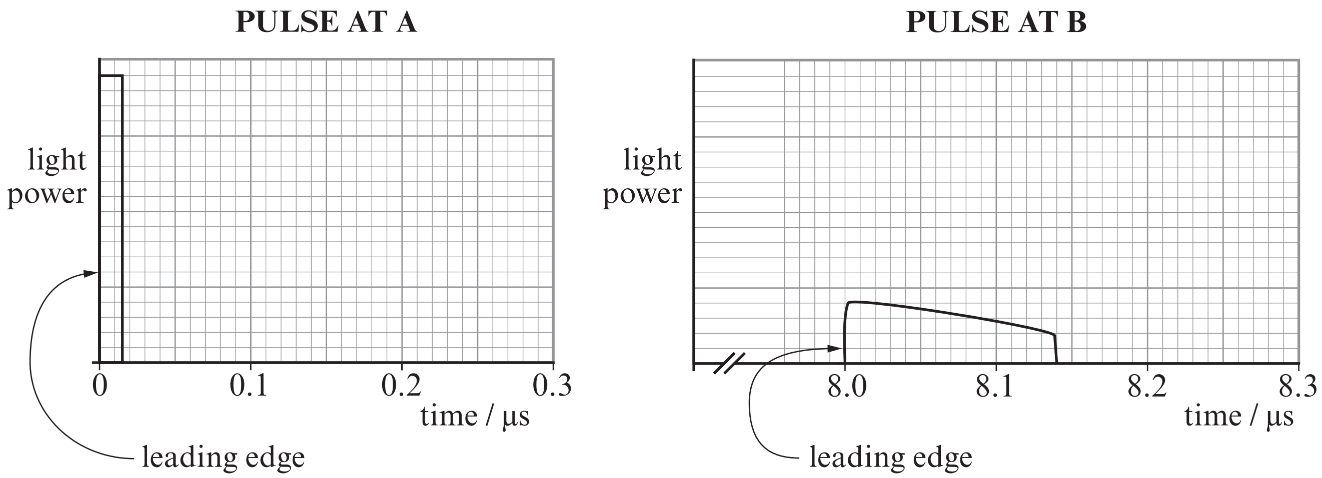
5. *(a)* Pulses of monochromatic light are sent from **A** to **B** through a multimode optical fibre. The graphs show the pulse at **A** and when it arrives at **B**.



(i) By considering the leading edge (the start) of the pulse, calculate the distance from **A** to **B** along the axis of the fibre. The refractive index of the fibre's core is 1.50. [3]

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(ii) Explain why the pulse is spread out over time when it arrives at **B**. A sketched diagram may help your explanation. [2]

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(b) Suppose a second pulse is sent from **A** to **B**.

(i) State the minimum time interval t_{min}, between the leading edges of the first and second pulses at **A**, for them to arrive at **B** without overlapping. [1]

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(ii) Show the second pulse on both graphs opposite, if the time interval between pulses at **A** is t_{min}. [2]

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6. *(a)* State, **in terms of energy**, the meaning of each term in Einstein's photoelectric equation

$$E_{k\max} = hf - \phi.$$

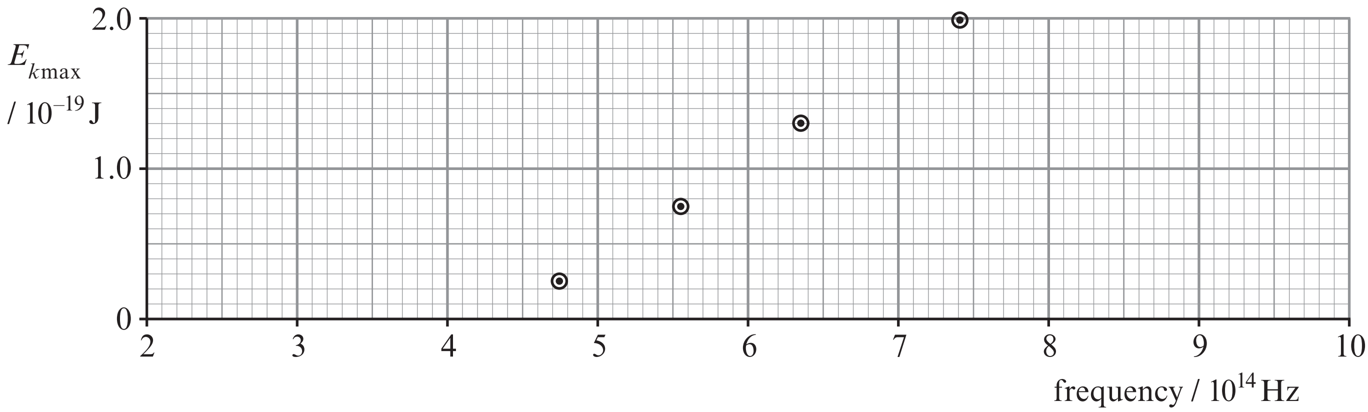
(i) $E_{k\max}$ .... [1]

(ii) hf .... [1]

(iii) ϕ ....

.... [1]

(b) Monochromatic light of frequency 7.40×10^{14} Hz is shone on to a caesium surface, and $E_{k\max}$ is measured. The procedure is repeated for three other frequencies, enabling four points to be plotted on the grid below.



(i) Showing your working, determine from the grid above

(I) a value for the Planck constant, [2]

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(II) the work function of caesium. [2]

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(ii) When a lithium surface is used instead of a caesium surface, $E_{k\max}$ is found to be 0.40×10^{-19} J for light of frequency 7.40×10^{14} Hz.

(I) Draw the expected line of $E_{k\max}$ against frequency on the same grid. [2]

(II) This line cannot be checked satisfactorily by experiment using visible light. Name the region of the electromagnetic spectrum which is required. [1]

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(III) What is different about lithium, as compared to caesium, which makes it necessary to use this region of the electromagnetic spectrum? [1]

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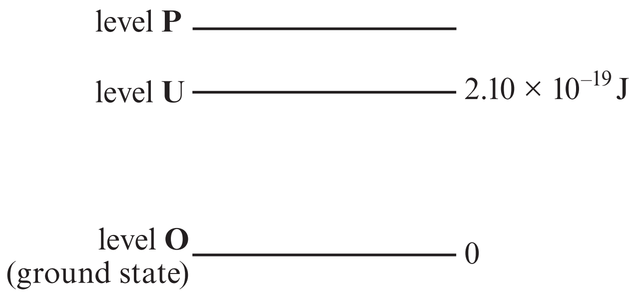
7. A simplified energy level diagram for the amplifying medium of a 3-level laser is given.



(a) Suppose that the laser is at room temperature and that it is **not being pumped**.

(i) Compare the (electron) populations of the three levels. [1]

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(ii) A photon of energy 2.10×10^{-19} J in the laser cavity could interact with the amplifying medium. Name the process involved, and explain briefly what happens. [2]

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(b) The laser is now pumped, to create a *population inversion* between levels **U** and **O**.

(i) Explain what is meant by a population inversion. [1]

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(ii) Draw **two** arrows on the diagram to show how the population inversion is achieved. [1]

(iii) Explain in detail how light amplification takes place. [4]

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(iv) Calculate the wavelength of the radiation emitted. [2]

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(c) In a 4-level laser the light output results from a transition to a lower level which is above the ground state. Explain the advantage over a 3-level system. [2]

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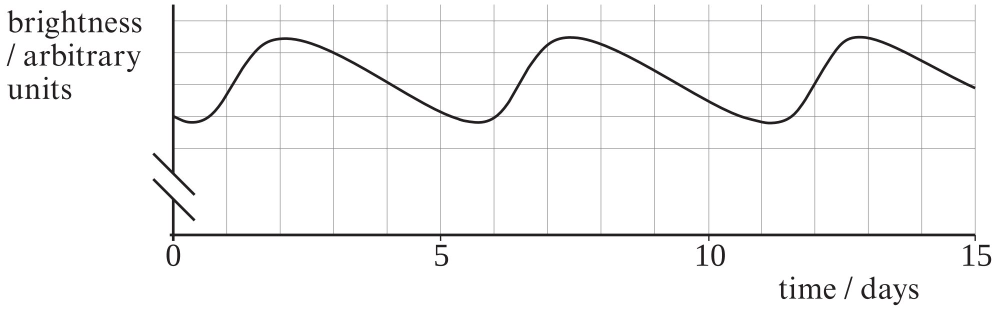
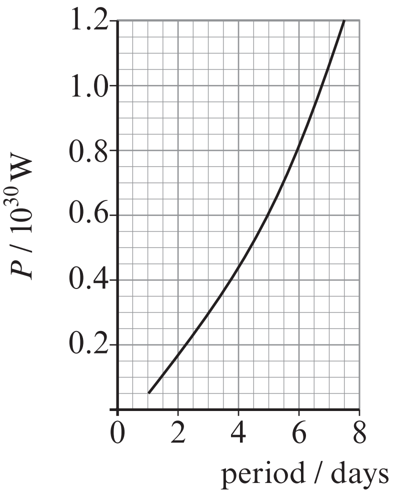
8. *Cepheid variables* are stars whose brightness varies in a characteristic, regular way. The variation is shown below for one such star.



The mean power, P, emitted as electromagnetic radiation from a Cepheid variable is related to the period of its brightness variation, as shown alongside.



(a) (i) Use the graphs to determine P for the star, showing briefly how you obtained your answer. [2]

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(ii) The mean *intensity* of the radiation from the star, as measured at the Earth is $8.0 \times 10^{-13}\,\mathrm{W\,m^{-2}}$. Using your answer to *(a)*(i), calculate the distance, r, between the star and the Earth. [2]

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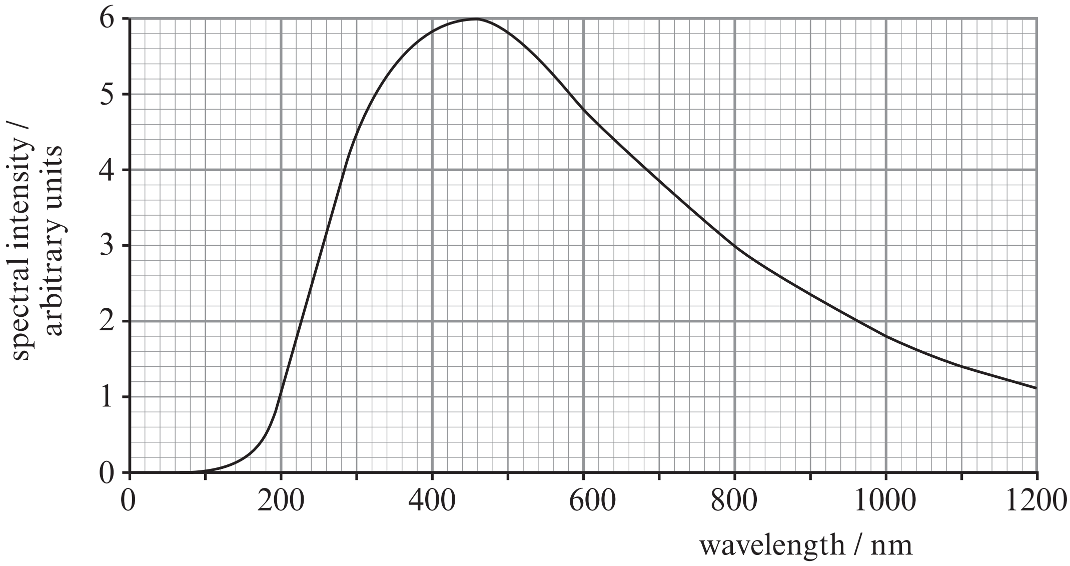
(b) The maximum power emitted by the star during its cycle of variation is estimated to be 9.5×10^{29} W, and the spectrum of its radiation corresponding to this point in its cycle is given below.



(i) Use Wien's law to calculate the temperature of the star. [2]

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(ii) Calculate the **diameter** of the star. [4]

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9. *(a)* An electron and a positron can annihilate (destroy) each other, in this interaction:

$$e^- + e^+ \longrightarrow \gamma + \gamma$$

(i) Explain how *lepton number* is conserved in this interaction. [2]

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(ii) State which force (strong, weak or electromagnetic) is involved in this interaction, giving a reason for your answer. [1]

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(b) A proton and an antiproton can annihilate each other, in this **strong** interaction:

$$p + \bar{p} \longrightarrow \pi^+ + x$$

By applying conservation rules, suggest the identity of particle x. [2]

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(c) The π^+ is unstable. It can decay, thus:

$$\pi^+ \longrightarrow y + \nu_e$$

(i) Identify y. [1]

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(ii) Which force is involved? [1]

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(d) Show below, as an equation, how the π^- might decay. [1]

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.

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