

APOLLO

Standing waves and resonance

HL

Physics

First assessment 2025

9 questions | questions

22. A pipe of length L is closed at one end.

What is the wavelength of the fifth-harmonic standing wave in this pipe?

A. $\frac{8L}{5}$

B. $\frac{5L}{4}$

C. $\frac{4L}{5}$

D. $\frac{5L}{8}$

— 13 —

2225-0101

- 19.** A fifth-harmonic standing wave is formed in a pipe of length 25 cm that is closed at both ends.

What two points along the pipe have a phase difference of π ?

- A. 2 cm and 7 cm
- B. 4 cm and 21 cm
- C. 7 cm and 9 cm
- D. 11 cm and 14 cm

- 25.** The frequency of the first harmonic for a pipe open at both ends is f . The length of the pipe is 0.4 m. A second pipe, open at one end and closed at the other, produces a first harmonic of the same frequency f .

What is the length of the second pipe?

- A. 0.1 m
- B. 0.2 m
- C. 0.4 m
- D. 0.8 m

— 16 —

Turn over
2225-0119

- 21.** A standing sound wave is formed in a pipe of length L that is open at both ends. The standing wave has two nodes. What is the wavelength of the standing wave?

A. $\frac{L}{2}$

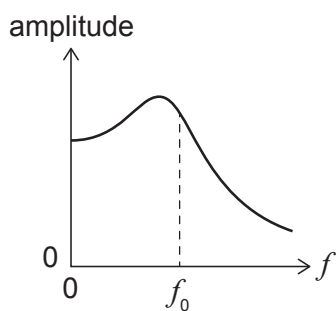
B. $\frac{2L}{3}$

C. L

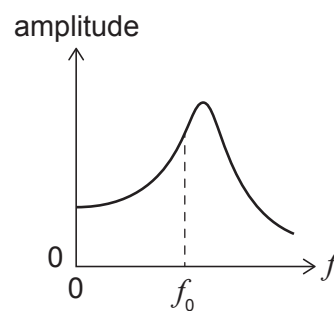
D. $2L$

22. A heavily damped oscillator of natural frequency f_0 is driven by a periodic force of frequency f . Which graph shows how the amplitude of the oscillations varies with f ?

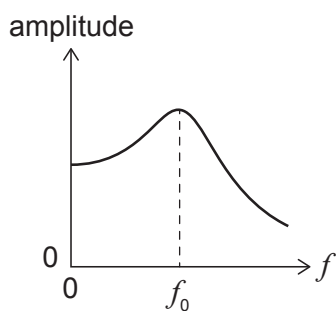
A.



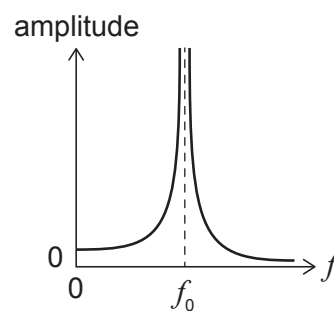
B.



C.



D.



Turn over
0020-0107

- 24.** A string that is fixed at both ends oscillates in the second harmonic with frequency 100 Hz. What other harmonic frequencies, in Hz, can this string oscillate at?
- A. 25 and 50
 - B. 25 and 75
 - C. 50 and 150
 - D. 75 and 150

9. (a) A copper rod has mass 0.400 kg. The density of solid copper is $8.94 \times 10^3 \text{ kg m}^{-3}$.
The molar mass (the mass of a mole) of copper is 63.5 g mol^{-1} .

Estimate

- (i) the mass of a copper atom;

[2]

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- (ii) the volume corresponding to each atom, given by $\frac{\text{volume of copper}}{\text{number of copper atoms}}$;

[2]

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- (iii) the average separation of two neighbouring copper atoms, assuming that the volume corresponding to each atom is a cube.

[1]

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- (b) The specific latent heat of fusion of copper is 206 kJ kg^{-1} . Calculate the energy needed to completely melt 0.400 kg of solid copper at its melting point.

[1]

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(Question 9 continued)

- (c) Copper atoms in the solid and liquid phase coexist at the melting point. Comparing equal numbers of atoms in the solid and liquid phase at the melting point, state and explain which atoms have the greater internal energy.

[3]

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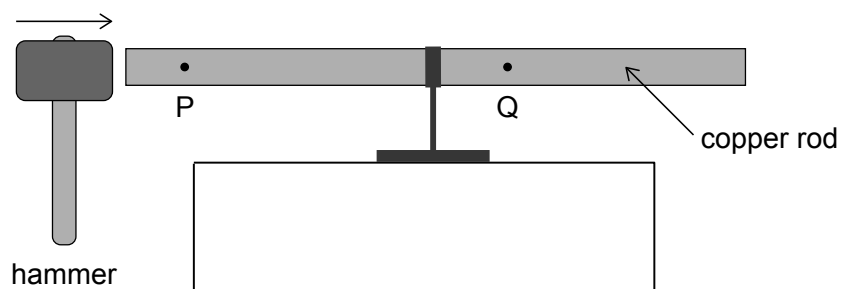
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- (d) A copper rod is suspended at its centre, as shown. P and Q are the equilibrium positions of two copper atoms in the rod. When a hammer taps the left-hand end of the rod, the first harmonic sound standing wave is formed in the rod. The longitudinal standing wave in this rod is identical to a standing wave in a pipe with both ends open.

diagram not to scale



- (i) Explain, by reference to the principle of superposition, why a standing wave is set up in the pipe.

[2]

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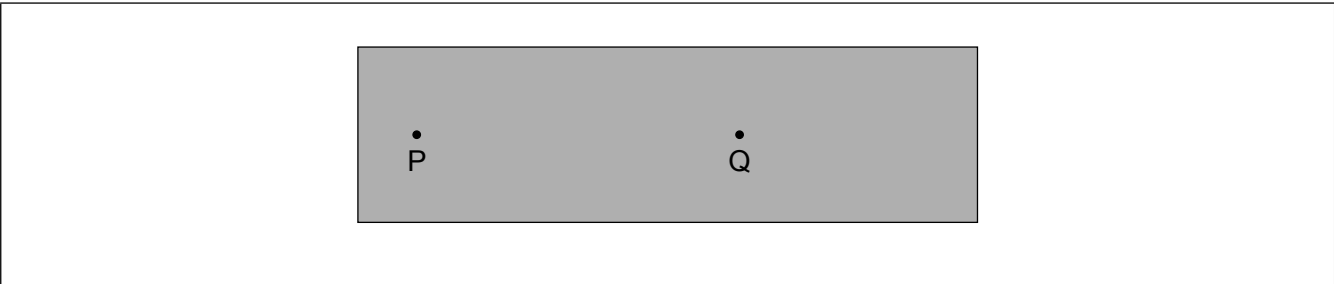
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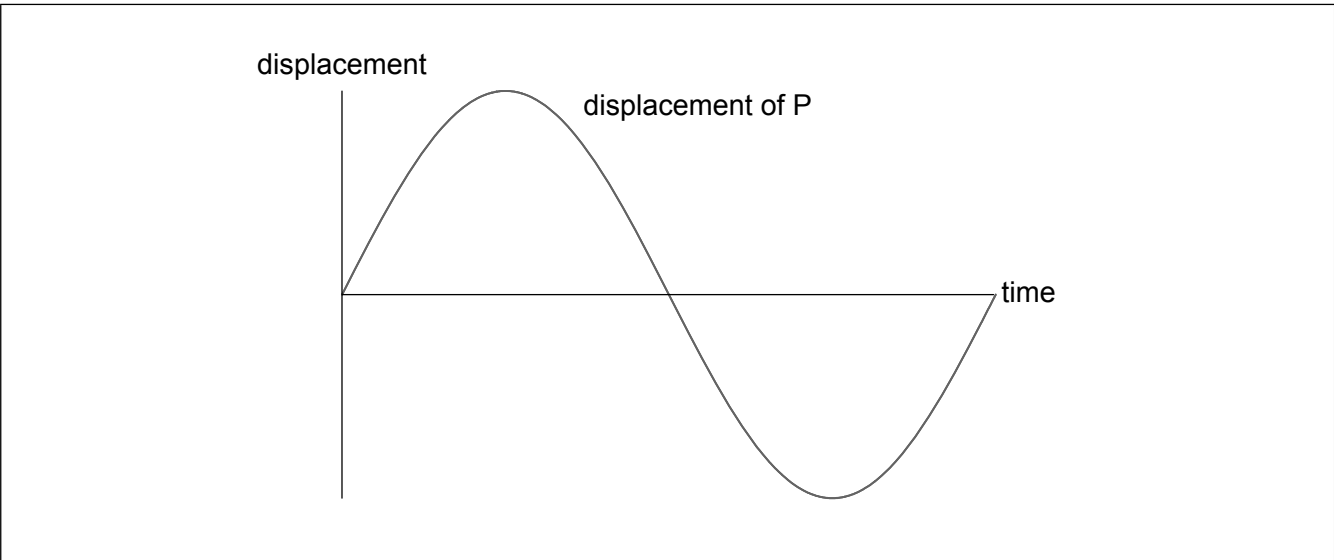
Turn over

(Question 9 continued)

- (ii) Draw, on the diagram, the standing wave in the rod. The width of the rod is shown larger to help with your drawing.
- [1]



- (iii) The graph shows the variation with time of the displacement of the atom at P. Draw, on the same axes, the variation with time of the displacement of the atom at Q.
- [2]

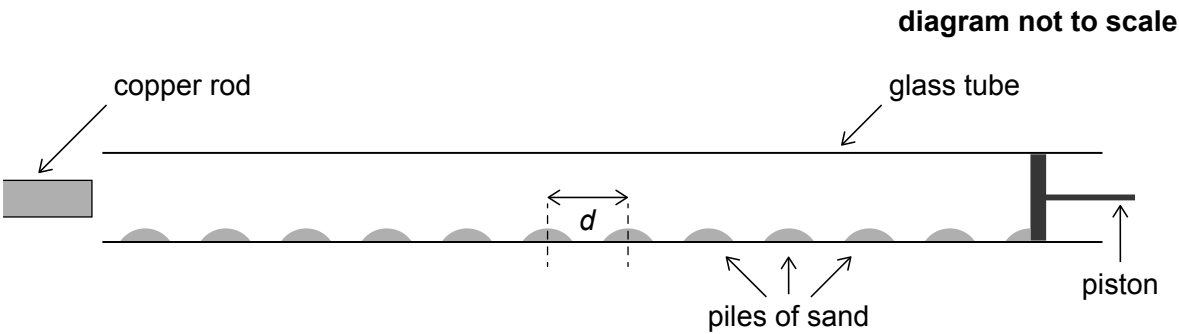


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(Question 9 continued)

- (e) The copper rod is brought close to a glass tube that contains light sand. When the left-hand end of the rod is tapped with a hammer and the length of the tube is adjusted by moving the piston, a standing wave is established in the tube. Sand collects in piles as shown. The distance between the centres of two consecutive piles of sand is d .



- (i) Outline why the sand collects in piles. [2]

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- (ii) The following data are available:

$$\begin{aligned}
 d &= 1.8 \text{ cm} \\
 \text{speed of sound in air} &= 330 \text{ m s}^{-1} \\
 \text{length of copper rod} &= 34 \text{ cm}
 \end{aligned}$$

Determine the speed of sound in copper. [4]

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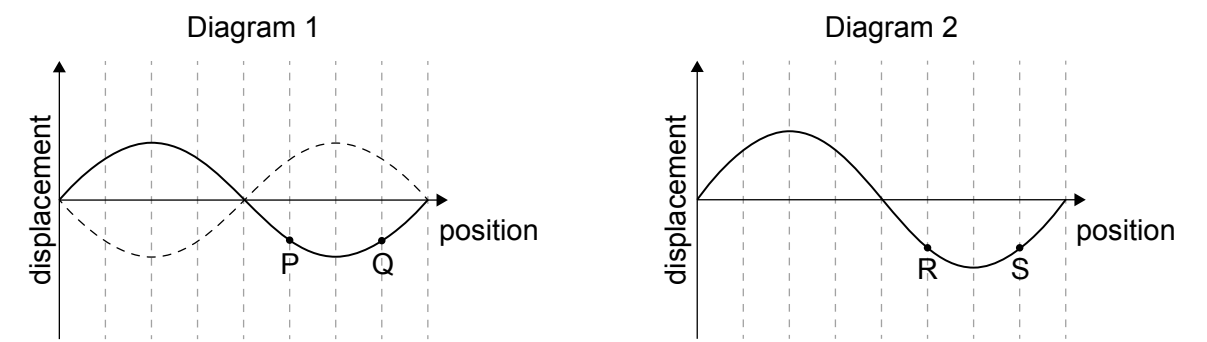


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0020-0121

20. Diagram 1 shows the variation with position of the displacement of a standing wave formed on a string.

Diagram 2 shows the variation with position of the displacement of a travelling wave moving to the right along a string.



Points P, Q, R and S are points on the string.

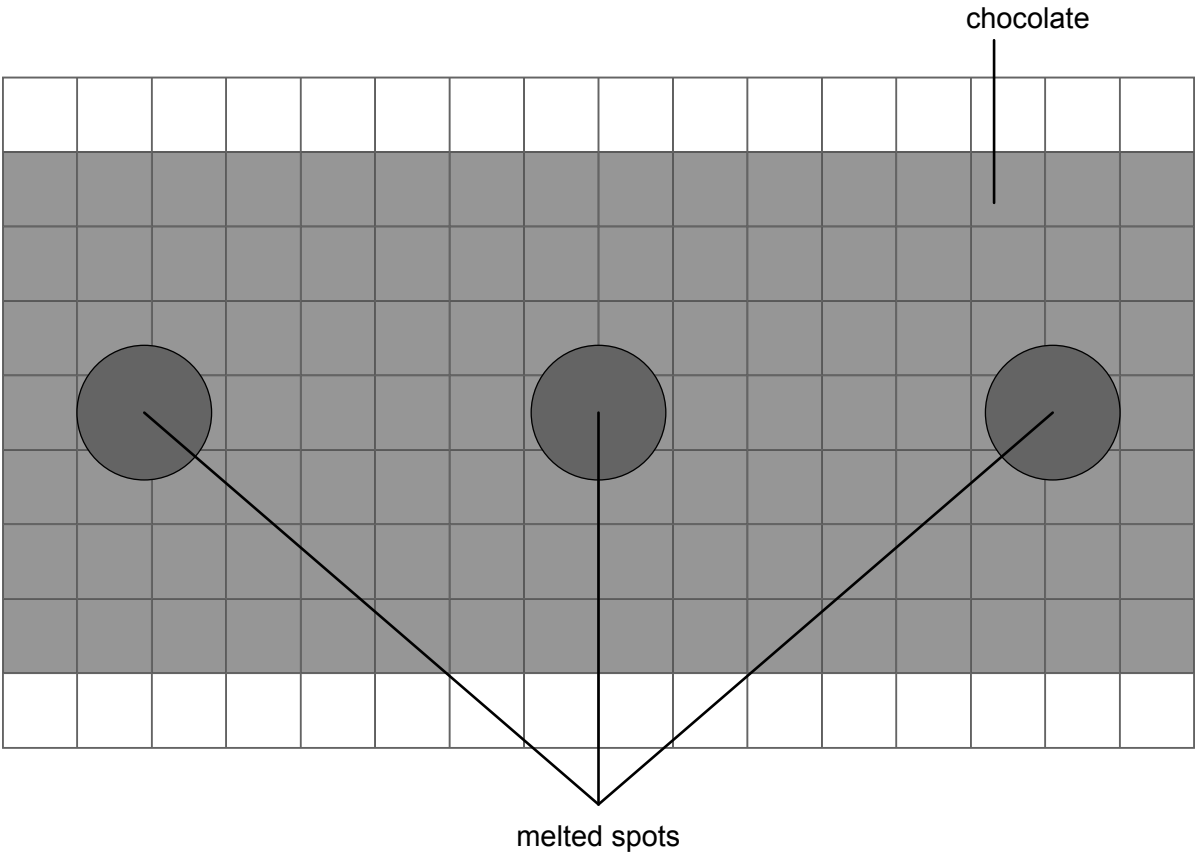
What is the phase difference between P and Q and the phase difference between R and S?

	Phase difference between P and Q	Phase difference between R and S
A.	0	0
B.	$\frac{\pi}{2}$	0
C.	0	$\frac{\pi}{2}$
D.	$\frac{\pi}{2}$	$\frac{\pi}{2}$

3. In a microwave oven electromagnetic waves are emitted so that a standing wave pattern is established inside the oven.

A flat piece of chocolate is placed inside the oven and the microwaves are switched on. The chocolate is stationary.

Melted spots form on the surface of the chocolate. The diagram shows the pattern of melting on the chocolate. Each square has a length of 1 cm.



(a) Outline how this standing wave pattern of melted spots is formed. [2]

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(Question 3 continued)

- (b) Determine, taking appropriate measurements from the diagram, the frequency of the electromagnetic waves in the oven.
- [3]



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