8. Superposition

8.1 Stationary waves

Paper 1

Question Paper

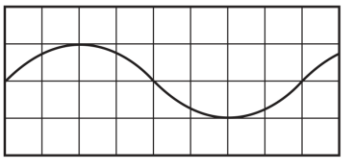
1 A stationary sound wave is set up between a loudspeaker and a wall.

A microphone is connected to a cathode-ray oscilloscope (CRO) and is moved along a line directly between the loudspeaker and the wall. The amplitude of the trace on the CRO rises to a maximum at a position X, falls to a minimum and then rises once again to a maximum at a position Y.

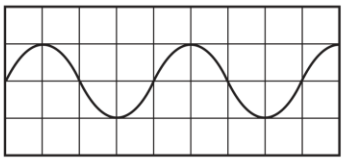
The distance between X and Y is 33 cm. The speed of sound in air is 330 m s^{-1}.

Which diagram could represent the CRO trace of the sound received at X?

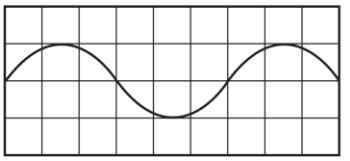
A



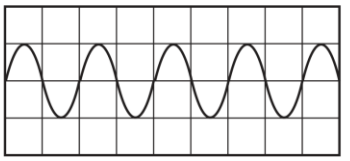
B



C



D



2 A stationary sound wave is formed in the air column inside a tube that is open at both ends.

The stationary wave has three nodes.

How many antinodes does it have?

A 1 **B** 2 **C** 3 **D** 4

3 What happens when two waves superpose at a point?

A Their amplitudes are added together.

B Their displacements are added together.

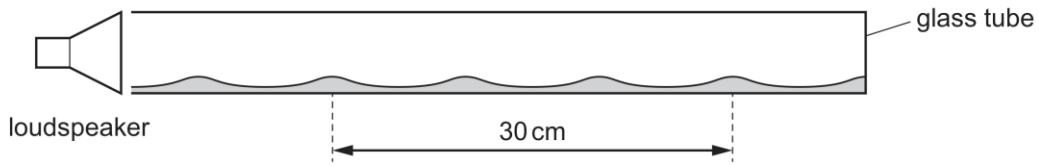
C Their frequencies are added together.

D Their velocities are added together.

4 A horizontal glass tube, closed at one end, has a layer of dust laid inside it on its lower side. Sound is emitted from a loudspeaker that is placed near the open end of the tube.

The frequency of the sound is varied and, at one frequency, a stationary wave is formed inside the tube so that the dust forms small heaps.

The distance between four heaps of dust is 30 cm.



The speed of sound in the air in the tube is 330 m s^{-1}.

What is the frequency of the sound emitted by the loudspeaker?

A 1650 Hz **B** 2200 Hz **C** 3300 Hz **D** 6600 Hz

5 Two progressive waves meet at a point.

Which condition must be met for superposition of the waves to occur?

A The waves must be coherent.

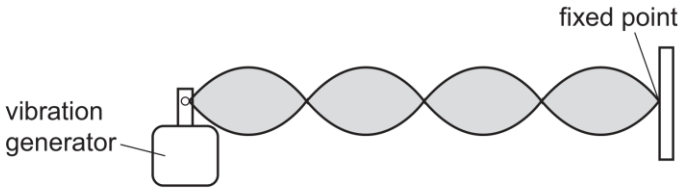
B The waves must be of the same type.

C The waves must be travelling in opposite directions.

D The waves must meet in phase.

6 A string is stretched between a vibration generator and a fixed point.

When the vibration generator is vibrating at a frequency *f*, a stationary wave with five nodes is created on the stretched string, as shown. There is a node at the end of the string that is attached to the vibration generator.



The frequency of vibration of the vibration generator is slowly increased.

What is the next frequency that produces a stationary wave on the string?

A 1.25*f* **B** 1.50*f* **C** 1.75*f* **D** 2.00*f*

7 A stationary wave is formed by two progressive waves travelling in opposite directions along the same line of travel.

Which statement about the two progressive waves is **not** correct?

A They must have a constant phase difference.

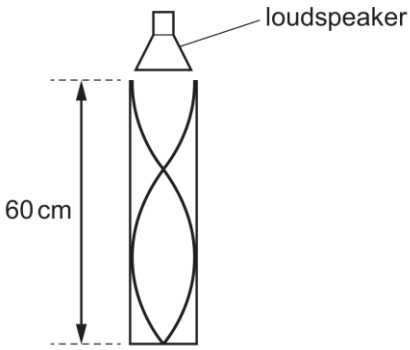
B They must have the same frequency.

C They must have the same wavelength.

D They must travel at the same speed.

8 The sound from a loudspeaker placed above a tube causes resonance of the air in the tube.

A stationary wave is formed with two nodes and two antinodes, as shown.



The tube has height 60 cm.

The speed of sound in the air is 340 m s^{-1}.

What is the frequency of the sound?

A 430 Hz **B** 570 Hz **C** 850 Hz **D** 1700 Hz

9 In an experiment, a stationary wave is formed on a string stretched horizontally between two fixed points.

Which statement about the experiment is correct?

A At certain times, the string between two nodes is horizontal with all points having zero displacement.

B Each point on the string between two antinodes has an oscillation of the same amplitude.

C The number of nodes is equal to the number of antinodes.

D Two adjacent antinodes oscillate in phase.

10 A musical organ produces notes by blowing air into a set of pipes that are open at one end and closed at the other.

The speed of sound in the air in the pipes is $320\,m\,s^{-1}$.

What is the lowest frequency of sound produced by a pipe of length 10 m?

A 4 Hz **B** 8 Hz **C** 16 Hz **D** 32 Hz

11 What can explain how stationary waves are formed from progressive waves?

A diffraction

B polarisation

C superposition

D the Doppler effect

12 A pipe has a length of 2.0 m. It is open at one end and closed at the other end.

A stationary sound wave is set up within the pipe. There are four nodes (N) and four antinodes (A) within the length of the pipe.



What is the wavelength of the sound wave?

A 0.57 m **B** 1.1 m **C** 1.3 m **D** 1.6 m

13 A stationary wave is set up on a string that is stretched between two fixed points that are 48 cm apart.

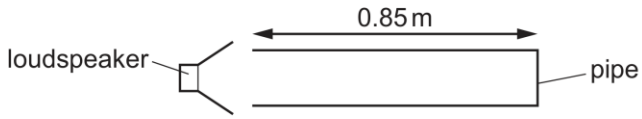
At one instant, the appearance of the string is as shown.



What is the wavelength of the stationary wave?

A 16 cm **B** 32 cm **C** 48 cm **D** 72 cm

14 A pipe, closed at one end, has a loudspeaker at the open end. For some frequencies of sound from the loudspeaker, a stationary sound wave is formed in the air within the pipe with an antinode at the open end of the pipe.



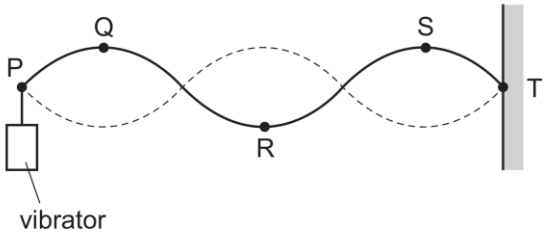
The length of the pipe is 0.85 m.

The speed of sound in air is 340 m s^{-1}.

Which frequency of sound from the loudspeaker would **not** produce a stationary wave?

A 100 Hz **B** 200 Hz **C** 300 Hz **D** 500 Hz

15 A stationary wave on a stretched string is set up between two points P and T.



Which statement about the stationary wave is correct?

A Point R is at a node.

B Points Q and S vibrate in phase.

C The distance between P and T is three wavelengths.

D The wave transfers energy from P to T.

16 Two waves of the same type overlap.

When does the principle of superposition apply?

A always

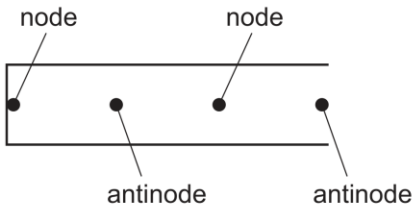
B only when the waves have the same amplitude

C only when the waves have the same frequency

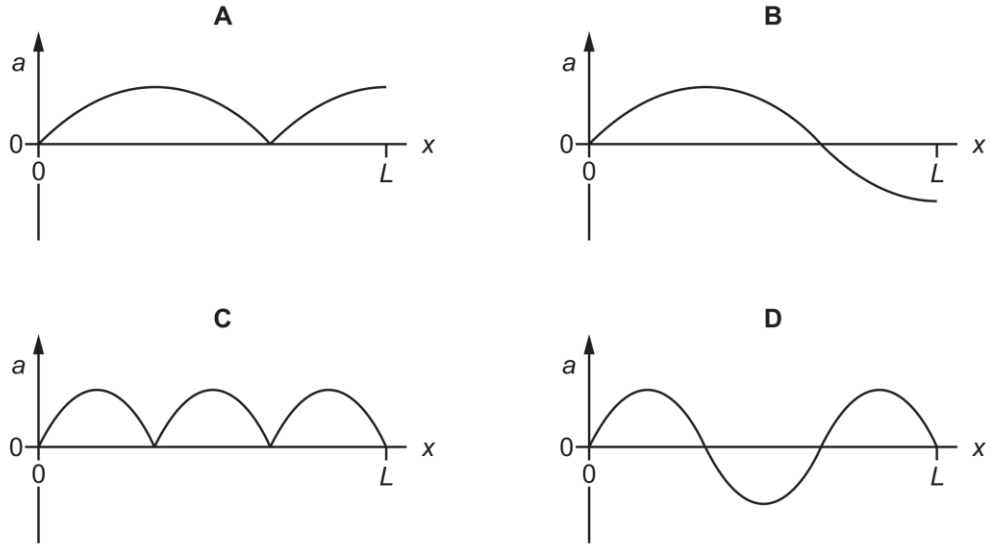
D only when the waves travel in opposite directions

17 A stationary sound wave is formed in a tube of length *L* that is closed at one end.

The diagram shows the positions of the nodes and antinodes of the stationary wave.



Which graph shows the variation of the amplitude *a* of the wave with distance *x* measured from the closed end of the tube?



18 The wavelength of sound in air may be determined by using stationary waves.

In one experiment, a loudspeaker produces a sound wave of constant frequency which is reflected directly back along its original path by a metal plate approximately 1 m away. A microphone connected to a cathode-ray oscilloscope (CRO) is moved between the loudspeaker and plate to identify regions of high sound intensity ('loud' spots) and low sound intensity ('quiet' spots).

The wavelength of the sound is determined using the **least** possible number of measured quantities.

Which row shows the quantities that are needed?

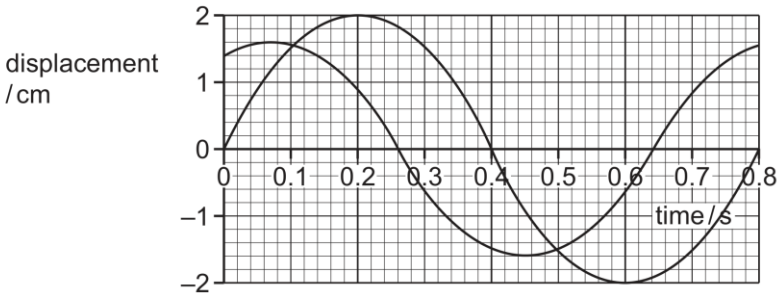
	frequency of sound	mean separation of 'quiet' spots	speed of sound in air
A	✓	✓	✗
B	✓	✗	✓
C	✓	✗	✗
D	✗	✓	✗

key

✓ = needed

✗ = not needed

19 Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown.



The two waves superpose at point P.

What is the resultant displacement at time 0.38 s?

A +1.0 cm **B** –1.0 cm **C** +1.8 cm **D** –1.8 cm

20 A stationary wave is formed from two identical sound waves.

A microphone is placed at a position of maximum loudness. It is then moved along the stationary wave from this first position of maximum loudness to the fourth position of maximum loudness. The microphone moves a distance of 12 cm.

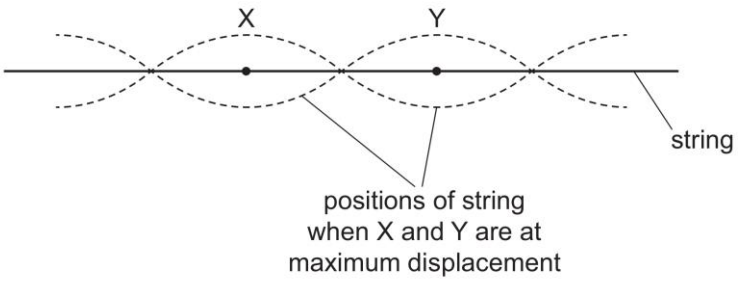
The speed of sound is 330 m s^{-1}.

What is the frequency of the sound waves?

A 4100 Hz **B** 5500 Hz **C** 8300 Hz **D** 11 000 Hz

21 The diagram shows part of a stationary wave on a string.

X and Y are points on the string. The vibrations at X and Y are 180° out of phase.



What is the distance between X and Y?

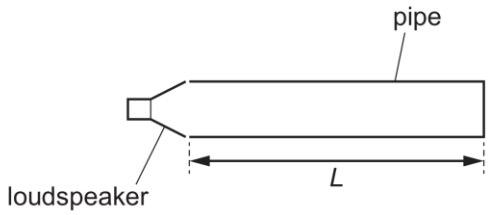
A one-quarter of a wavelength

B half a wavelength

C one wavelength

D two wavelengths

22 A pipe of length L is open at one end and closed at the other end. A loudspeaker is at the open end and emits a sound wave into the pipe.

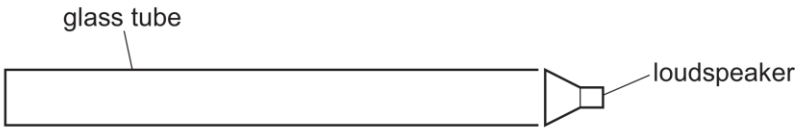


When a stationary wave is formed, there is an antinode at the open end of the pipe.

Which wavelength of sound could be used to produce a stationary wave?

A $\frac{2L}{3}$ **B** L **C** $\frac{4L}{3}$ **D** $2L$

23 A glass tube is closed at one end and has a loudspeaker at the other end.



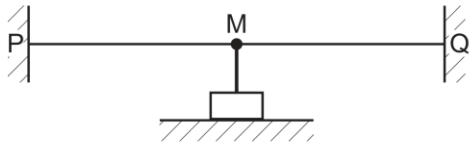
A stationary wave is formed with a node at the closed end of the tube when the sound has frequency f_0. There are no other nodes.

The frequency of the sound is then slowly increased.

What is the frequency of the sound that produces the next stationary wave?

A $1.25f_0$ **B** $1.50f_0$ **C** $2.00f_0$ **D** $3.00f_0$

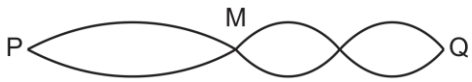
24 A string is fixed between point P and an oscillator M. Another string is fixed between M and point Q. M is midway between P and Q.



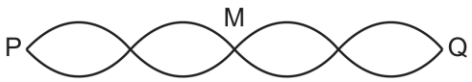
The frequency of the oscillator is adjusted until a stationary wave is formed on both strings. The speed of the wave between P and M is twice the speed of the wave between M and Q.

Which diagram could represent the stationary wave pattern?

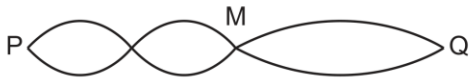
A



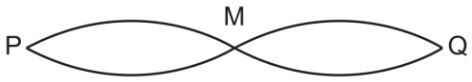
B



C

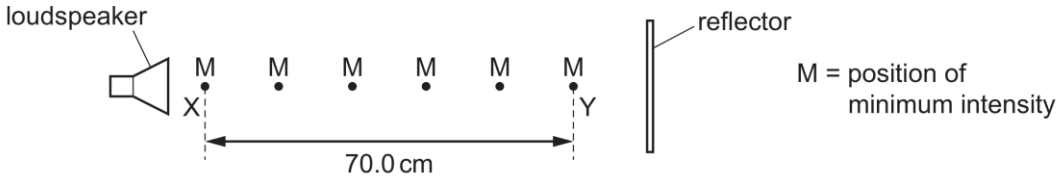


D



25 A sound wave from a loudspeaker is reflected back along its original path by a reflector.

A microphone is initially at point X where the sound intensity is a minimum, as shown.

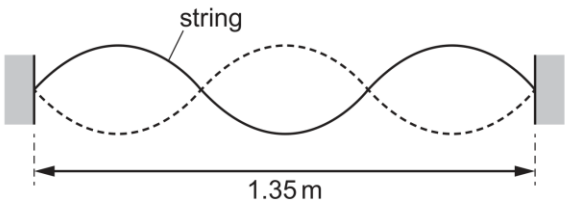


The microphone is moved towards the reflector and passes through four more intensity minima until reaching a fifth minimum at point Y. The distance XY is 70.0 cm.

What is the wavelength of the sound?

A 11.7 cm **B** 14.0 cm **C** 23.3 cm **D** 28.0 cm

26 A stationary wave is produced on a string that is stretched between two fixed points that are a distance of 1.35 m apart, as shown.



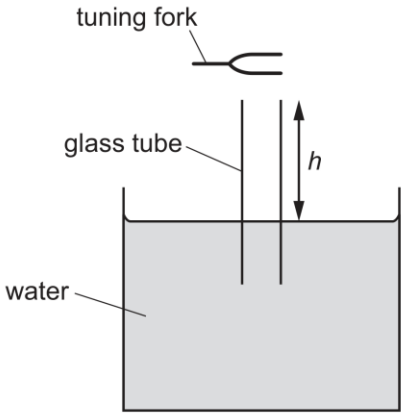
The speed of the waves on the string is 450 m s^{-1}.

What is the frequency of oscillation of the stationary wave?

A 333 Hz **B** 405 Hz **C** 500 Hz **D** 1000 Hz

27 A long glass tube is almost completely immersed in a large tank of water. A tuning fork is struck and held just above the open end of the tube as it is slowly raised.

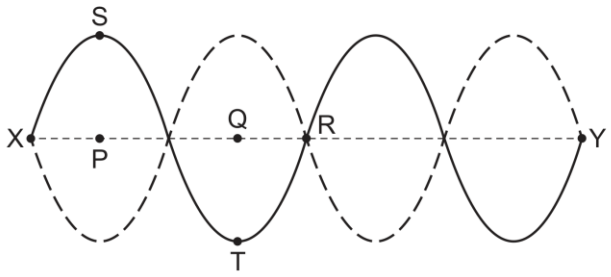
A louder sound is first heard when the height *h* of the end of the tube above the water is 18.8 cm. A louder sound is next heard when *h* is 56.4 cm. The speed of sound in air is 330 m s^{-1}.



What is the frequency of the sound produced by the tuning fork?

A 220 Hz **B** 440 Hz **C** 660 Hz **D** 880 Hz

28 The diagram shows a string stretched between fixed points X and Y. There is a stationary wave on the string.



The solid curve shows the string at a position of maximum displacement. The dashed curve shows the other position of maximum displacement. The straight central dashed line shows the mean position of the string. Point S on the string is directly above point P. Point T on the string is directly below Q.

Which statement is correct?

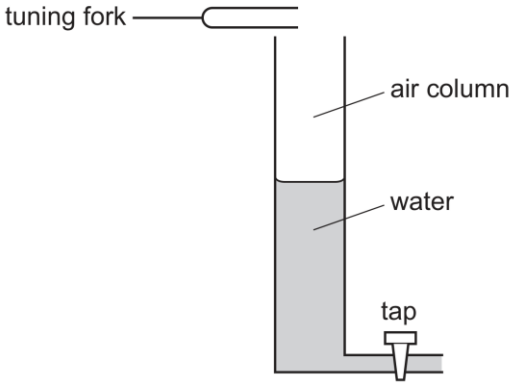
A A short time later, point R on the string will be displaced.

B Points S and T on the string move in opposite directions.

C The distance between P and Q is one wavelength.

D Two points on the string that are equal distances from point R vibrate in phase.

29 The diagram shows an experiment to produce a stationary wave in an air column. A tuning fork, placed above the column, vibrates and produces a sound wave. The length of the air column can be varied by altering the volume of the water in the tube.

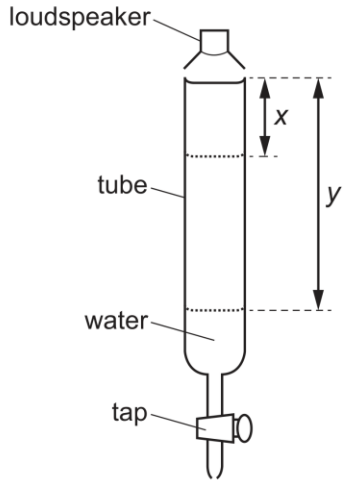


The tube is filled and then water is allowed to run out of it. The first two stationary waves occur when the air column lengths are 0.14 m and 0.42 m.

What is the wavelength of the sound wave?

A 0.14 m **B** 0.28 m **C** 0.42 m **D** 0.56 m

30 A loudspeaker emits a sound wave into a tube initially full of water.



A tap at the bottom of the tube is opened so that water slowly leaves the tube. For some lengths of the air column in the tube, the sound heard is much louder.

The first loud sound is heard when the air column in the tube has length x.

The next time that a loud sound is heard is when the air column in the tube has length y.

What is the wavelength of the sound wave from the loudspeaker?

A $2x$ **B** $4y$ **C** $2(y - x)$ **D** $4(y - x)$

31 Which statement concerning a stationary wave is correct?

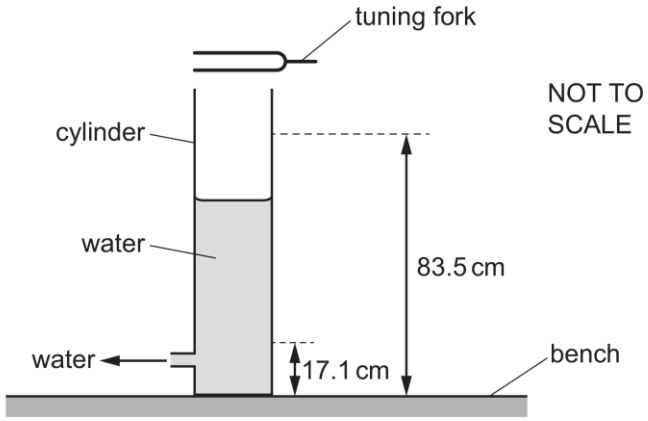
A All the particles between two adjacent nodes oscillate in phase.

B The amplitude of the stationary wave is equal to the amplitude of one of the waves creating it.

C The wavelength of the stationary wave is equal to the separation of two adjacent nodes.

D There is no displacement of a particle at an antinode at any time.

32 A vibrating tuning fork is held above a glass cylinder filled to the top with water. The water level is steadily lowered. A loud sound is first heard when the water level is 83.5 cm above the bench. The next loud sound is heard when the water level is 17.1 cm above the bench.



The speed of sound in air is 340 m s^{-1}.

What is the frequency of the tuning fork?

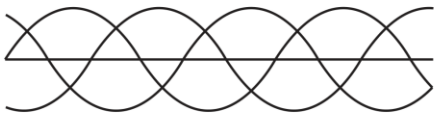
A 128 Hz **B** 256 Hz **C** 384 Hz **D** 512 Hz

33 The three waves shown in each diagram have the same amplitude and frequency but different phase.

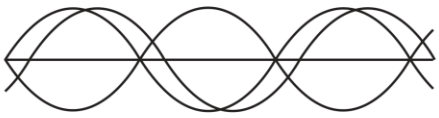
They are added together to give a resultant wave.

In which case is the resultant wave zero at this instant?

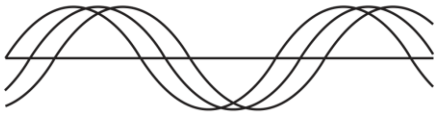
A



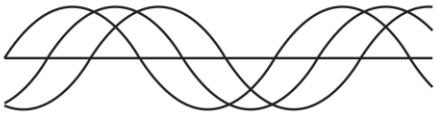
B



C

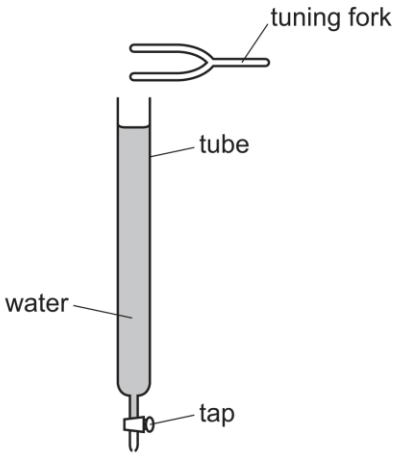


D



34 A long tube, filled with water, has a tap fitted at its base, as shown.

A tuning fork is sounded above the tube and the water is allowed to run gradually out of the tube.



A louder sound is heard at intervals as the water runs out of the tube. The change in water level between louder sounds is 32 cm.

What is the wavelength of the sound in the tube?

A 16 cm **B** 32 cm **C** 64 cm **D** 128 cm

35 Two progressive waves of frequency 300 Hz superpose to produce a stationary wave in which adjacent nodes are 1.5 m apart.

What is the speed of the progressive waves?

A $100\,m\,s^{-1}$ **B** $200\,m\,s^{-1}$ **C** $450\,m\,s^{-1}$ **D** $900\,m\,s^{-1}$

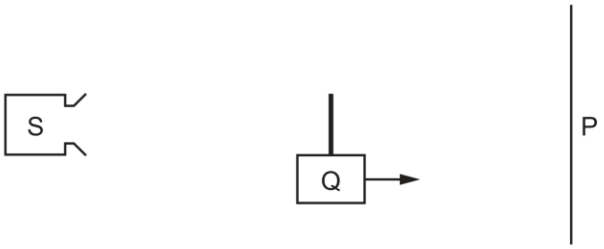
36 In an experiment to determine the wavelength of sound in air, a stationary wave is set up in an air column.

The distance between a node and an adjacent antinode is L.

What is the wavelength of the sound?

A $\frac{1}{2}L$ **B** L **C** $2L$ **D** $4L$

37 Source S emits microwaves with a constant amplitude. The microwaves hit a metal screen P and are reflected. A stationary wave is formed between S and P. The wavelength of the microwaves is much smaller than the distance between S and P.



A detector Q is moved at a slow, constant speed from S to P.

What happens to the amplitude of the signal detected by Q?

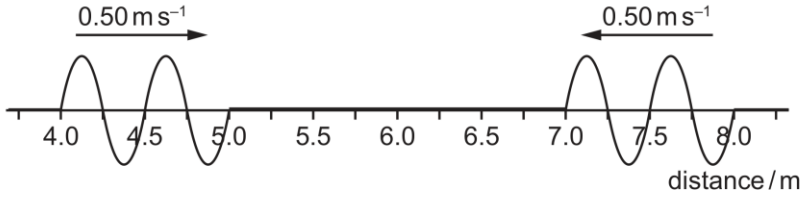
A decreases steadily

B increases and decreases regularly

C increases steadily

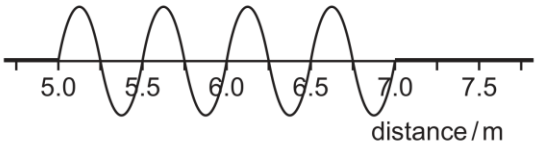
D remains constant

38 Two wave pulses are travelling towards each other on a long rope. The pulses have the same amplitude and wavelength and are travelling at a speed of 0.50 m s^{-1}. The diagram shows the rope at time t = 0.

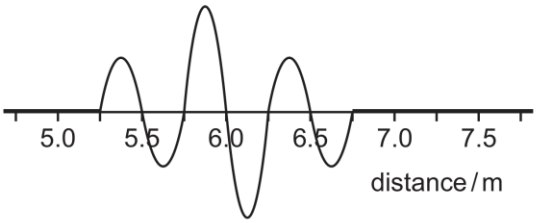


Which diagram shows the rope at time t = 3.0 s?

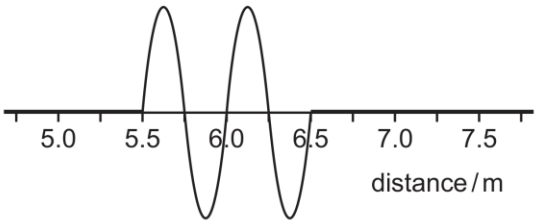
A



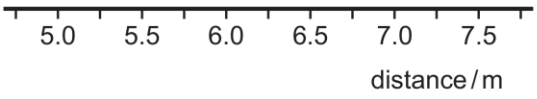
B



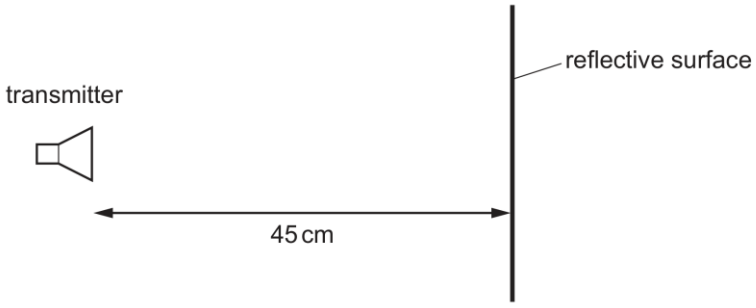
C



D



39 A transmitter of electromagnetic waves is placed 45 cm from a reflective surface.

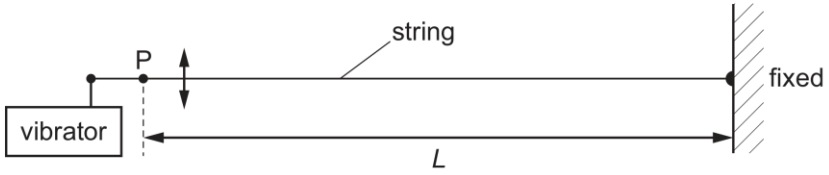


The emitted waves have a frequency of 1.00 GHz. A stationary wave is produced with a node at the transmitter and a node at the surface.

How many antinodes are in the space between the transmitter and the surface?

A 1 **B** 2 **C** 3 **D** 4

40 A string is fixed at one end and the other end is attached to a vibrator. The frequency of the vibrator is slowly increased from zero. A series of stationary waves is formed. Assume that for a stationary wave there is a node at point P.



What are the first five wavelengths of the stationary waves that could be formed?

A $2\frac{L}{1}, 2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}$

B $2\frac{L}{2}, 2\frac{L}{3}, 2\frac{L}{4}, 2\frac{L}{5}, 2\frac{L}{6}$

C $4\frac{L}{1}, 4\frac{L}{2}, 4\frac{L}{3}, 4\frac{L}{4}, 4\frac{L}{5}$

D $4\frac{L}{1}, 4\frac{L}{3}, 4\frac{L}{5}, 4\frac{L}{7}, 4\frac{L}{9}$

41 The diagram shows apparatus for the measurement of the frequency of a sound wave.



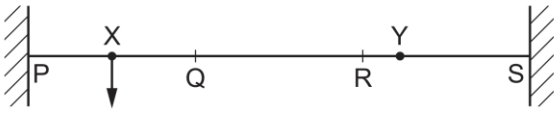
Sound of the unknown frequency is reflected back from a metal plate. A microphone placed at a distance D from the metal plate detects the sound intensity. A minimum intensity is detected with D = 12.0 cm. The plate is moved further away from the microphone until the next minimum is detected with D = 15.0 cm.

The speed of sound in air is 336 m s^{-1}.

What is the frequency of the sound?

A 56 Hz **B** 112 Hz **C** 5600 Hz **D** 11 200 Hz

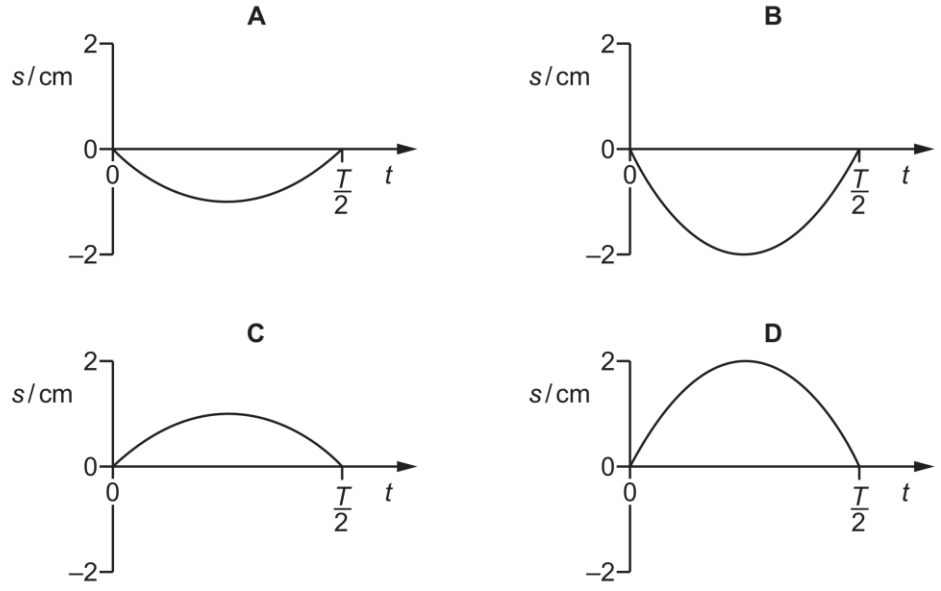
42 The diagram shows a stationary wave, at time t = 0, that has been set up on a string fixed between points P and S.



The nodes of the stationary wave occur on the string at P, Q, R and S. Point X is moving down at time t = 0. The points on the string vibrate with time period T and maximum amplitude 2 cm.

The displacement s is positive in the upward direction.

Which graph best shows the variation with t of the displacement s of point Y on the string?



43 What may be used to produce stationary waves?

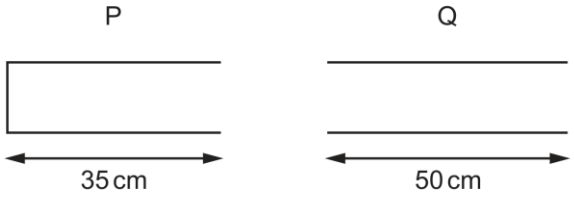
A blowing air over the top of an empty bottle

B making a loud sound near a mountain

C passing monochromatic light through a double slit

D passing water waves through a narrow slit

44 Progressive sound waves of wavelength 20 cm enter the air columns in a closed pipe P and an open pipe Q. The lengths of the pipes are shown.



In which pipe or pipes are stationary waves formed?

A P and Q

B P only

C Q only

D neither P nor Q