7. Waves

7.1 Progressive waves

Paper 1

Question Paper

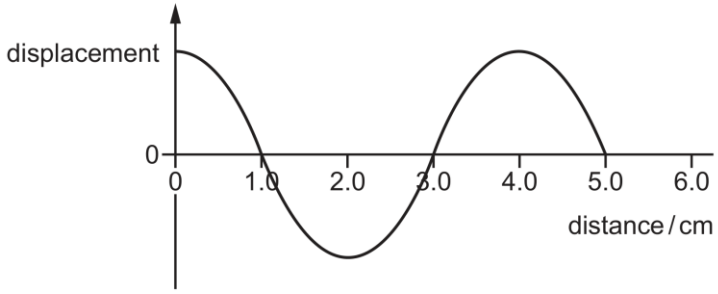
1 A plane wave of amplitude A is incident on a surface of area S placed so that it is perpendicular to the direction of travel of the wave. The energy per unit time reaching the surface is E.

The amplitude of the wave is increased to $2A$ and the area of the surface is reduced to $\frac{1}{2}S$.

How much energy per unit time reaches this smaller surface?

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

2 The graph shows the variation of the displacement with distance for a progressive wave at one instant in time.



The period of the wave is 91 ms.

What can be determined about the wave?

A It has a velocity of 0.44 m s^{-1} and a frequency of 11 Hz.

B It has a velocity of 0.55 m s^{-1} and a wavelength of 5.0 cm.

C It is longitudinal and has a frequency of 11 Hz.

D It is transverse and has a wavelength of 4.0 cm.

3 A wave has a frequency of 5 GHz.

What is the period of the wave?

A 200 ps **B** 2 ns **C** 20 ns **D** 20 000 μs

4 Waves P and Q have the same amplitude. The waves meet in phase at point X and interfere to give a resultant wave with intensity I.

The amplitude of wave P is doubled.

What is the new intensity of the resultant wave at X, in terms of I?

A $0.44I$ **B** $1.5I$ **C** $2.3I$ **D** $3.0I$

5 What could describe the time-base of a cathode-ray oscilloscope (CRO)?

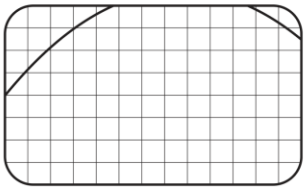
A the frequency per division on the screen

B the number of divisions on the screen per unit frequency

C the number of divisions on the screen per unit time

D the time per division on the screen

6 In an experiment, a student uses a microphone and a cathode-ray oscilloscope (CRO) to analyse a sound wave. The diagram shows the trace on the screen of the CRO.

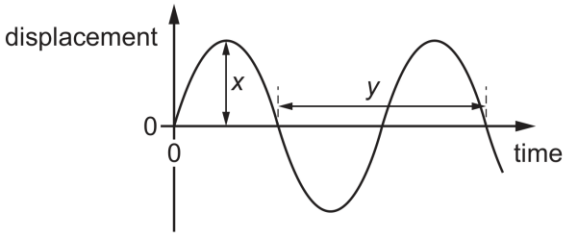


The student is expecting a sinusoidal waveform to be shown on the screen.

Which changes should the student make to the time-base and the *y*-gain of the CRO so that the screen shows a continuous trace for one complete cycle of the waveform?

	time-base	*y*-gain
A	decrease	decrease
B	decrease	increase
C	increase	decrease
D	increase	increase

7 The graph shows the variation with time of the displacement of a particle in a progressive wave.



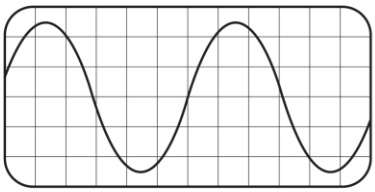
Two measurements, *x* and *y*, are labelled on the graph.

What do *x* and *y* represent?

	x	*y*
A	amplitude	period
B	frequency	period
C	amplitude	wavelength
D	frequency	wavelength

8 A microphone detects a sound wave. The microphone is connected to a cathode-ray oscilloscope (CRO).

The shape of the trace on the screen of the CRO is shown.



Which property of the sound wave can be determined by using only the measurement of a horizontal distance on the screen and the value of a control setting of the CRO?

A amplitude

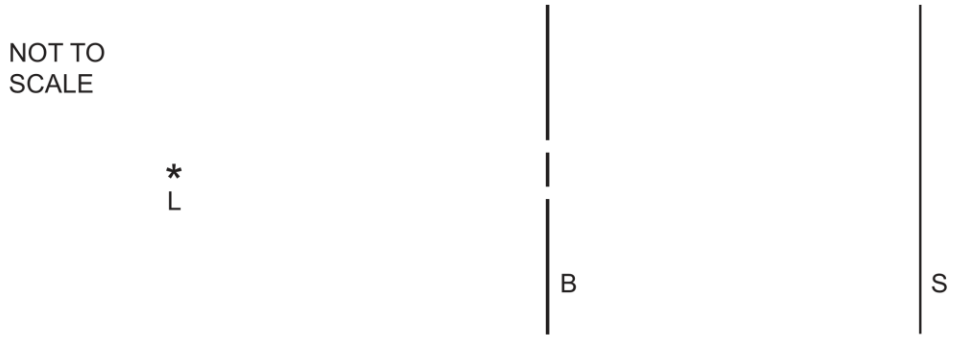
B frequency

C speed

D wavelength

9 The diagram shows a view from above of a double-slit interference demonstration.

L is a monochromatic light source with a vertical filament. B is a barrier with two narrow vertical slits and S is a screen upon which interference fringes form.

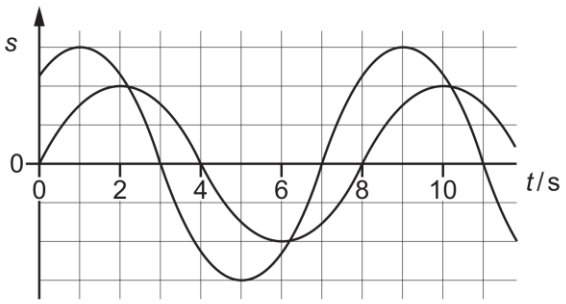


The intensity is I at the point on the screen where the centre of the fringe pattern forms.

When one of the slits is covered, what is the intensity at the same point on the screen?

A $\frac{I}{\sqrt{2}}$ **B** $\frac{I}{2}$ **C** $\frac{I}{2\sqrt{2}}$ **D** $\frac{I}{4}$

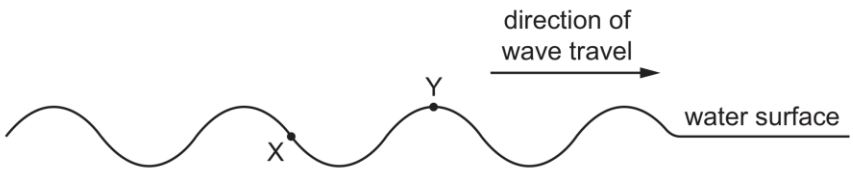
10 Two waves pass through a point P. The graph shows the variation with time t of the displacement s of the two waves at point P.



What is the phase difference between the two waves at point P?

A 0° **B** 45° **C** 90° **D** 180°

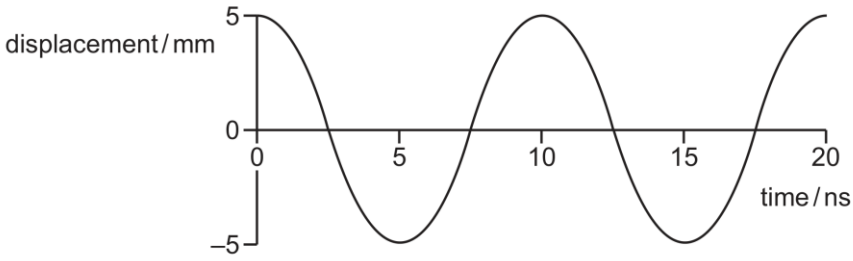
11 X and Y are two points on the surface of water in a ripple tank. A source of constant frequency generates a wave which travels past X and Y, causing them to oscillate vertically.



What is the phase difference between X and Y?

A 45° **B** 135° **C** 180° **D** 270°

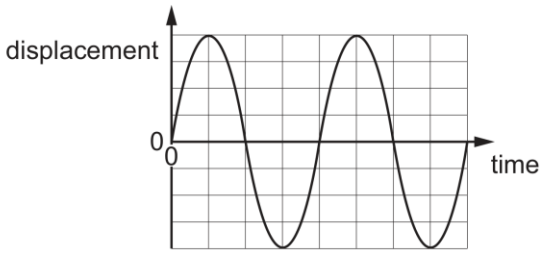
12 The graph shows the variation with time of the displacement of a particle as a progressive wave passes.



What are the frequency and the amplitude of the wave?

	frequency / MHz	amplitude / mm
A	100	5
B	200	5
C	100	10
D	200	10

13 The graph shows the variation of the displacement of an air particle with time as a sound wave passes through air.

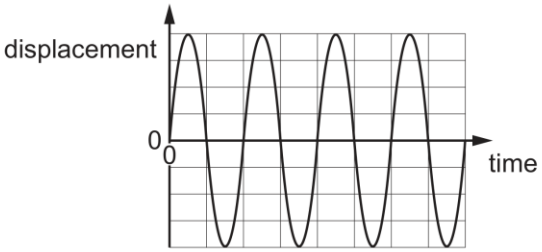


The intensity of the sound is halved while the frequency remains constant.

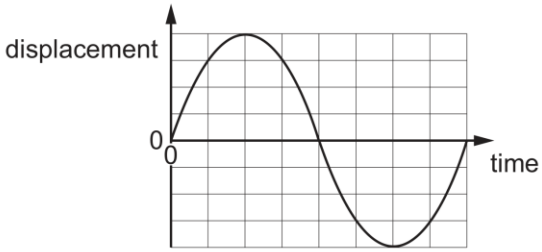
The four graphs below are drawn to the same scale as the graph above.

Which graph shows the displacement of the air particle?

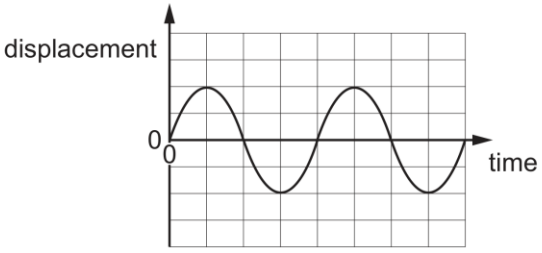
A



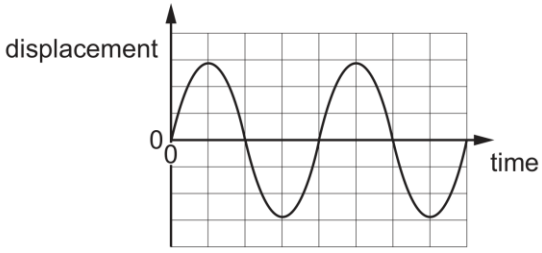
B



C



D



14 Which statement is correct for **all** types of progressive wave?

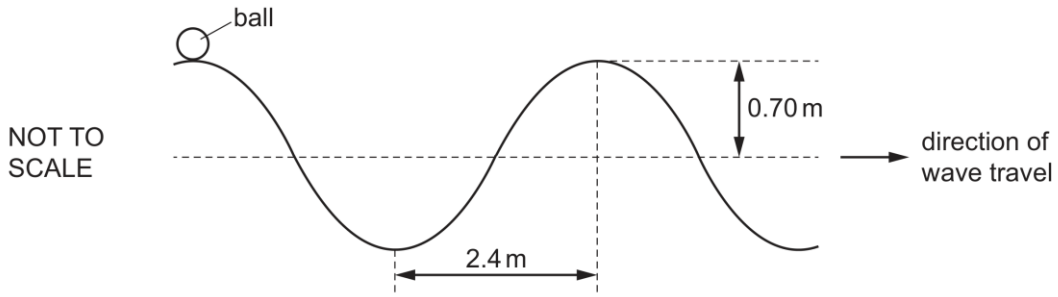
A The distance from a peak to the next trough is equal to a wavelength.

B They can be demonstrated in ripple tanks.

C They consist of vibrating atoms.

D They transfer energy from one position to another.

15 A transverse water wave is moving along the surface of some water. This causes a ball to move vertically without moving horizontally as it floats upon the surface. At one instant, the ball is at the position shown.



The wave has a frequency of 0.20 Hz and an amplitude of 0.70 m. The distance between a trough and an adjacent peak is 2.4 m.

What is the distance travelled by the ball in a time of 20 s?

A 5.6 m **B** 9.6 m **C** 11.2 m **D** 19.2 m

16 A signal generator, amplifier and loudspeaker are used to produce different sound waves in the air of a room. The relationships between the properties of these waves are investigated.

Which relationship is **not** correct?

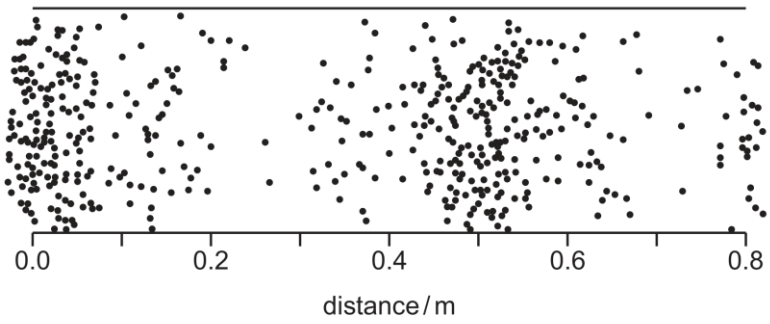
A Amplitude is proportional to wavelength.

B Frequency is inversely proportional to wavelength.

C Intensity is proportional to amplitude squared at a given frequency.

D Period is equal to the reciprocal of frequency.

17 When a guitar string is plucked, it causes a longitudinal sound wave in the air, as shown.

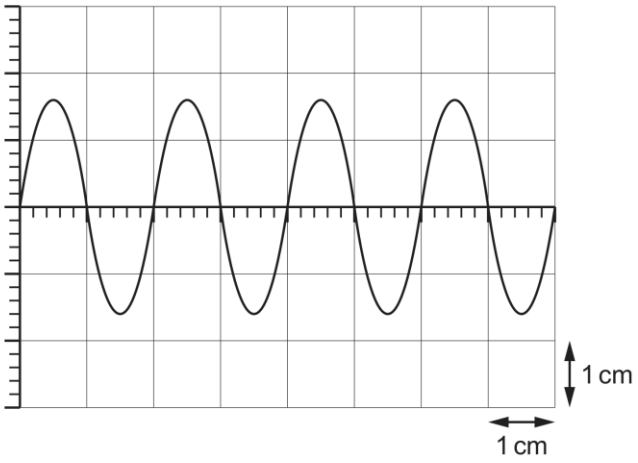


The speed of sound in the air is 340 m s^{-1}.

What is the approximate frequency of the sound wave shown?

A 430 Hz **B** 680 Hz **C** 1100 Hz **D** 1400 Hz

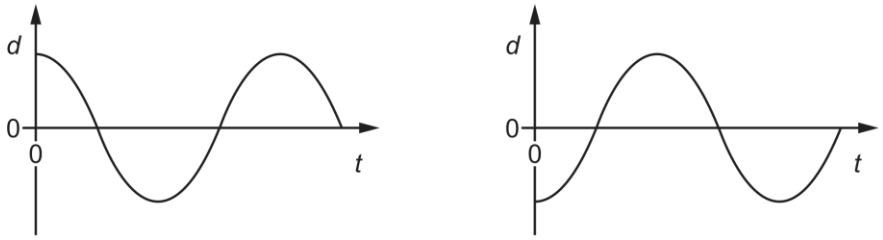
18 A signal of frequency 25 Hz is displayed on the screen of a cathode-ray oscilloscope.



What is the time-base setting?

A $10\,\text{ms}\,\text{cm}^{-1}$ **B** $20\,\text{ms}\,\text{cm}^{-1}$ **C** $25\,\text{ms}\,\text{cm}^{-1}$ **D** $40\,\text{ms}\,\text{cm}^{-1}$

19 Two particles in a progressive wave are a distance 10 cm apart. The two graphs show the variation with time *t* of the displacement *d* of the two particles.



What could be represented by the two graphs?

A particles in a longitudinal wave with a compression and the nearest rarefaction separated by 10 cm

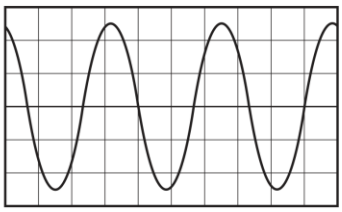
B particles in a longitudinal wave with a compression and the nearest rarefaction separated by 20 cm

C particles in a transverse wave with a peak and the nearest trough separated by 20 cm

D particles in a transverse wave with two adjacent peaks separated by 10 cm

20 A sound wave is detected by a microphone that is connected to a cathode-ray oscilloscope (CRO).

The screen of the CRO displays a waveform, as shown.



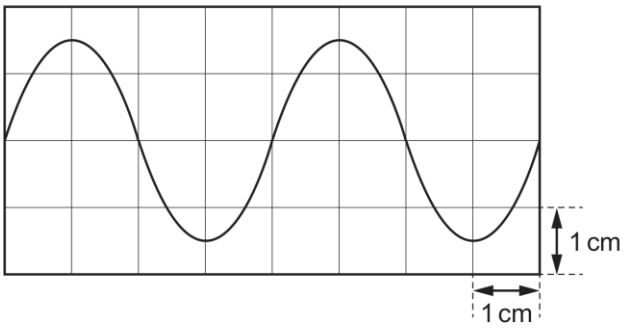
The time-base is set to 20 μs div^{-1}.

What is the frequency of the sound wave?

A 15 Hz **B** 15 000 Hz **C** 20 000 Hz **D** 30 000 Hz

21 A cathode-ray oscilloscope (CRO) is used to display a sound wave of frequency 2000 Hz.

The display of the CRO is shown.

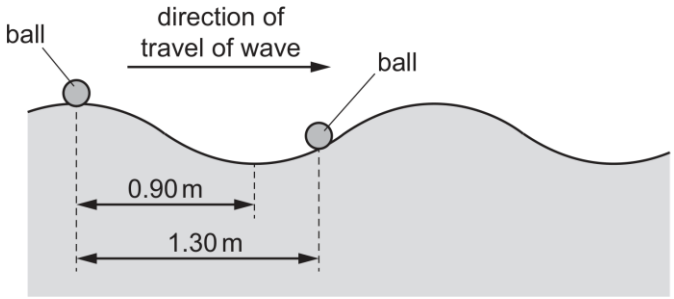


What is the time-base setting on the CRO?

A 125 μs cm^{-1} **B** 250 μs cm^{-1} **C** 500 μs cm^{-1} **D** 1000 μs cm^{-1}

22 Two balls float on the surface of the sea. The balls are separated by a distance of 1.30 m.

A wave travels on the surface of the sea so that the balls move vertically up and down.



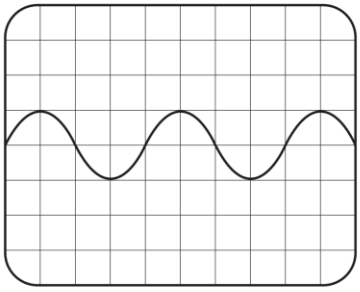
The distance between a crest and an adjacent trough of the wave is 0.90 m.

What is the phase difference between the two balls?

A 55° **B** 110° **C** 160° **D** 260°

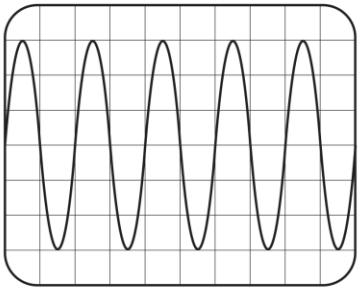
23 Four cathode-ray oscilloscope (CRO) screens each display a waveform. The screen and the time-base setting of each CRO is shown.

1



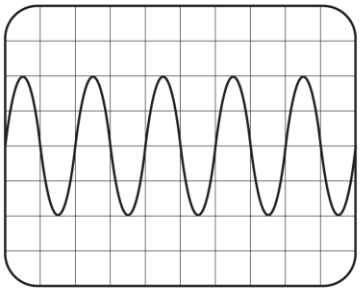
time-base setting: 0.02 s / div

2



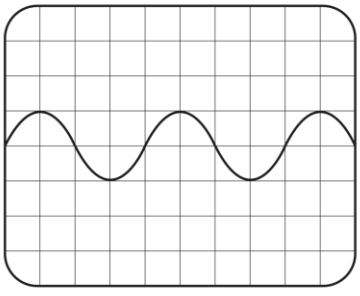
time-base setting: 0.04 s / div

3



time-base setting: 0.01 s / div

4

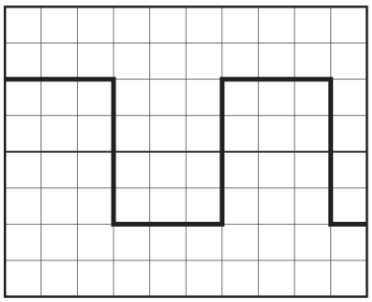


time-base setting: 0.08 s / div

Which screens show waveforms of the same frequency?

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

24 A cathode-ray oscilloscope displays a square wave, as shown.



The time-base setting is 0.20 ms per division.

What is the frequency of the square wave?

A 0.83 Hz **B** 830 Hz **C** 1300 Hz **D** 1700 Hz

25 A sound wave reduces in intensity but maintains a constant frequency as it travels through air.

Which statement is correct?

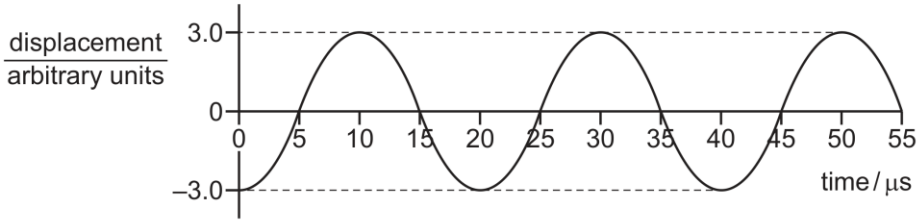
A The maximum displacement of the particles changes between one particle and the next particle.

B The phase difference between adjacent particles is zero.

C The wavelength is the distance between two particles that have a phase difference of 180°.

D Two particles that have a phase difference of 360° have the same maximum displacement.

26 The graph shows the variation with time of the displacement of an electromagnetic wave at a point.



The wave is travelling in a vacuum.

What is the amplitude and what is the wavelength of the wave?

	amplitude / arbitrary units	wavelength / m
A	3.0	6000
B	6.0	6000
C	3.0	7500
D	6.0	7500

27 A transverse wave is moving along a rope. Two points X and Y on the rope are a quarter of a wavelength apart from each other.

Which statement is **not** possible for the two points X and Y at any instant?

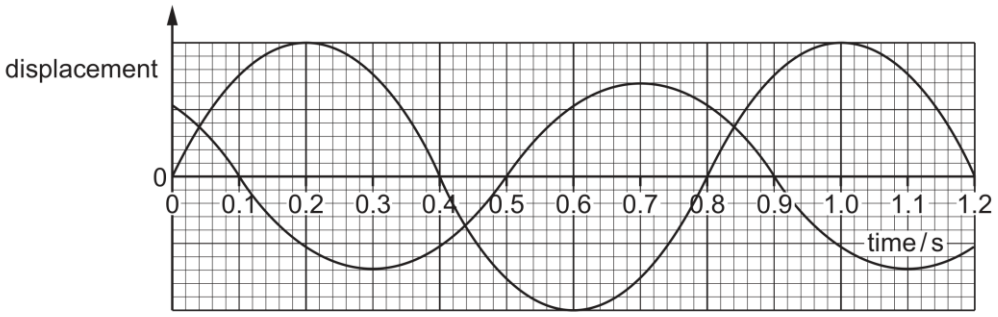
A They are both stationary.

B They are displaced in opposite directions from their equilibrium position.

C They are moving in opposite directions.

D They both have displacements of the same magnitude from their equilibrium positions.

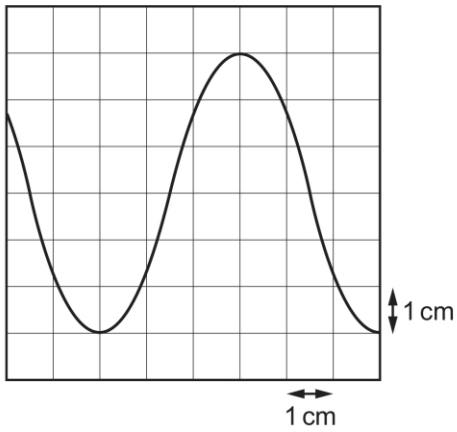
28 Two progressive waves meet at a fixed point P. The variation with time of the displacement of each wave at point P is shown in the graph.



What is the phase difference between the two waves at point P?

A 45° **B** 90° **C** 135° **D** 180°

29 A microphone connected to the Y-plates of a cathode-ray oscilloscope (CRO) is placed in front of a loudspeaker. The trace on the screen of the CRO is shown.

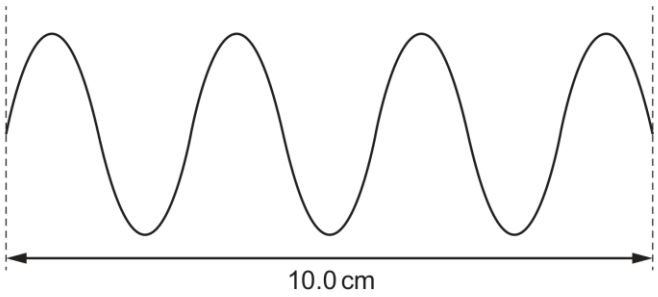


The time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 0.2 mV cm^{-1}.

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the CRO?

	frequency / Hz	amplitude / mV
A	330	0.6
B	330	1.2
C	670	0.6
D	670	1.2

30 A student uses a cathode-ray oscilloscope (CRO) to measure the period of a signal. She sets the time-base of the CRO to 5 ms cm^{-1} and observes the trace illustrated below. The trace has a length of 10.0 cm.

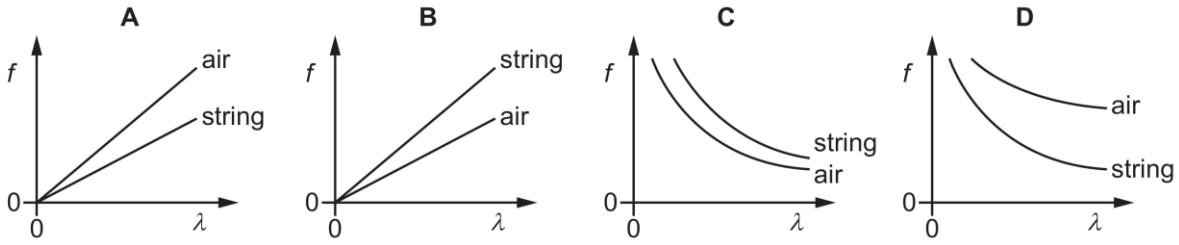


What is the period of the signal?

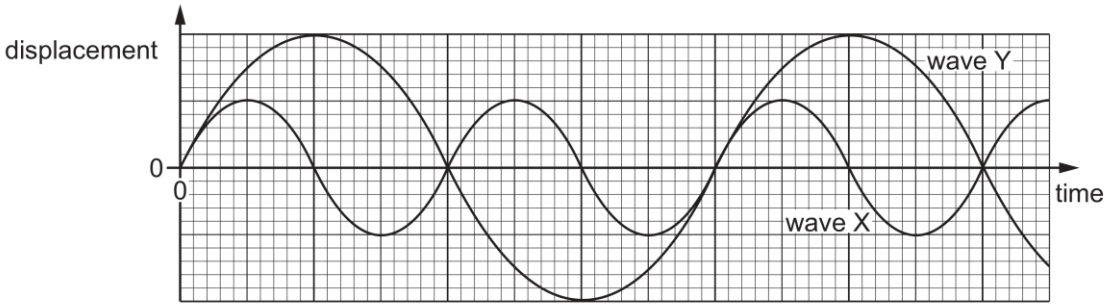
A 7.1×10^{-6} s **B** 1.4×10^{-5} s **C** 7.1×10^{-3} s **D** 1.4×10^{-2} s

31 A guitar string vibrates to create a sound. The speed of the wave in the guitar string is always $440\,m\,s^{-1}$. The vibrating string creates a sound wave that moves in the air with a speed of $330\,m\,s^{-1}$.

Which graph shows the variation of frequency f with the wavelength λ for the waves in the string and in the air?



32 The graph shows the variation with time of displacement for two different waves X and Y.



Wave X has frequency f and amplitude A.

What is the frequency and what is the amplitude of wave Y?

	frequency	amplitude
A	$\frac{1}{2}f$	$\frac{1}{2}A$
B	$\frac{1}{2}f$	$2A$
C	$2f$	$\frac{1}{2}A$
D	$2f$	$2A$

33 The speed v of waves in deep water is given by the equation

$$v^2 = \frac{g\lambda}{2\pi}$$

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

Which graph should he plot to give a straight line through the origin?

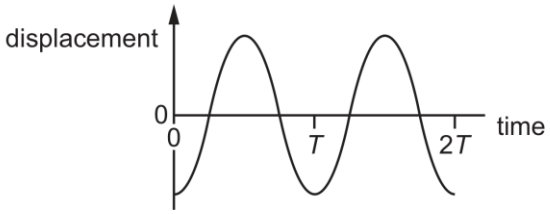
A f^2 against λ

B f against λ^2

C f against $\frac{1}{\lambda}$

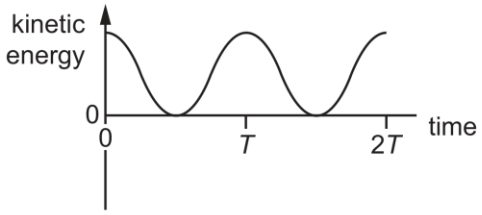
D f^2 against $\frac{1}{\lambda}$

34 When sound travels through air, the air particles vibrate. A graph of displacement against time for a single air particle is shown.

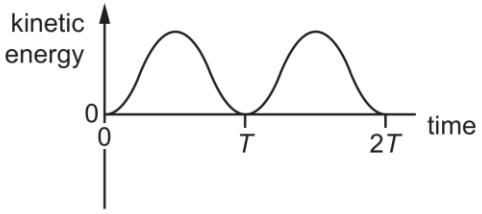


Which graph shows how the kinetic energy of the air particle varies with time?

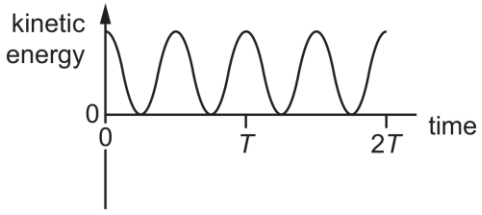
A



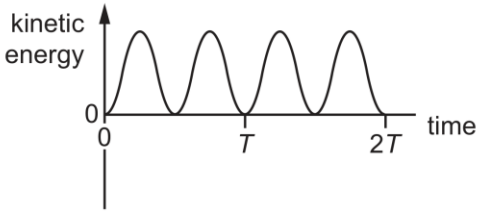
B



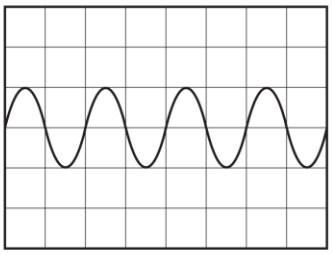
C



D



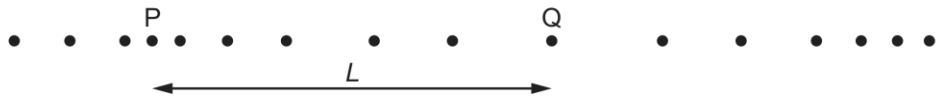
35 A whale produces sound waves of frequency 5 Hz. The waves are detected by a microphone and displayed on an oscilloscope.



What is the time-base setting on the oscilloscope?

A $0.1\,\text{ms div}^{-1}$ **B** $1\,\text{ms div}^{-1}$ **C** $10\,\text{ms div}^{-1}$ **D** $100\,\text{ms div}^{-1}$

36 The diagram illustrates the position of particles in a progressive sound wave at one instant in time.

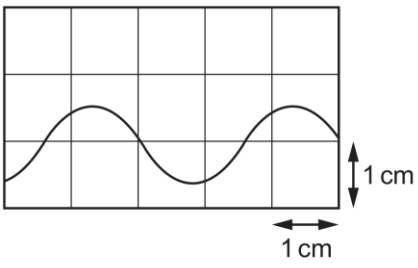


The speed of the wave is v. P and Q are two points in the wave a distance L apart.

What is an expression for the frequency of the wave?

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

37 A cathode-ray oscilloscope (CRO) is used to display the trace from a sound wave. The time-base is set at $5\,\mu\text{s mm}^{-1}$.

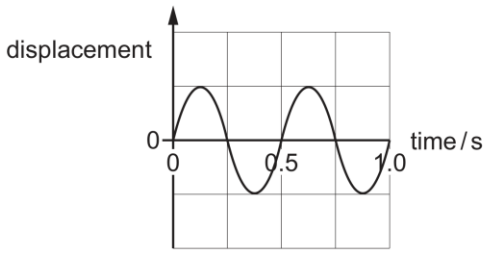


What is the frequency of the sound wave?

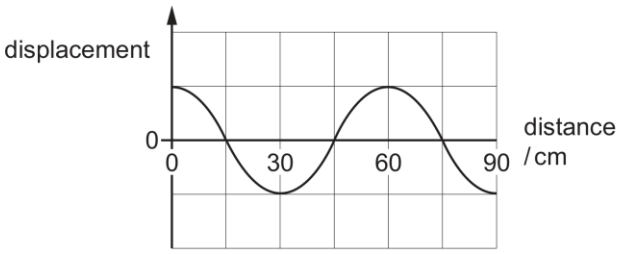
A 6.7 Hz **B** 67 Hz **C** 6.7 kHz **D** 67 kHz

38 The two graphs represent the same wave.

Graph 1 shows the variation with time of the displacement at a particular distance. Graph 2 shows the variation with distance of the displacement at one instant.



graph 1

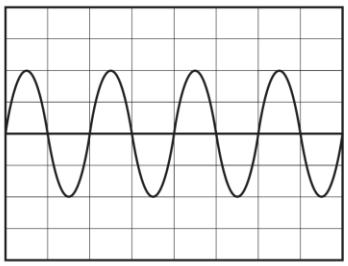


graph 2

What is the speed of the wave?

A $22.5\,cm\,s^{-1}$ **B** $30.0\,cm\,s^{-1}$ **C** $90.0\,cm\,s^{-1}$ **D** $120\,cm\,s^{-1}$

39 A microphone is connected to a cathode-ray oscilloscope (CRO). When a tuning fork is struck and then held next to the microphone, the following waveform is shown on the display of the CRO.



The time-base setting on the CRO is 2.00 ms per division.

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

A 63 Hz **B** 170 Hz **C** 250 Hz **D** 500 Hz

40 Which statement about a light wave and a sound wave is correct?

A Both can travel through free space.

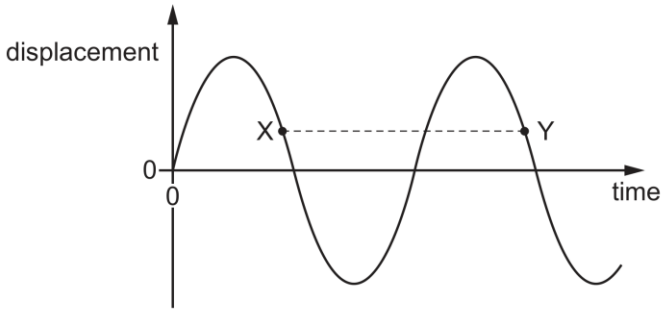
B Both have a frequency inversely proportional to their wavelength.

C Both have an intensity proportional to their amplitude.

D Both have oscillations perpendicular to the direction of energy transfer.

41 A transverse progressive wave is set up on a string.

The graph shows the variation with time of displacement for a point on this string.



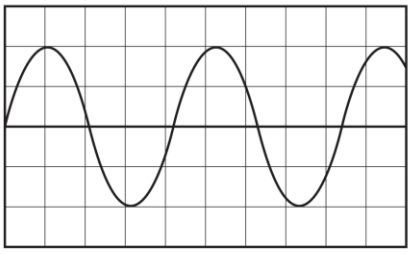
The separation XY on the graph represents the ……1…… of the wave.

X and Y have equal ……2…… .

Which words correctly complete gaps 1 and 2?

	1	2
A	time period	amplitudes
B	time period	displacements
C	wavelength	amplitudes
D	wavelength	displacements

42 The diagram shows the screen of a cathode-ray oscilloscope (c.r.o.) displaying a wave.

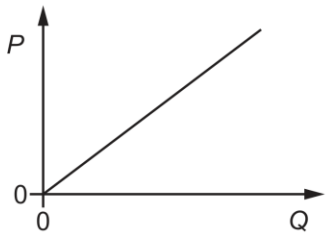


The time-base of the c.r.o. is set at 10 ms / division.

What is the frequency of the wave?

A 0.24 Hz **B** 4.2 Hz **C** 12 Hz **D** 24 Hz

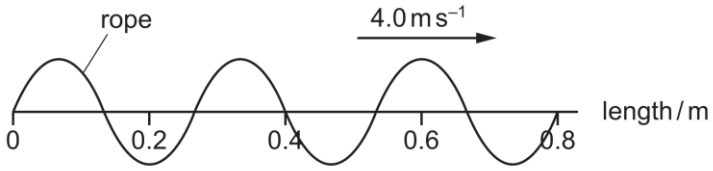
43 The graph shows the variation of a quantity *P* with a quantity *Q* for a sound wave travelling in air.



What could *P* and *Q* be?

	P	*Q*
A	amplitude	intensity
B	frequency	wavelength
C	speed	frequency
D	wavelength	period

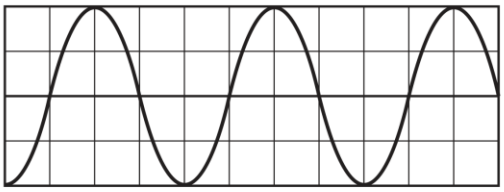
44 A vibration generator produces a progressive wave on a rope. The diagram shows the rope at one instant. The wave travels at a speed of $4.0\,m\,s^{-1}$.



What are the wavelength and the frequency of the wave?

	wavelength / m	frequency / Hz
A	0.13	15
B	0.13	30
C	0.27	15
D	0.27	30

45 The diagram shows the waveform of a signal displayed on a cathode-ray oscilloscope.



The time-base is set at 5.0 ms per division.

The Y-gain is set at 5.0 mV per division.

What are the amplitude and the frequency of the signal?

	amplitude / mV	frequency / Hz
A	10	50
B	10	100
C	20	50
D	20	100

46 A progressive wave on a wire has a frequency of 10 Hz. Two points on the wire, separated by a distance of 0.25 m, have a phase difference of 22.5°.

What is the maximum speed of the wave?

A $2.5\,m\,s^{-1}$ **B** $10\,m\,s^{-1}$ **C** $20\,m\,s^{-1}$ **D** $40\,m\,s^{-1}$