

PHYSICS



EXAM QUESTION PACK

7 WAVES

SCORE

/

PERCENTAGE

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Chapter 8

Waves

8.1 Progressive waves

721. 9702_m20_qp_12 Q: 21

A wave of frequency 15 Hz travels at 24 m s^{-1} through a medium.

What is the phase difference between two points 2.0 m apart?

- A** There is no phase difference.
- B** They are out of phase by a quarter of a cycle.
- C** They are out of phase by half a cycle.
- D** They are out of phase by 0.80 of a cycle.

722. 9702_s20_qp_11 Q: 22

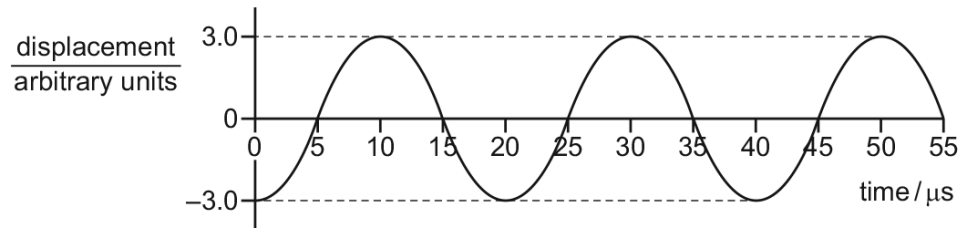
A sound wave reduces in intensity but maintains a constant frequency as it travels through air.

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.
-

723. 9702_s20_qp_11 Q: 23

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



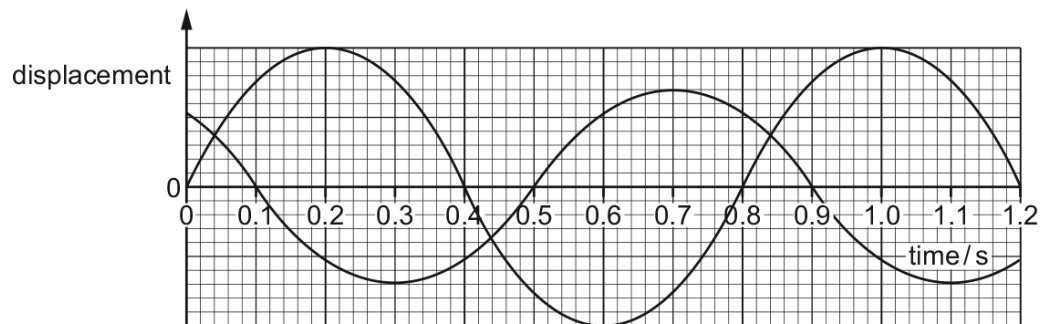
The wave is travelling in a vacuum.

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

724. 9702_s20_qp_12 Q: 22

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°

725. 9702_s20_qp_13 Q: 22

A wave of amplitude A has an intensity I .

After passing through a certain medium, the wave has a new intensity of $\frac{I}{4}$.

What is the new amplitude of the wave?

- A** $2A$ **B** $\frac{A}{2}$ **C** $\frac{A}{4}$ **D** $\frac{A}{16}$

726. 9702_m19_qp_12 Q: 1

A wave has a frequency of 5 GHz.

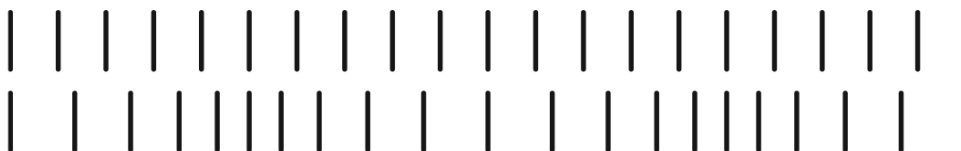
What is the period of the wave?

- A** 200 ps
B 2 ns
C 20 ns
D 20 000 μ s

727. 9702_m19_qp_12 Q: 23

The top row of bars represents a set of particles inside the Earth and at rest.

The lower row represents the same particles at one instant as a longitudinal wave passes from left to right through the Earth.



What should be measured to determine the amplitude of the oscillations of the particles in the lower row as the wave passes?

- A** half the maximum displacement of the particles from their position at rest
B half the maximum distance apart of the particles
C the maximum displacement of the particles from their position at rest
D the maximum distance apart of the particles

728. 9702_s19_qp_11 Q: 27

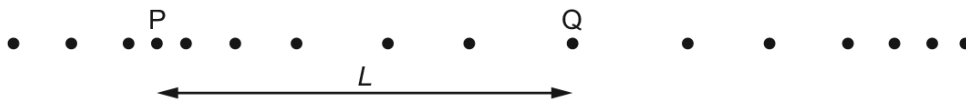
Two progressive waves of frequency 300 Hz superpose to produce a stationary wave in which adjacent nodes are 1.5 m apart.

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}
-

729. 9702_s19_qp_12 Q: 23

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.

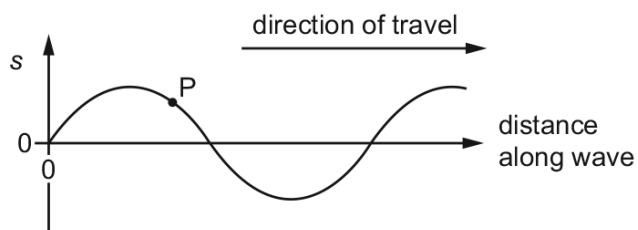
What is an expression for the frequency of the wave?

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

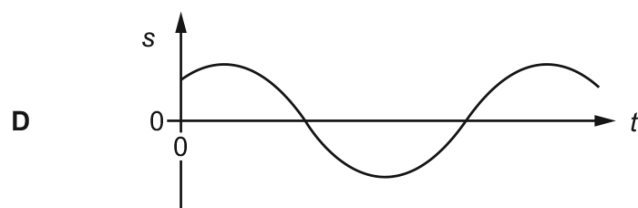
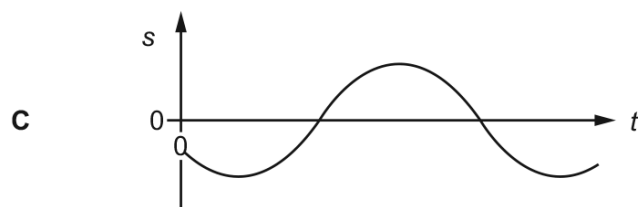
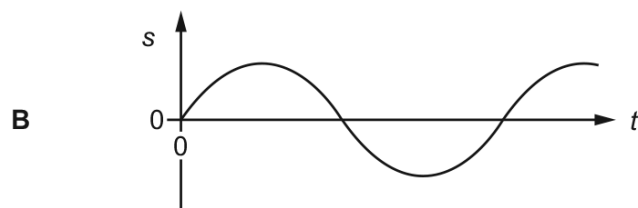
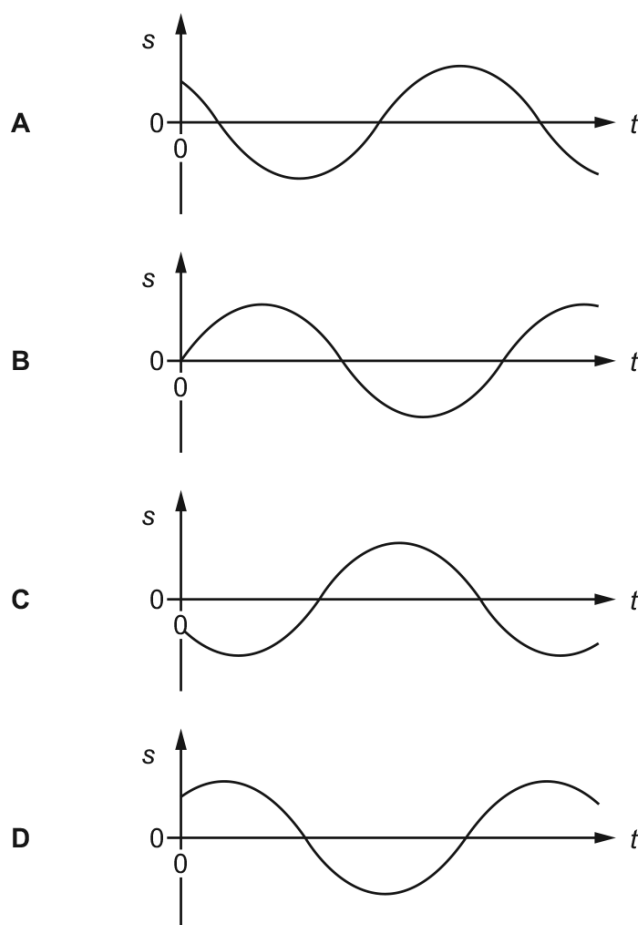
730. 9702_s19_qp_12 Q: 24

A wave moves along the surface of water.

The diagram shows the variation of displacement s with distance along the wave at time $t = 0$.

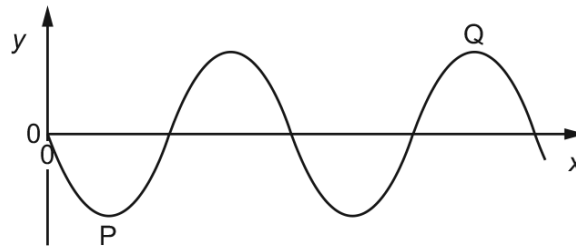


Which graph best shows the variation with time t of the displacement s of the point P on the wave?



731. 9702_s19_qp_13 Q: 21

The graph shows the variation of displacement y with distance x along a progressive wave at one instant in time.



What is the phase difference between points P and Q on the wave?

- A** 90° **B** 270° **C** 540° **D** 630°

732. 9702_s19_qp_13 Q: 22

Wave-power generators take advantage of the energy that is transferred by the motion of waves across the surface of the oceans. The energy of a wave depends on its amplitude.

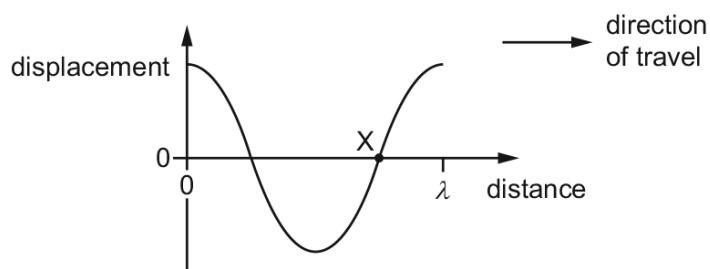
What is the correct definition of amplitude?

- A** the average amount of energy possessed by a wave
B the difference in displacement between a peak and a trough
C the maximum displacement of a point on the wave from equilibrium
D the number of oscillations of a wave that occur per second

733. 9702_w19_qp_11 Q: 21

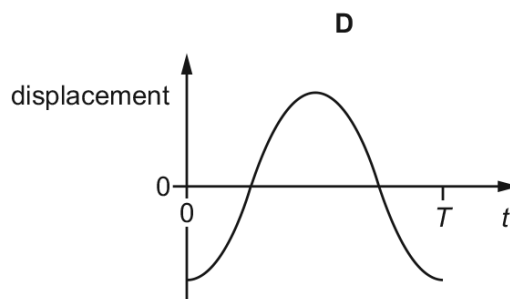
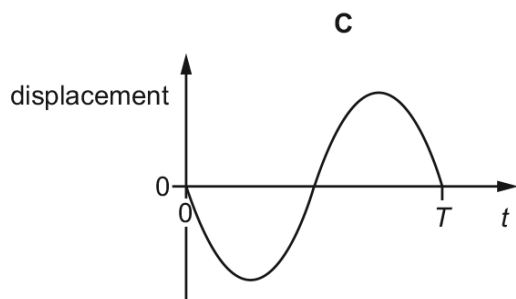
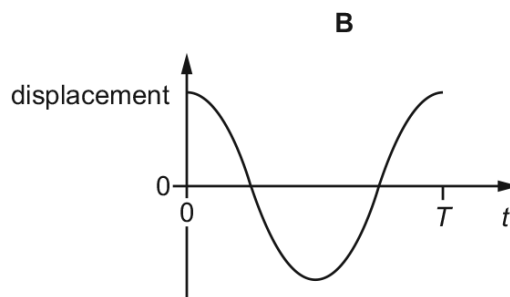
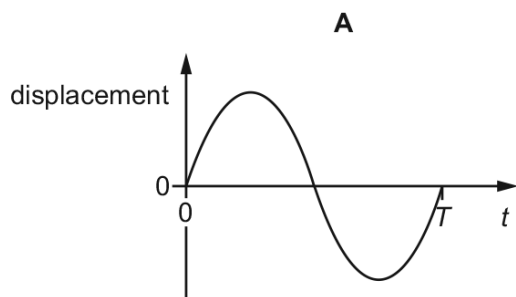
A transverse wave on a rope has wavelength λ and period T .

The graph shows the variation of the displacement of the particles of the rope with distance in the direction of travel of the wave at time $t = 0$.



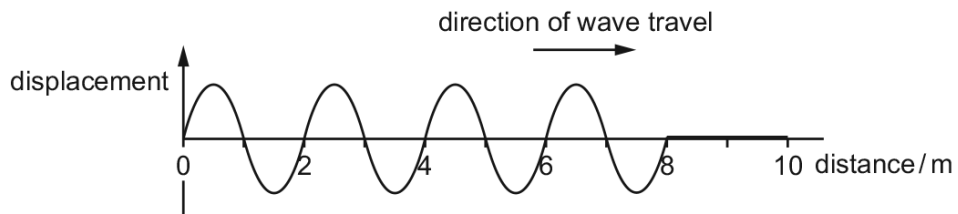
A particle X is labelled.

Which graph shows the variation of the displacement of particle X with time t ?

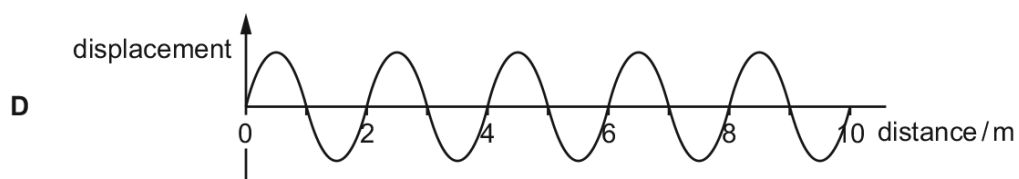
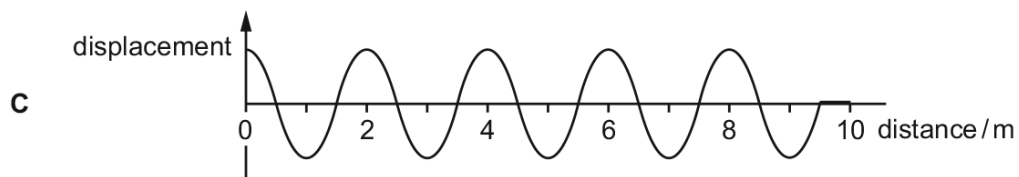
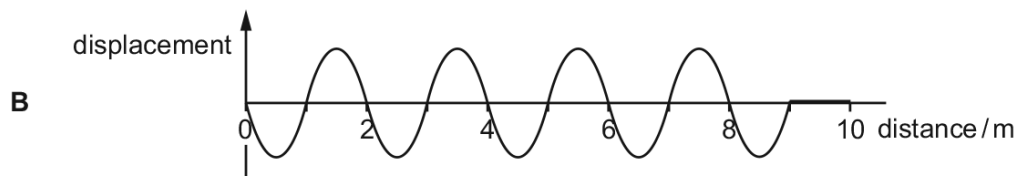
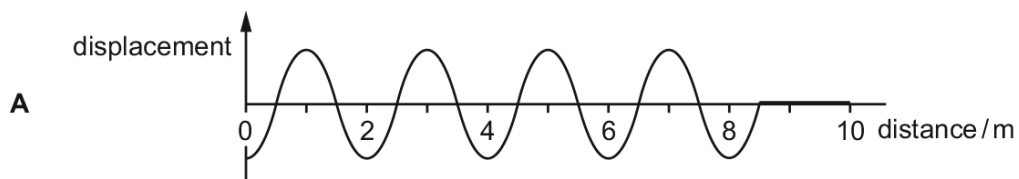


734. 9702_w19_qp_12 Q: 20

A transverse wave is travelling along a rope. The frequency of the wave is 2.0 Hz . The graph shows the variation with distance of the displacement of the wave at time $t = 0$.



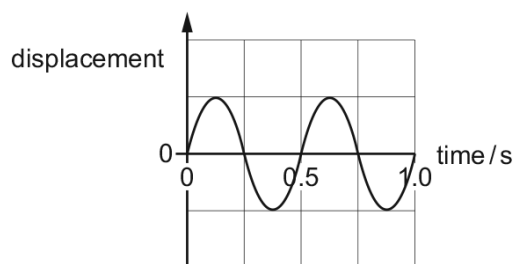
Which diagram shows the position of the wave at time $t = 0.5\text{ s}$?



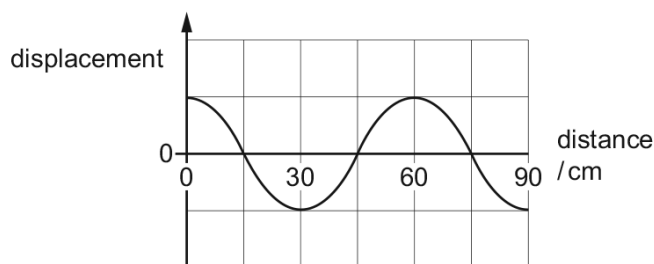
735. 9702_w19_qp_12 Q: 21

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

736. 9702_w19_qp_13 Q: 25

A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

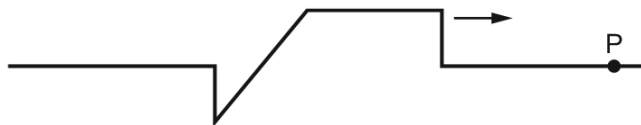
$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

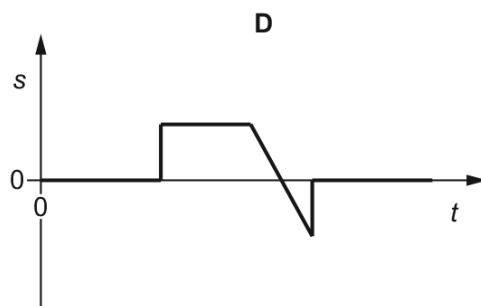
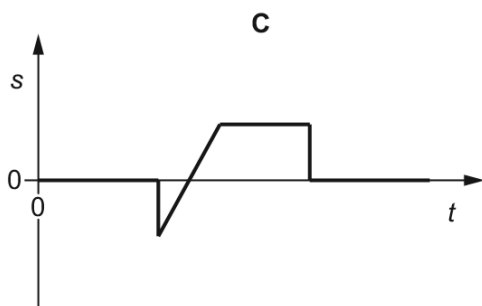
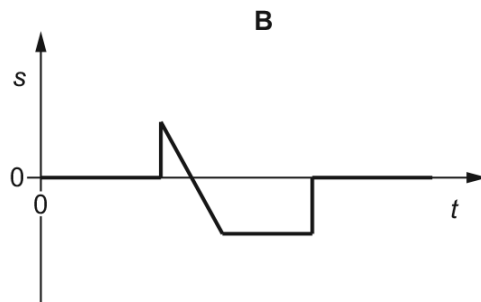
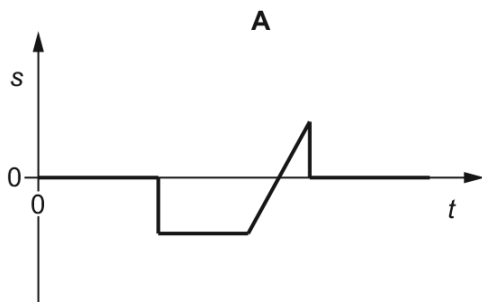
- A** $a \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r^2}$ **C** $a \propto r$ **D** $a \propto r^2$

737. 9702_m18_qp_12 Q: 21

A wave pulse moves along a stretched rope in the direction shown.



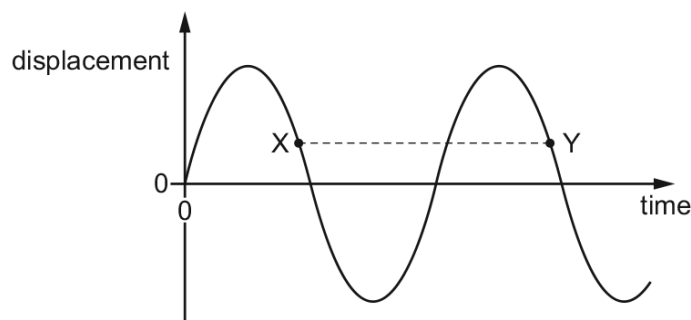
Which diagram shows the variation with time t of the displacement s of the particle P in the rope?



738. 9702_s18_qp_11 Q: 20

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.

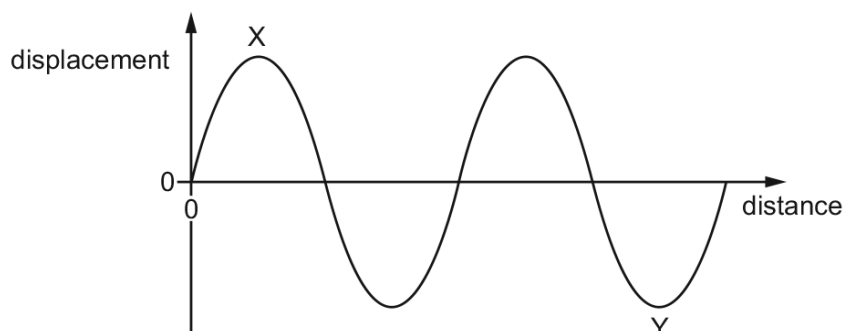
X and Y have equal 2..... .

Which words correctly complete gaps 1 and 2?

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

739. 9702_s18_qp_13 Q: 20

The displacement-distance graph for a transverse progressive wave is shown.



The phase difference between points X and Y can be expressed as $(180n)^\circ$.

What is the value of n ?

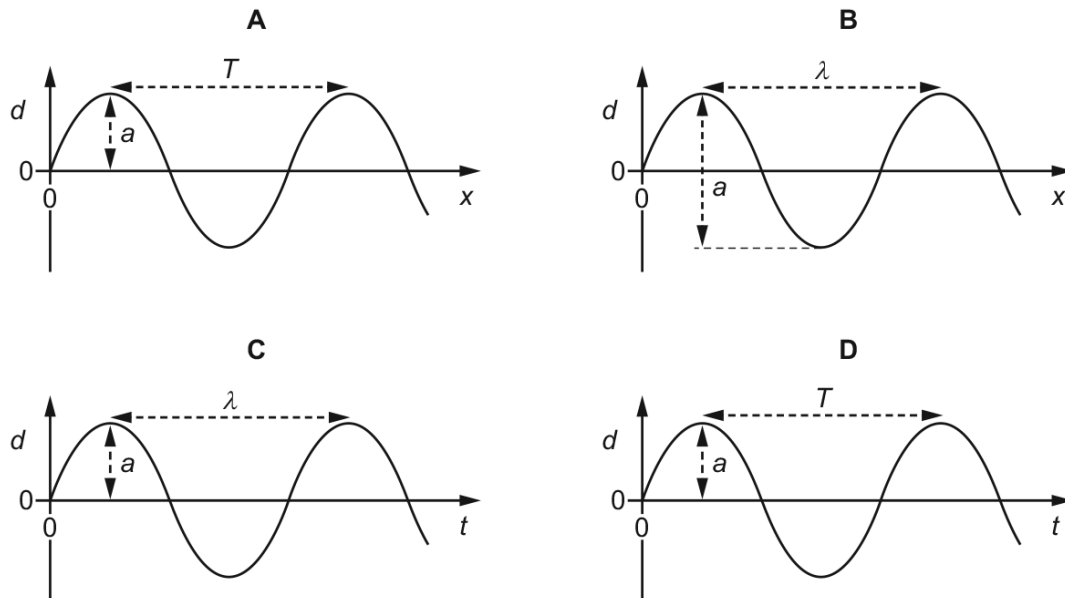
- A** 1.5 **B** 2.5 **C** 3.0 **D** 6.0

740. 9702_s18_qp_13 Q: 21

The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x .

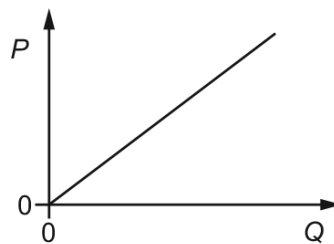
The labels on the graphs are intended to show the wavelength λ , the period T and the amplitude a of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?



741. 9702_w18_qp_11 Q: 21

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

742. 9702_w18_qp_12 Q: 22

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 ms^{-1} **B** 10 ms^{-1} **C** 20 ms^{-1} **D** 40 ms^{-1}
-

743. 9702_w18_qp_13 Q: 21

A progressive sound wave in air has amplitude x_0 and intensity I .

The amplitude of the wave increases to $3x_0$.

What is the new intensity of the wave?

- A** $\frac{I}{9}$ **B** $\frac{I}{3}$ **C** $3I$ **D** $9I$
-

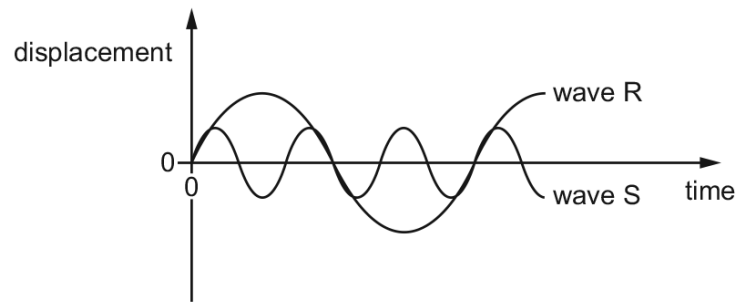
744. 9702_m17_qp_12 Q: 22

What is the relationship between the amplitude of a wave and its intensity?

- A** amplitude $\propto$ intensity
B amplitude $\propto$ (intensity)²
C amplitude $\propto \sqrt{\text{intensity}}$
D (amplitude)² $\propto \sqrt{\text{intensity}}$
-

745. 9702_m17_qp_12 Q: 24

The diagram shows two waves R and S.



Wave R has an amplitude of 8 cm and a period of 30 ms.

What are the amplitude and the period of wave S?

	amplitude / cm	period / ms
A	2	10
B	2	90
C	4	10
D	4	90

746. 9702_s17_qp_12 Q: 22

The period of an electromagnetic wave is 1.0 ns.

What are the frequency and wavelength of the wave?

	frequency / Hz	wavelength / m
A	1.0	3.0×10^8
B	1.0×10^6	300
C	1.0×10^9	0.30
D	1.0×10^{12}	3.0×10^{-4}

747. 9702_s17_qp_13 Q: 21

Which statement about electromagnetic waves in a vacuum is correct?

- A** Amplitude is inversely proportional to velocity.
- B** Frequency is inversely proportional to wavelength.
- C** Intensity is proportional to amplitude.
- D** Velocity is proportional to wavelength.

748. 9702_s16_qp_11 Q: 22

Two sound waves have frequencies of 250 Hz and 300 Hz. The speed of sound is 340 m s^{-1} .

What is the difference between the wavelengths of the two waves?

- A** 0.23 m **B** 1.1 m **C** 1.4 m **D** 6.8 m

749. 9702_s16_qp_13 Q: 23

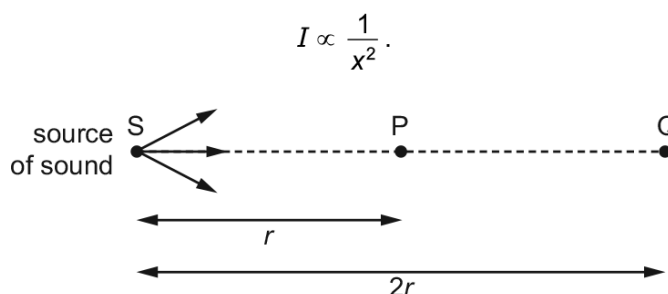
A beam of red laser light has length 1.0 m.

What is the order of magnitude of the number of wavelengths of the red light in 1.0 m?

- A** 10^4 **B** 10^6 **C** 10^8 **D** 10^{10}

750. 9702_s16_qp_13 Q: 25

The intensity I of sound is inversely proportional to the square of the distance x from the source of the sound. This can be represented as



Air molecules at point P, a distance r from the source S, oscillate with amplitude $8.0 \mu\text{m}$.

Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

- A** $1.4 \mu\text{m}$ **B** $2.0 \mu\text{m}$ **C** $2.8 \mu\text{m}$ **D** $4.0 \mu\text{m}$

751. 9702_w16_qp_12 Q: 23

High-frequency sound waves with frequency 2.0 MHz travel with a speed of 2.0 km s^{-1} through a liquid.

What is the shortest distance between a compression and a rarefaction (expansion) in the liquid?

- A** 0.5 mm **B** 1.0 mm **C** 5.0 mm **D** 10.0 mm

752. 9702_s15_qp_11 Q: 25

A wave of frequency 15 Hz travels at 24 m s^{-1} through a medium.

What is the phase difference between two points 2 m apart?

- A** There is no phase difference.
 - B** They are out of phase by a quarter of a cycle.
 - C** They are out of phase by half a cycle.
 - D** They are out of phase by 0.8 of a cycle.
-

753. 9702_s15_qp_11 Q: 26

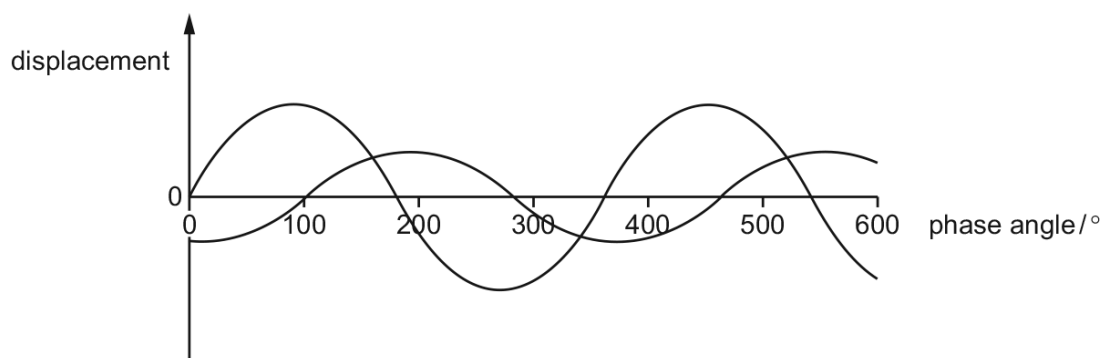
A wave of amplitude a has an intensity of 3.0 W m^{-2} .

What is the intensity of a wave of the same frequency that has an amplitude $2a$?

- A** 4.2 W m^{-2}
 - B** 6.0 W m^{-2}
 - C** 9.0 W m^{-2}
 - D** 12 W m^{-2}
-

754. 9702_s15_qp_12 Q: 24

Two light waves of the same frequency are represented by the diagram.



What could be the phase difference between the two waves?

- A** 150°
 - B** 220°
 - C** 260°
 - D** 330°
-

755. 9702_s15_qp_12 Q: 25

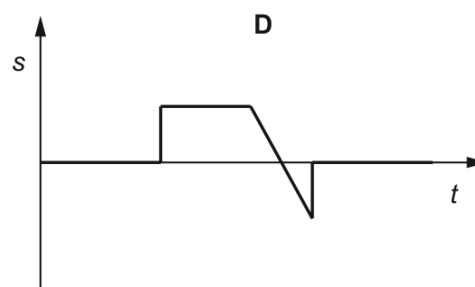
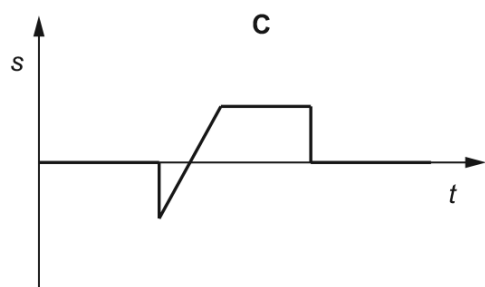
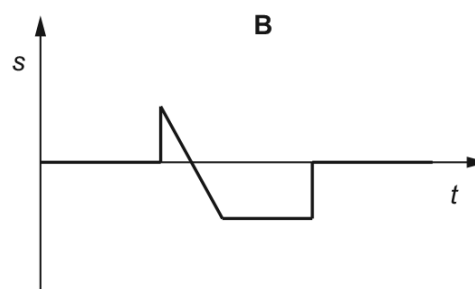
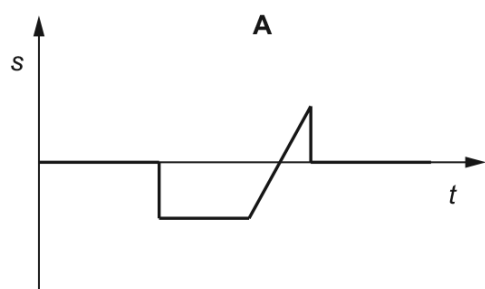
A sound wave has a speed of 330 m s^{-1} and a frequency of 50 Hz .

What is a possible distance between two points on the wave that have a phase difference of 60° ?

- A** 0.03 m
 - B** 1.1 m
 - C** 2.2 m
 - D** 6.6 m
-

756. 9702_s15_qp_13 Q: 26

Which diagram correctly shows the variation with time t of the displacement s of the particle P in the rope?



8.2 Transverse and longitudinal waves

757. 9702_m20_qp_12 Q: 22

Which row describes a longitudinal wave and a medium through which it can travel?

	direction of oscillation of the medium compared with the direction of propagation of wave energy	medium
A	parallel	air
B	parallel	vacuum
C	perpendicular	air
D	perpendicular	vacuum

758. 9702_s20_qp_12 Q: 21

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.

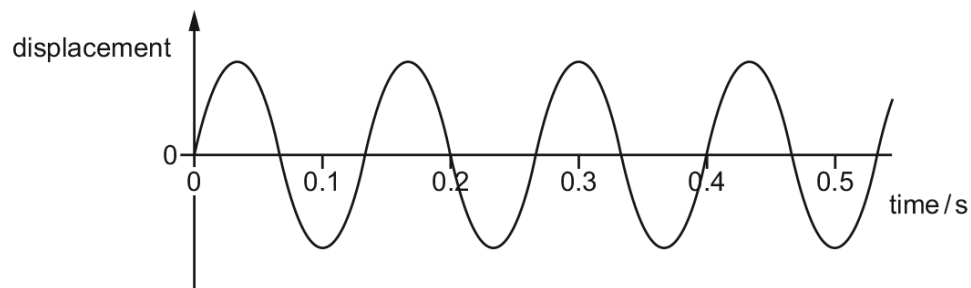
Which statement is **not** possible for the two points X and Y at any instant?

- 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.
-

759. 9702_s20_qp_13 Q: 23

A wave travels along a coiled spring.

The graph shows the variation with time of the displacement of a point on the spring.



What is the frequency of the wave?

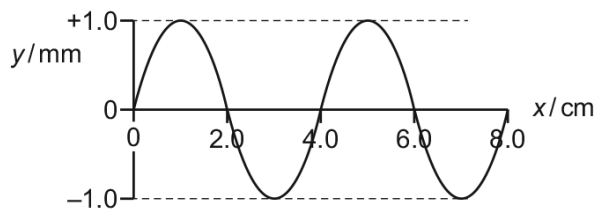
- A** 0.13 Hz
 - B** 0.20 Hz
 - C** 5.0 Hz
 - D** 7.5 Hz
-

760. 9702_s19_qp_11 Q: 22

A transverse wave in a medium has the waveform shown, where

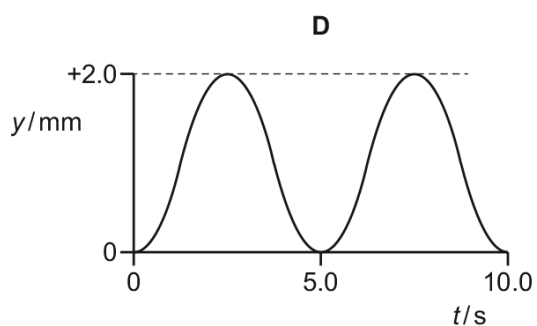
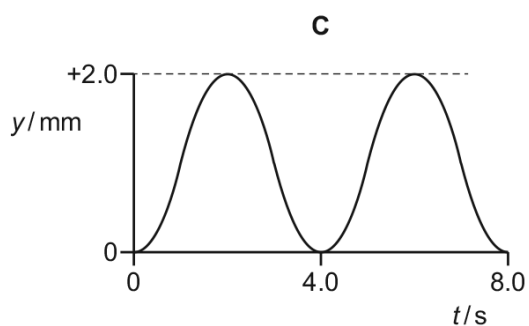
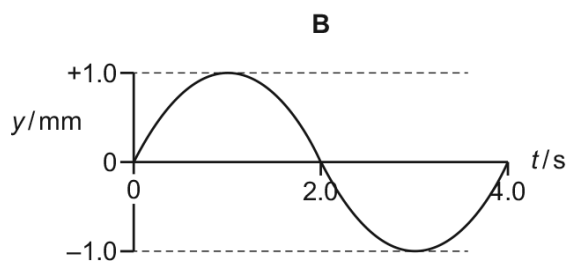
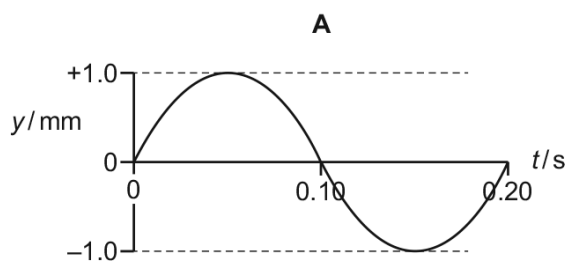
y = vertical displacement and x = horizontal distance.

The speed of the wave is 20.0 cm s^{-1} .



A particle of the medium oscillates vertically.

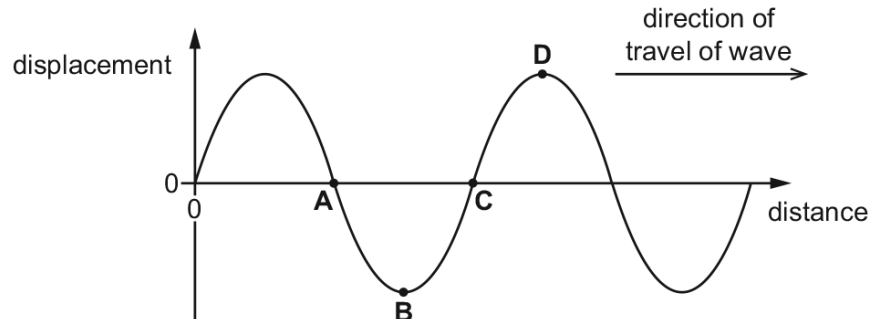
Which graph of vertical displacement y against time t best represents the motion of this particle?



761. 9702_s19_qp_11 Q: 23

The graph shows the variation of the displacement of particles with distance along a transverse wave at an instant in time. The wave is moving to the right.

Which position along the wave corresponds to a point where particles in the wave are travelling the fastest upwards?



762. 9702_w19_qp_11 Q: 22

Which statement about all types of transverse waves is correct?

- A They all have the same speed.
- B They all have vibrations that are parallel to the direction of propagation of energy.
- C They can all form stationary waves.
- D They can all travel through a vacuum.

763. 9702_w19_qp_12 Q: 26

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.

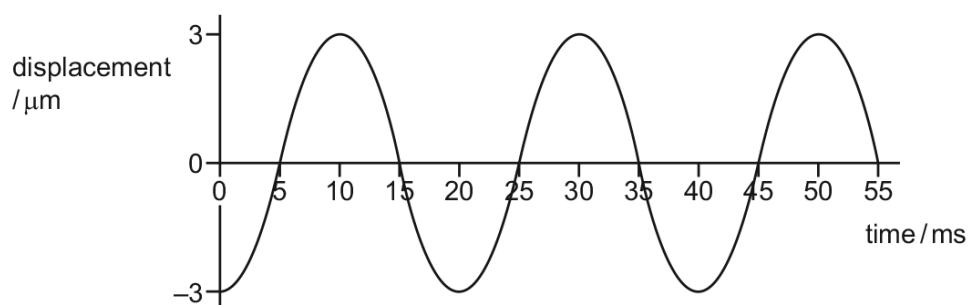
764. 9702_w19_qp_13 Q: 21

Which statement about light waves and sound waves is **not** correct?

- A** Light waves and sound waves can both demonstrate the Doppler effect.
 - B** Light waves are transverse waves and sound waves are longitudinal waves.
 - C** Light waves can be diffracted but sound waves cannot.
 - D** Light waves can travel in a vacuum but sound waves cannot.
-

765. 9702_w19_qp_13 Q: 22

The graph represents a sound wave.

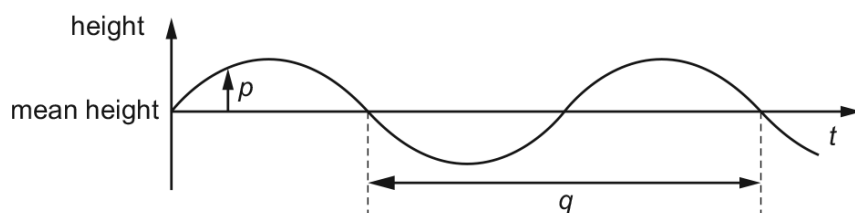


Which statement is correct?

- A** The wave is longitudinal and has a period of 25 ms.
 - B** The wave is longitudinal and has a frequency of 50 Hz.
 - C** The wave is transverse and has an amplitude of $3\ \mu\text{m}$.
 - D** The wave is transverse and has a wavelength of 20 ms.
-

766. 9702_w19_qp_13 Q: 27

The graph shows how the height of the water surface at a point in a harbour varies with time t as waves pass the point.



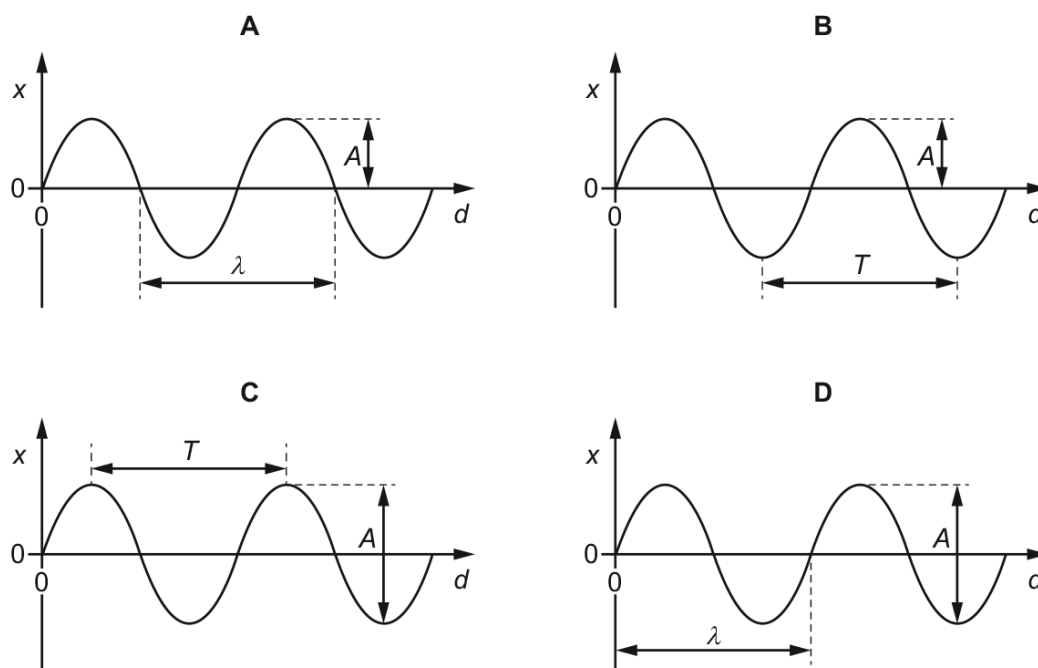
What are p and q ?

	p	q
A	displacement	period
B	displacement	wavelength
C	amplitude	period
D	amplitude	wavelength

767. 9702_m18_qp_12 Q: 22

A wave has period T , wavelength λ and amplitude A . The wave is shown on a graph of displacement x against distance d .

Which graph is correctly labelled?

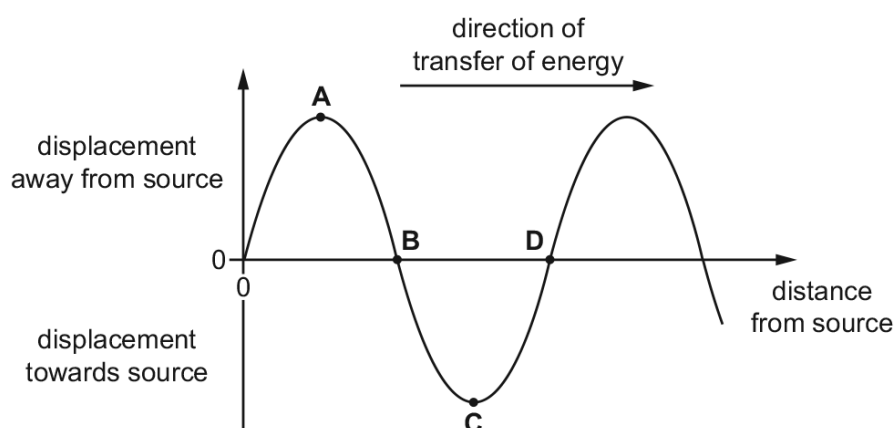


768. 9702_s18_qp_11 Q: 22

A longitudinal wave has vibrations parallel to the direction of transfer of energy by the wave.

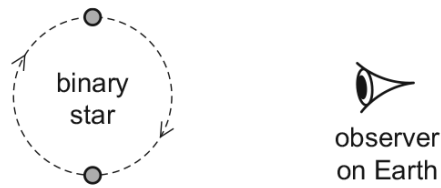
The wave can be represented on a graph showing the variation of the displacement of the particles with distance from the source.

Which point on the graph is the centre of a compression?

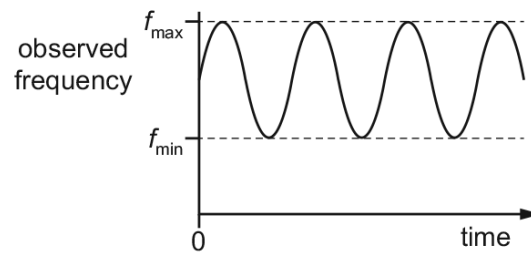


769. 9702_s18_qp_11 Q: 24

A binary star consists of two stars rotating around a common centre. Light from one of the stars is observed on the Earth.



The observed frequency of the light varies between a minimum frequency $f_{\min}$ and a maximum frequency $f_{\max}$, as shown.



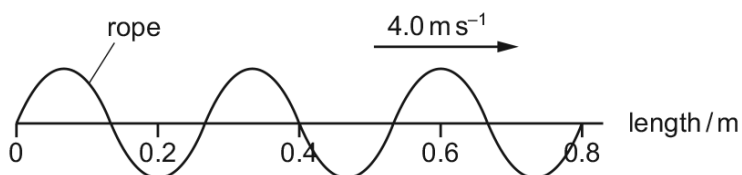
The rate of rotation of the binary star increases.

What is the change to $f_{\max}$ and the change to $f_{\min}$?

	$f_{\max}$	$f_{\min}$
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

770. 9702_w18_qp_11 Q: 22

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} .

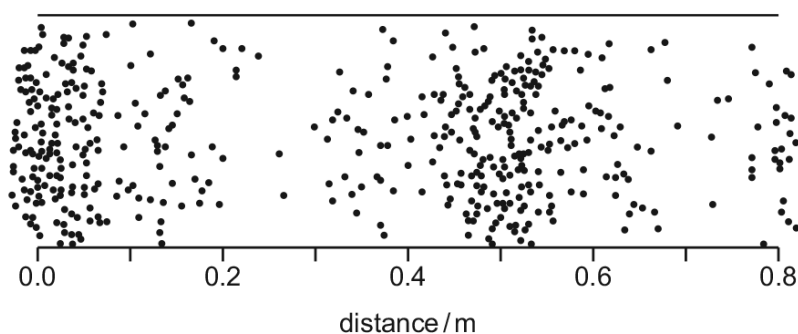


What are the wavelength and the frequency of the wave?

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

771. 9702_w18_qp_12 Q: 23

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

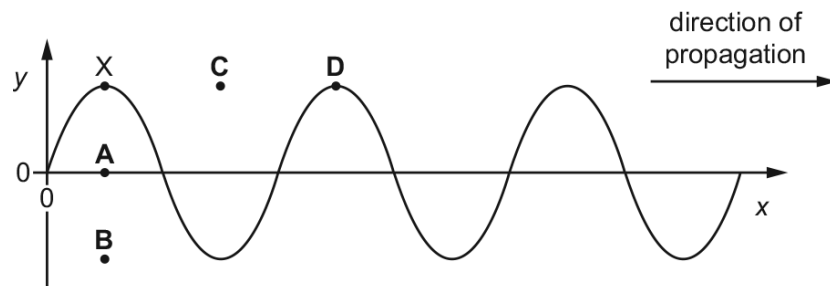
772. 9702_w18_qp_13 Q: 22

The variation with distance x of the displacement y of a transverse wave on a rope is shown at time $t = 0$.

The wave has a frequency of 0.5 Hz.

A point X on the rope is marked. The diagram shows the original position of X and four new positions.

What is the position of X at time $t = 1$ s?



773. 9702_m17_qp_12 Q: 23

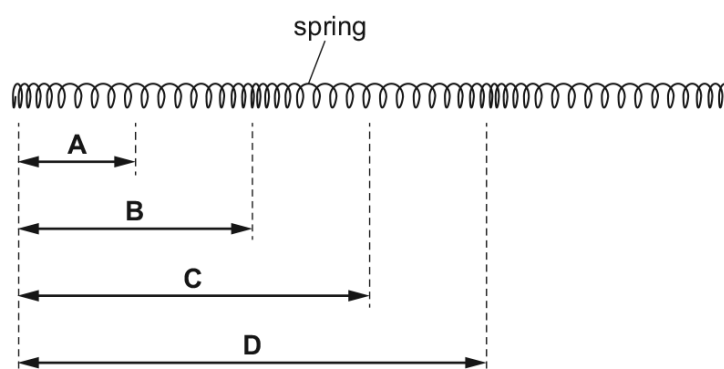
Which statement about light waves and sound waves is correct?

- A** Both light waves and sound waves show the Doppler effect.
- B** Light waves can be diffracted but sound waves cannot be diffracted.
- C** Sound waves are transverse waves and light waves are longitudinal waves.
- D** Sound waves can travel in a vacuum but light waves cannot travel in a vacuum.

774. 9702_s17_qp_11 Q: 22

A longitudinal wave travels through a long spring. The spring is shown at one instant.

What is the wavelength of the wave?



775. 9702_s17_qp_11 Q: 23

A sound wave has a frequency of 2500 Hz and a speed of 1500 ms^{-1} .

What is the shortest distance from a point of maximum pressure in the wave to a point of minimum pressure?

- A** 0.15 m **B** 0.30 m **C** 0.60 m **D** 1.20 m
-

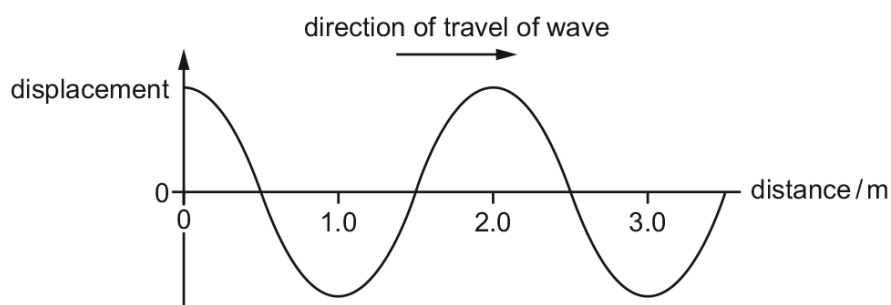
776. 9702_s17_qp_12 Q: 23

Which statement about progressive longitudinal waves is **not** correct?

- A** The oscillations of the particles are parallel to the direction of travel of the wave energy.
B They have a series of nodes and antinodes.
C They need a medium through which to travel.
D They transfer energy.
-

777. 9702_s17_qp_13 Q: 22

A transverse wave travels along a rope. The graph shows the variation of the displacement of the particles in the rope with distance along it at a particular instant.

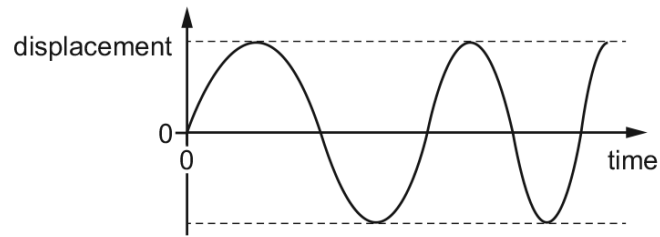


At which distance along the rope do the particles have maximum upwards velocity?

- A** 0.5 m **B** 1.0 m **C** 1.5 m **D** 2.0 m
-

778. 9702_w17_qp_11 Q: 22

The displacement-time graph for a layer of air in the path of a sound wave is shown.

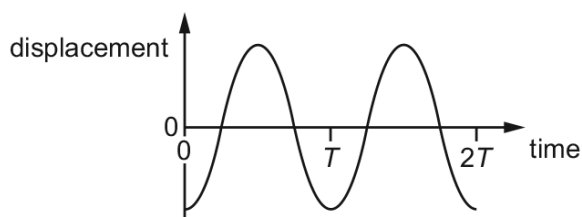


Which wave quantity is increasing?

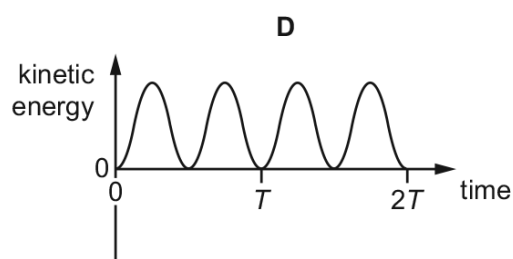
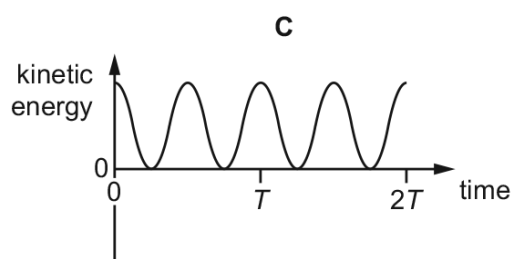
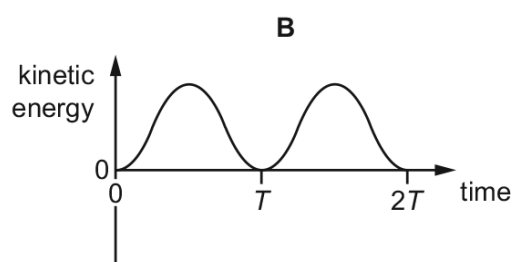
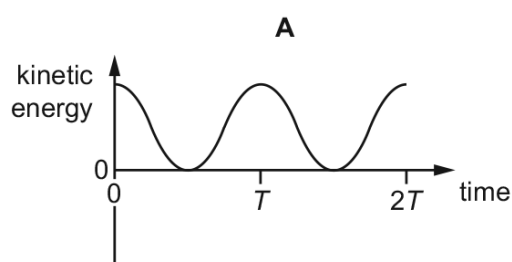
- A** amplitude
- B** frequency
- C** period
- D** wavelength

779. 9702_w17_qp_12 Q: 22

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



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



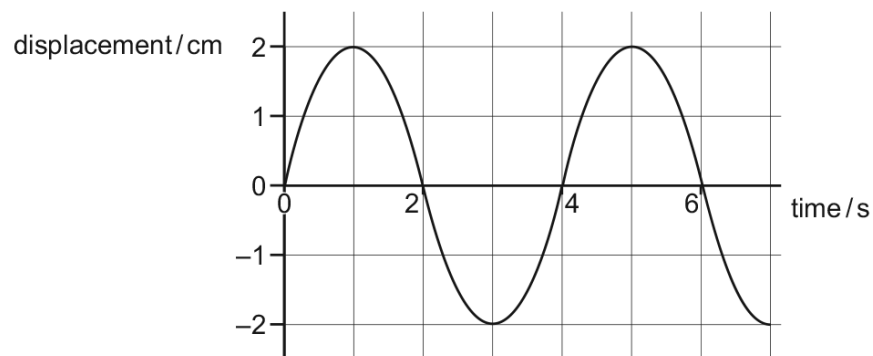
780. 9702_w17_qp_12 Q: 23

Which wave is a longitudinal wave?

- A** a light wave travelling through air
- B** a radio wave from a broadcasting station
- C** a ripple on the surface of water
- D** a sound wave travelling through air

781. 9702_w17_qp_13 Q: 22

The graph shows how the displacement of a particle in a wave varies with time.



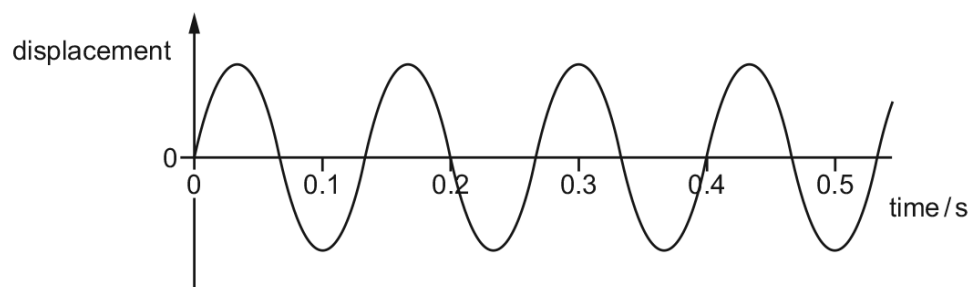
Which statement is correct?

- A** The wave has a period of 2 s and could be either transverse or longitudinal.
- B** The wave has a period of 2 s and must be transverse.
- C** The wave has a period of 4 s and could be either transverse or longitudinal.
- D** The wave has a period of 4 s and must be transverse.

782. 9702_w17_qp_13 Q: 23

A wave travels along a coiled spring.

The graph shows the variation with time of the displacement of a point on the spring.

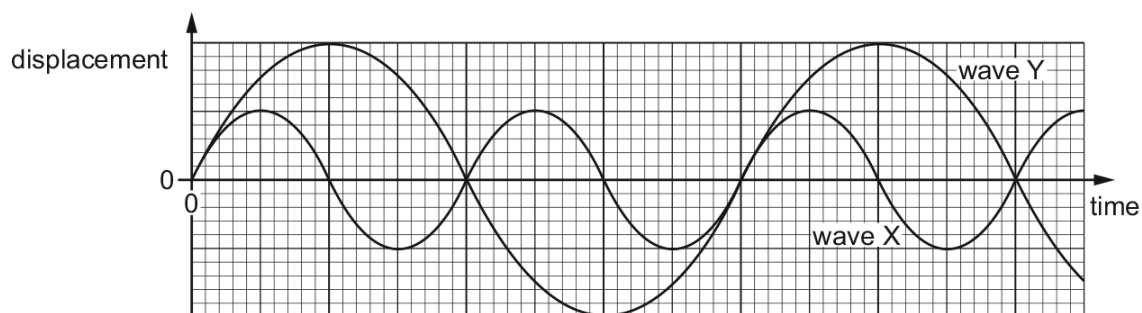


What is the frequency of the wave?

- A** 0.13 Hz
- B** 0.20 Hz
- C** 5.0 Hz
- D** 7.5 Hz

783. 9702_m16_qp_12 Q: 22

The graph shows the variation with time of the displacement of two separate 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	$2f$	$2A$

784. 9702_s16_qp_12 Q: 25

A stationary wave is set up on a stretched string.

The diagram shows the string at two instants of time when it has maximum displacement.



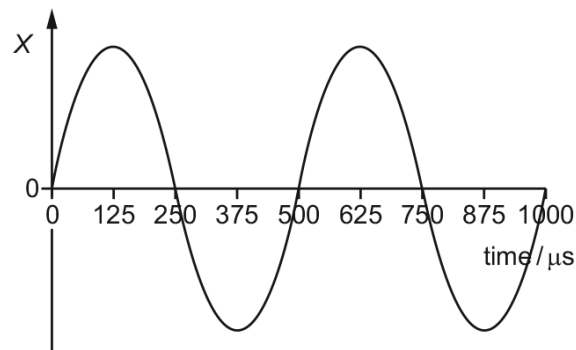
The oscillations of point P on the string have amplitude A .

What is the distance moved by P from the position shown in the diagram after half a time period of the wave?

- A** 0 **B** A **C** $2A$ **D** $4A$

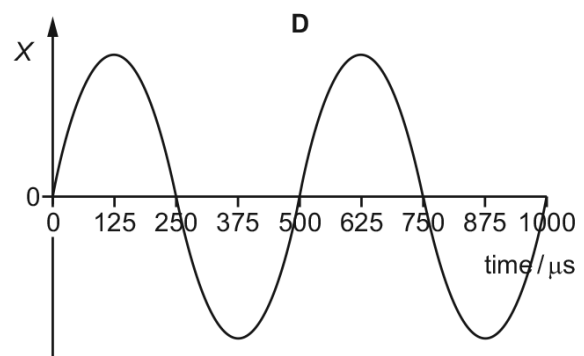
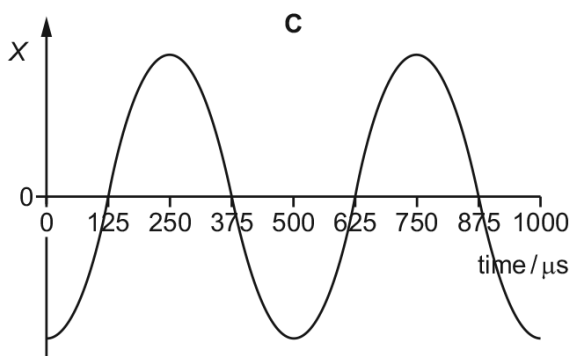
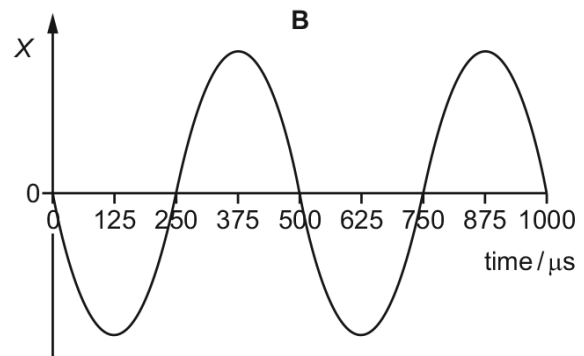
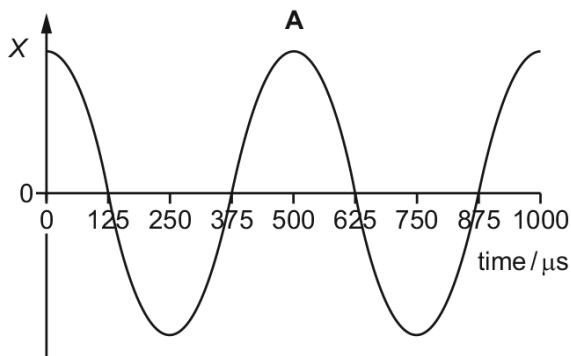
785. 9702_w16_qp_11 Q: 25

The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.



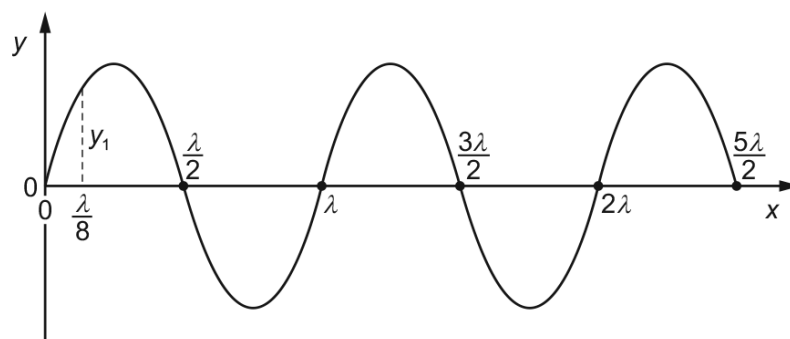
The velocity of sound in the gas is 330 m s^{-1} . All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?



786. 9702_w16_qp_12 Q: 24

A transverse progressive wave of wavelength λ is set up on a stretched string. The graph shows the variation of displacement y with distance x at a particular instant of time. The displacement where distance $x = \frac{\lambda}{8}$ is y_1 .

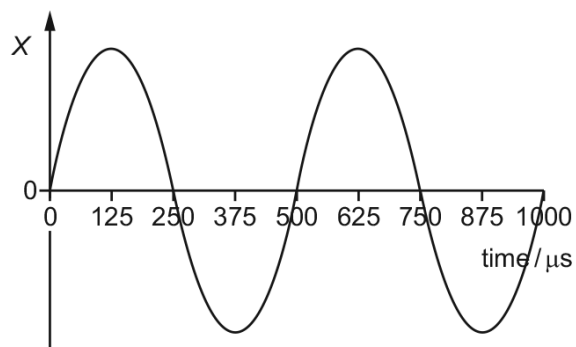


What are the next two values of x where the displacement y is again equal to y_1 ?

- A** $\frac{3\lambda}{8}$ and $\frac{5\lambda}{8}$
- B** $\frac{3\lambda}{8}$ and $\frac{9\lambda}{8}$
- C** $\frac{5\lambda}{8}$ and $\frac{9\lambda}{8}$
- D** $\frac{9\lambda}{8}$ and $\frac{17\lambda}{8}$

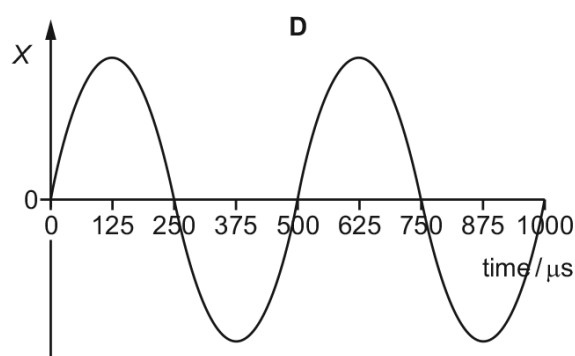
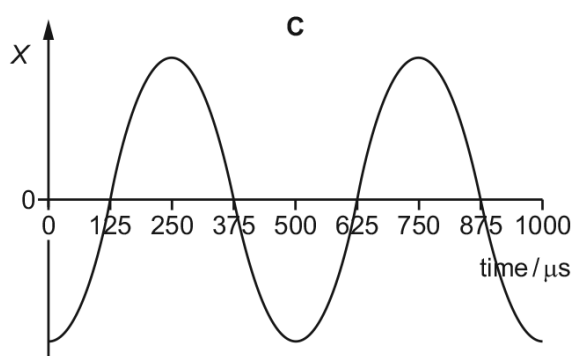
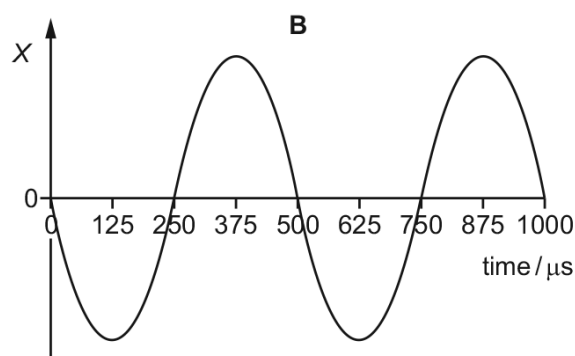
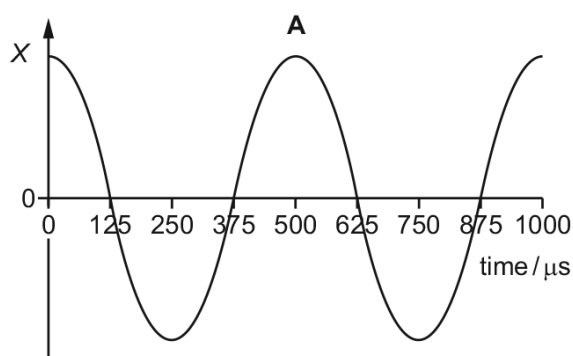
787. 9702_w16_qp_13 Q: 25

The graph shows the variation with time of the displacement X of a gas molecule as a continuous sound wave passes through a gas.



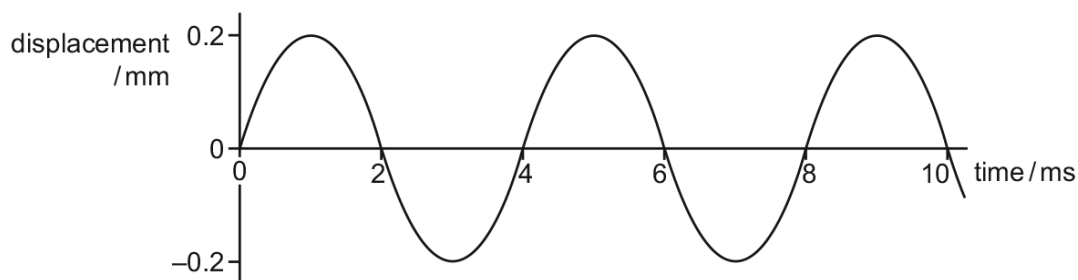
The velocity of sound in the gas is 330 m s^{-1} . All the graphs below have the same zero time as the graph above.

What is the displacement-time graph for a molecule that is a distance of 0.165 m further away from the source of the sound?



788. 9702_s15_qp_11 Q: 24

A sound wave moves with a speed of 320 ms^{-1} through air. The variation with time of the displacement of an air particle due to this wave is shown in the graph.

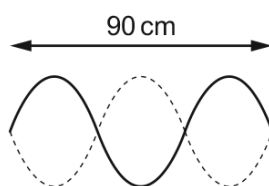


Which statement about the sound wave is correct?

- A** The frequency of the wave is 500 Hz.
- B** The graph shows that sound is a transverse wave.
- C** The intensity of the wave will be doubled if its amplitude is increased to 0.4 mm.
- D** The wavelength of the sound wave is 1.28 m.

789. 9702_s15_qp_11 Q: 28

The diagram shows a stationary wave on a string at two instants of maximum vertical displacement.



The frequency of the wave is 12 Hz.

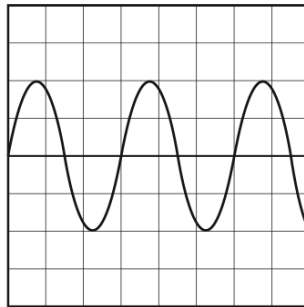
What is the speed of the wave?

- A** 3.6 ms^{-1}
- B** 7.2 ms^{-1}
- C** 360 ms^{-1}
- D** 720 ms^{-1}

8.3 Determination of frequency and wavelength of sound waves

790. 9702_m20_qp_12 Q: 23

A sound wave is displayed on the screen of a cathode-ray oscilloscope, as shown.



The time-base setting is 0.50 ms per division.

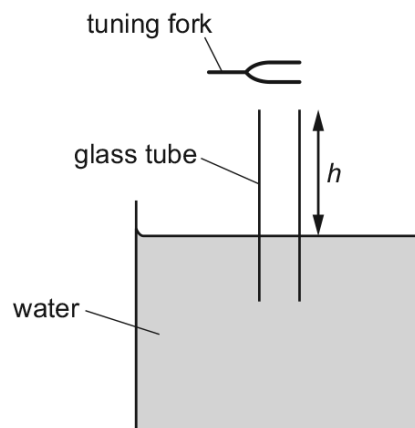
What is the frequency of the sound wave?

- A** 500 Hz **B** 670 Hz **C** 1000 Hz **D** 1300 Hz

791. 9702_s20_qp_11 Q: 24

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} .

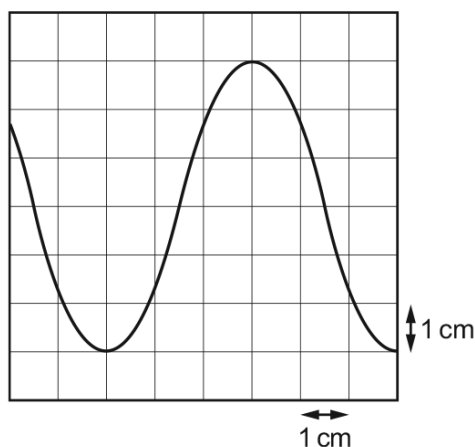


What is the frequency of the sound produced by the tuning fork?

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

792. 9702_s20_qp_12 Q: 23

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} .

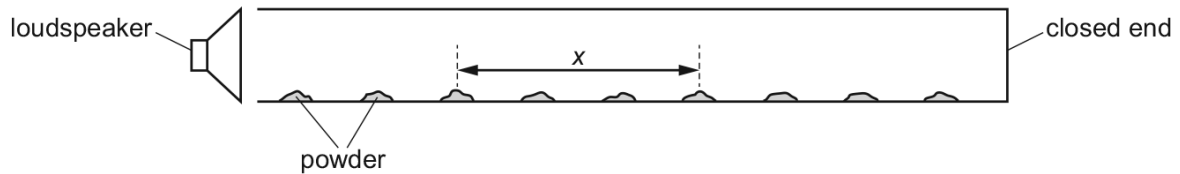
What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the CRO?

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

793. 9702_s20_qp_13 Q: 24

A loudspeaker is set up at the open end of a closed tube containing powder.

When the loudspeaker produces sound of frequency 1200 Hz, a stationary wave is produced in the tube. The powder gathers at the nodes of the stationary wave as shown.



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

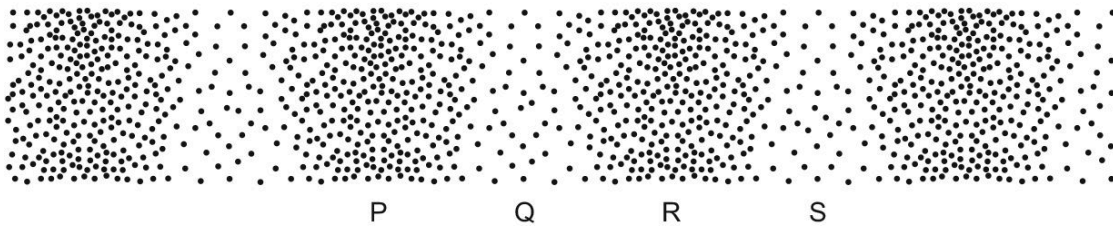
What is the value of distance x ?

- A** 28 cm **B** 42 cm **C** 84 cm **D** 112 cm

794. 9702_m19_qp_12 Q: 22

A sound wave passes through air.

The diagram shows the positions of the molecules of the air at one instant.



Which distance is equal to the wavelength of the wave?

- A** PQ **B** PS **C** QR **D** QS

795. 9702_m19_qp_12 Q: 24

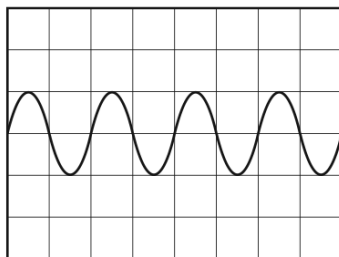
A straight tube is closed at one end and has a loudspeaker positioned at the open end. The frequency of the loudspeaker is initially very low and is increased slowly. A series of loudness maxima are heard. The stationary wave which gives the first maximum has a node at the closed end and an antinode at the open end. The frequency of the loudspeaker is f_1 when the first maximum is heard.

What is the frequency of the loudspeaker when the fourth maximum is heard?

- A** $\frac{7f_1}{4}$ **B** $2f_1$ **C** $4f_1$ **D** $7f_1$

796. 9702_s19_qp_11 Q: 4

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



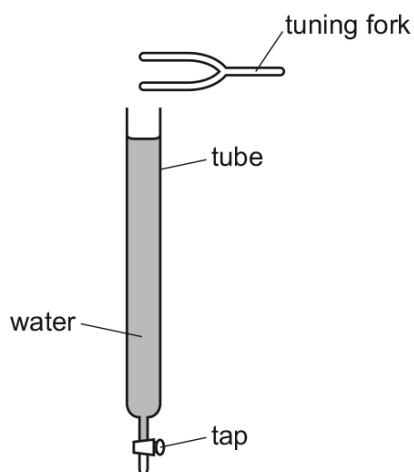
What is the time-base setting on the oscilloscope?

- A** 0.1 ms div⁻¹ **B** 1 ms div⁻¹ **C** 10 ms div⁻¹ **D** 100 ms div⁻¹

797. 9702_s19_qp_11 Q: 24

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

798. 9702_s19_qp_12 Q: 25

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

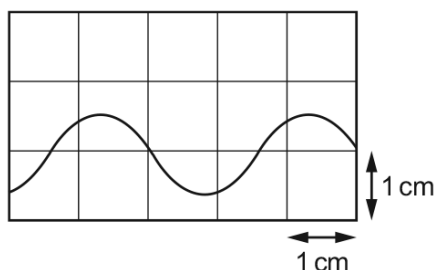
The distance between a node and an adjacent antinode is L .

What is the wavelength of the sound?

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

799. 9702_s19_qp_12 Q: 28

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

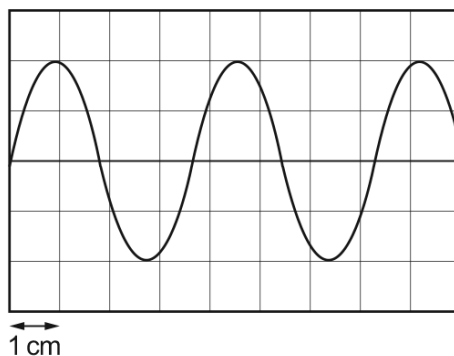


What is the frequency of the sound wave?

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

800. 9702_s19_qp_13 Q: 23

A sound wave of frequency 270 Hz is recorded by a cathode-ray oscilloscope (CRO). The waveform on the CRO is shown.

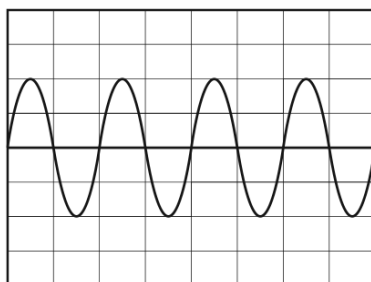


What is the time-base setting on the CRO?

- A** 0.1 ms cm^{-1} **B** 1 ms cm^{-1} **C** 10 ms cm^{-1} **D** 100 ms cm^{-1}

801. 9702_w19_qp_12 Q: 22

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.



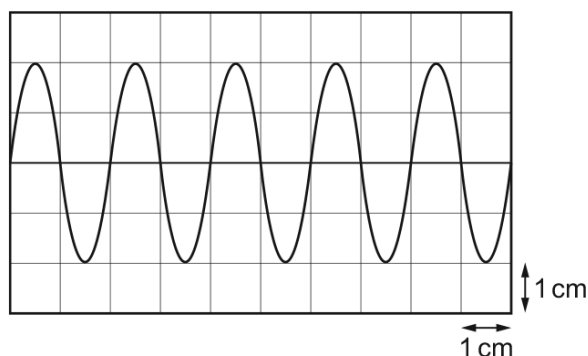
The time-base setting on the CRO is 2.00 ms per division.

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

802. 9702_w19_qp_13 Q: 23

A cathode-ray oscilloscope (CRO) is used to display a wave of frequency 5.0 kHz. The display is shown.

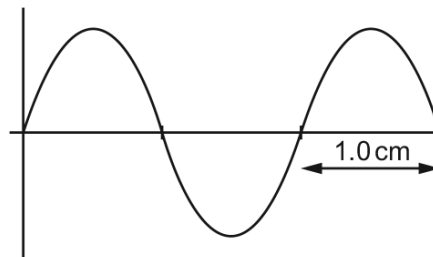


What is the time-base setting of the CRO?

- A** $10\ \mu\text{s cm}^{-1}$ **B** $100\ \mu\text{s cm}^{-1}$ **C** $10\ \text{ms cm}^{-1}$ **D** $100\ \text{ms cm}^{-1}$

803. 9702_m18_qp_12 Q: 25

The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave.



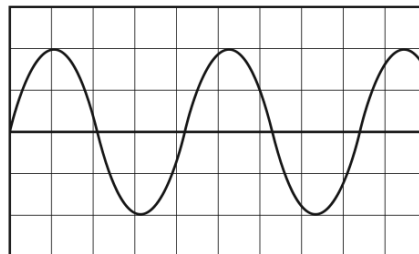
The time base setting is $0.20 \mu\text{s cm}^{-1}$.

Which statement is correct?

- A** The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.
- B** The frequency of the wave is 2.5 MHz and it lies in the radio-wave region of the electromagnetic spectrum.
- C** The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.
- D** The frequency of the wave is 5.0 MHz and it lies in the radio-wave region of the electromagnetic spectrum.

804. 9702_s18_qp_12 Q: 23

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

805. 9702_s18_qp_12 Q: 26

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} .

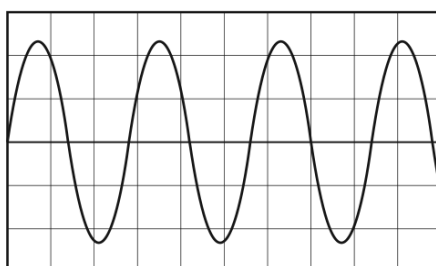
What is the frequency of the sound?

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

806. 9702_s18_qp_13 Q: 22

A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of a sound wave.

The diagram shows the waveform on the screen.



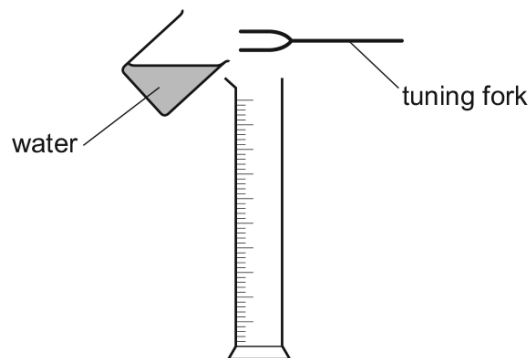
The time-base setting is 5.0 ms/div .

What is the frequency of the sound wave?

- A** 57 Hz **B** 71 Hz **C** 114 Hz **D** 143 Hz

807. 9702_s18_qp_13 Q: 24

A vibrating tuning fork is held over a measuring cylinder, as shown.



Water is then gradually poured into the measuring cylinder. A much louder sound is first heard when the water level is 2.9 cm above the base of the measuring cylinder. A second much louder sound is heard when the water level reaches a height of 67.3 cm above the base.

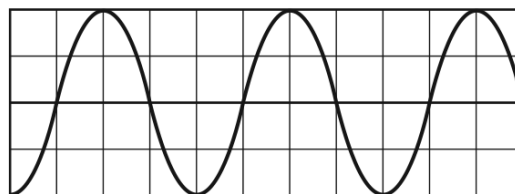
The speed of sound in air is 330 ms^{-1} .

What is the frequency of the tuning fork?

- A** 128 Hz **B** 256 Hz **C** 512 Hz **D** 1024 Hz

808. 9702_w18_qp_11 Q: 23

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.

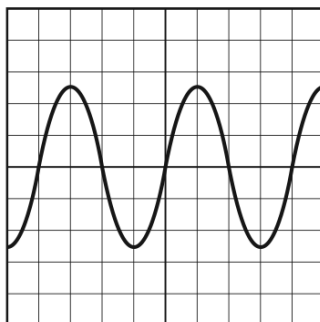
The Y-gain is set at 5.0 mV per division.

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

809. 9702_w18_qp_13 Q: 23

A sound wave is detected by a microphone. The output from the microphone is connected to the Y-input of a cathode-ray oscilloscope (c.r.o.). The trace on the c.r.o. is shown.



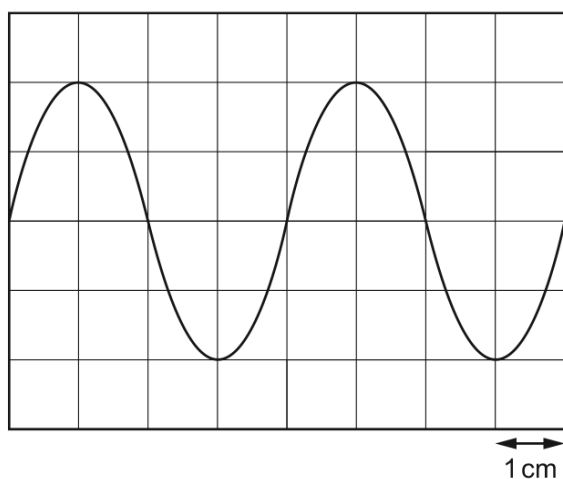
The time-base is set at 0.20 ms per division.

What is the frequency of the sound wave?

- A** 1000 Hz **B** 1250 Hz **C** 2000 Hz **D** 2500 Hz

810. 9702_s17_qp_11 Q: 24

A sound wave is displayed on the screen of a cathode-ray oscilloscope (c.r.o.) as shown.



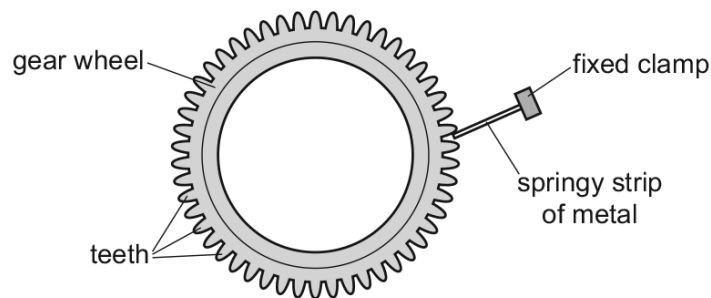
The time-base of the c.r.o. is set at 2.5 ms cm^{-1} .

What is the frequency of the sound wave?

- A** 50 Hz **B** 100 Hz **C** 200 Hz **D** 400 Hz

811. 9702_s17_qp_12 Q: 24

A bicycle gear wheel is a disc with 50 'teeth' equally spaced around its edge, as shown. The gear wheel is rotated 10 times each second. A springy strip of metal is vibrated by the rotating 'teeth'. The metal strip produces a sound of frequency that is equal to the frequency of vibration of the strip.



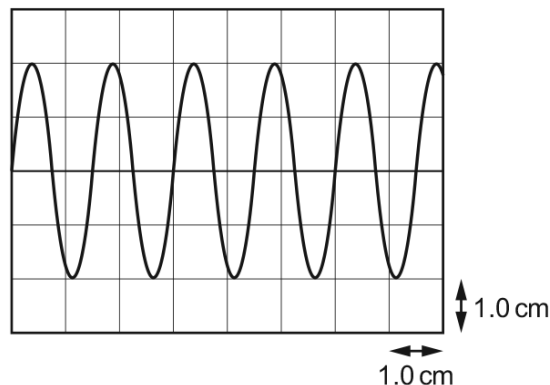
The speed of sound in air is 330 ms^{-1} .

What is the wavelength of the emitted sound?

- A** 0.66 m **B** 1.5 m **C** 6.6 m **D** 500 m

812. 9702_s17_qp_13 Q: 23

A trace is shown on the screen of a cathode-ray oscilloscope (c.r.o.).



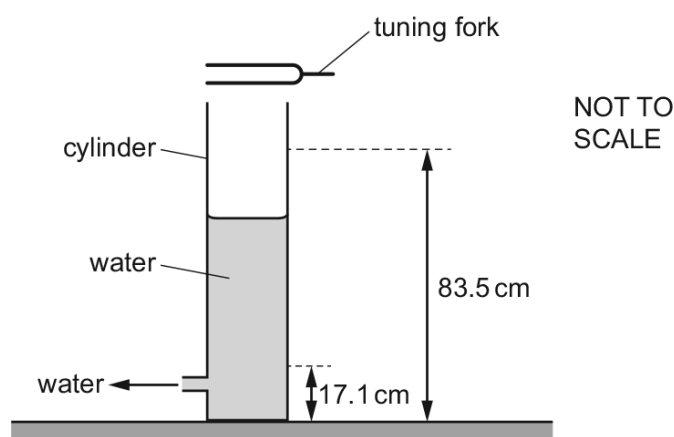
The time-base setting is 2.5 ms cm^{-1} and the Y-gain is 2.0 V cm^{-1} .

What is the frequency and the amplitude of the waveform displayed by the c.r.o.?

	frequency / Hz	amplitude / V
A	0.00375	4.0
B	0.00375	8.0
C	267	4.0
D	267	8.0

813. 9702_w17_qp_12 Q: 24

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.



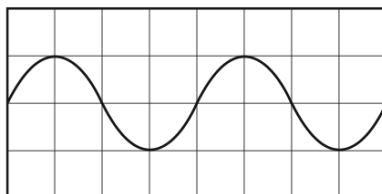
The speed of sound in air is 340 m s^{-1} .

What is the frequency of the tuning fork?

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

814. 9702_w17_qp_13 Q: 24

An electrical signal is displayed on a cathode-ray oscilloscope (c.r.o.).



The time-base setting is 50 ms div^{-1} .

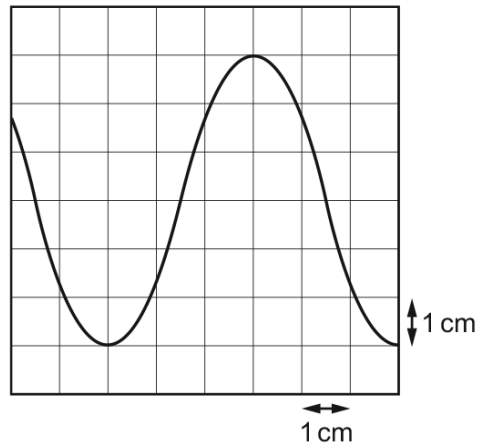
The Y-gain setting is 2 V div^{-1} .

What is the amplitude of the signal?

- A** 2 V **B** 4 V **C** 5 V **D** 10 V

815. 9702_s16_qp_12 Q: 22

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



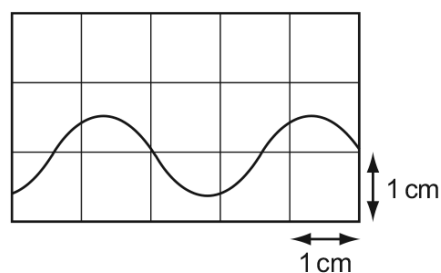
The time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 0.2 mV cm^{-1} .

What is the frequency of the sound from the loudspeaker and what is the amplitude of the trace on the c.r.o.?

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

816. 9702_s15_qp_13 Q: 25

A cathode-ray oscilloscope (c.r.o.) 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

8.4 Doppler effect

817. 9702_m20_qp_12 Q: 24

An observer is situated at the top of a tall tower. An aeroplane emitting sound at a frequency of 1000 Hz approaches the observer at a speed of 165 m s^{-1} .

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

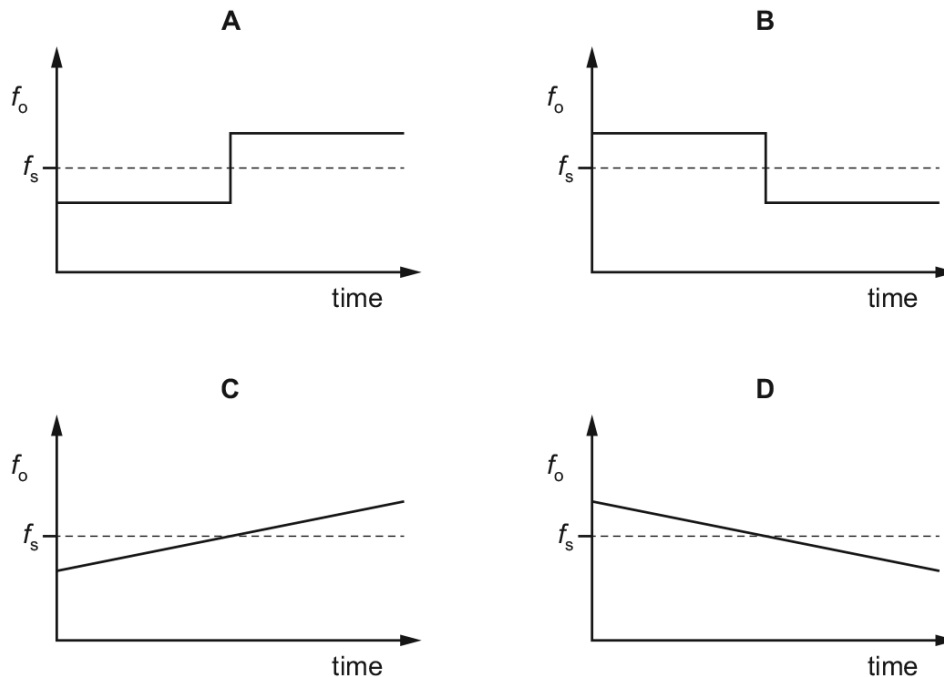
What is the frequency of the sound received by the observer?

- A** 330 Hz **B** 667 Hz **C** 1000 Hz **D** 2000 Hz

818. 9702_s20_qp_11 Q: 25

A source emitting sound of a single frequency f_s travels at constant speed directly towards an observer. The source then passes the observer and continues to move directly away from the observer. The velocity of the source remains constant.

Which graph represents the variation with time of the frequency f_o of the sound heard by the observer?



819. 9702_s20_qp_12 Q: 25

A stationary person measures the speed and wavelength of the sound from a horn on a stationary vehicle. The person then repeats the measurements when the vehicle is approaching at a constant speed.

Which row describes the measured wavelength and the measured speed of the sound wave from the moving vehicle when compared with the sound wave from the stationary vehicle?

	wavelength of the sound wave	speed of the sound wave
A	longer	greater
B	shorter	greater
C	longer	same
D	shorter	same

820. 9702_s20_qp_13 Q: 25

A stationary source S emits a sound wave of frequency f .

The source now moves away from a stationary observer.

Which statement is correct?

- A** The frequency of the source S and the observed frequency are now both higher than f .
- B** The frequency of the source S and the observed frequency are now both lower than f .
- C** The frequency of the source S is now lower than f .
- D** The observed frequency is now lower than f .

821. 9702_m19_qp_12 Q: 25

A buzzer emitting sound of frequency 846 Hz is attached to a string and rotated in a horizontal circle. The linear speed of the buzzer is 25.0 m s^{-1} .



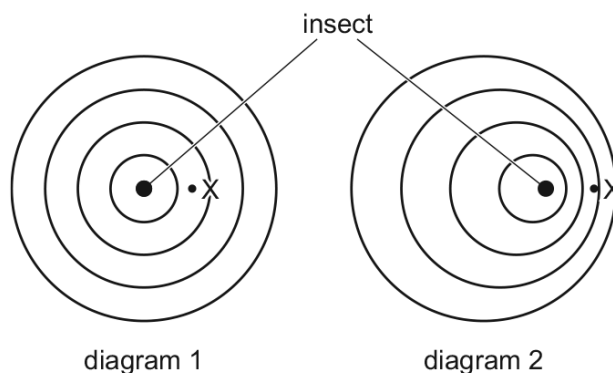
The speed of sound is 340 m s^{-1} .

What is the maximum frequency heard by the observer?

- A** 783 Hz **B** 788 Hz **C** 908 Hz **D** 913 Hz

822. 9702_s19_qp_11 Q: 25

A stationary insect on the surface of water creates circular waves with its legs, as shown in diagram 1. The insect begins to travel to the right as shown in diagram 2.



Which row describes the change to the waves at X caused by the movement of the insect?

	frequency	wave speed
A	decreases	increases
B	decreases	stays the same
C	increases	increases
D	increases	stays the same

823. 9702_s19_qp_11 Q: 26

A toy motorboat moving with constant velocity v vibrates up and down on the surface of a pond. This causes the boat to act as a source of circular water waves of frequency 2.0 Hz. The speed of the waves is 1.5 m s^{-1} .

A man, standing at the edge of the pond, observes that the waves from the boat approach him with a frequency of 3.0 Hz.

The formula for Doppler effect calculations with sound waves may also be used for water waves.

What is a possible value of v ?

	speed / m s^{-1}	direction
A	0.50	directly away from the man
B	0.50	directly towards the man
C	0.75	directly away from the man
D	0.75	directly towards the man

824. 9702_s19_qp_12 Q: 26

In one of the first experiments to demonstrate the Doppler effect, a train was filled with trumpeters all playing a note of frequency 440 Hz. The difference in observed frequency of the note as the train directly approached a stationary observer was 22 Hz. The speed of sound was 340 m s^{-1} .

At which speed was the train moving?

- A** 15.4 m s^{-1} **B** 16.2 m s^{-1} **C** 17.0 m s^{-1} **D** 17.9 m s^{-1}
-

825. 9702_s19_qp_13 Q: 24

A motor boat vibrates in the water so that it produces water waves of frequency 0.20 Hz. The speed of these waves in the water is 20 m s^{-1} . The motor boat moves with a speed of 5.0 m s^{-1} directly towards a stationary sailing boat.

The Doppler effect equation for sound waves also applies to water waves.

What is the frequency with which the waves hit the stationary sailing boat?

- A** 0.15 Hz **B** 0.16 Hz **C** 0.25 Hz **D** 0.27 Hz
-

826. 9702_w19_qp_11 Q: 24

The siren of a moving police car emits a sound wave with a frequency of 440 Hz. A stationary observer hears sound of frequency 494 Hz. The speed of sound in the air is 340 m s^{-1} .

What could be the speed and the direction of movement of the car?

- A** 37 m s^{-1} directly towards the observer
B 37 m s^{-1} directly away from the observer
C 42 m s^{-1} directly towards the observer
D 42 m s^{-1} directly away from the observer
-

827. 9702_w19_qp_12 Q: 23

A loudspeaker emitting a constant frequency of 2000 Hz is swung in a horizontal circle with a speed of 15.0 m s^{-1} .

A stationary observer is level with the loudspeaker and situated a long distance from the loudspeaker. The observer hears a sound of varying frequency. The maximum frequency heard is 2097 Hz.

What is the speed of the sound in the air?

- A** 294 m s^{-1} **B** 309 m s^{-1} **C** 324 m s^{-1} **D** 330 m s^{-1}
-

828. 9702_w19_qp_13 Q: 24

A siren emits sound of frequency 1000 Hz. The siren moves at 20 m s^{-1} towards an observer who is standing still.

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

Which expression would correctly give the frequency heard by the observer?

- A $\frac{1000 \times 330}{330 + 20}$
- B $\frac{1000 \times 330}{330 - 20}$
- C $\frac{1000 (330 + 20)}{330}$
- D $\frac{1000 (330 - 20)}{330}$

829. 9702_m18_qp_12 Q: 24

A vehicle carries a microwave transmitter that emits microwaves of a constant frequency. A stationary observer has a microwave receiver.

The vehicle moves directly towards the observer at constant speed. The observer detects microwaves of frequency F_o .

The vehicle then accelerates, still moving towards the observer, travels at higher steady speed for a time and then decelerates until it stops.

What is the variation in the frequency of the microwaves that are detected by the observer?

- A The observed frequency will fall, then remain steady then return to the frequency F_o .
- B The observed frequency will fall, then remain steady then rise to a higher frequency than F_o .
- C The observed frequency will rise, then remain steady then fall to a lower frequency than F_o .
- D The observed frequency will rise, then remain steady then return to the frequency F_o .

830. 9702_s18_qp_12 Q: 27

An astronomer observes the light from a star that is moving away from the Earth.

For the observed light, what has been increased due to the star's motion?

- A** amplitude
- B** frequency
- C** speed
- D** wavelength

831. 9702_s18_qp_13 Q: 23

A police car travels at a velocity of 30.0 m s^{-1} directly towards a stationary observer. The horn of the car emits sound of frequency 2000 Hz . The speed of sound is 340 m s^{-1} .

What is the frequency of the sound heard by the observer?

- A** 1840 Hz
- B** 2000 Hz
- C** 2180 Hz
- D** 2190 Hz

832. 9702_w18_qp_11 Q: 24

A jet aircraft travels at a speed of $0.8v$ where v is the speed of sound. The aircraft approaches a stationary observer. The frequency of sound emitted by the aircraft is 100 Hz .

Which frequency does the observer hear?

- A** 56 Hz
- B** 180 Hz
- C** 400 Hz
- D** 500 Hz

833. 9702_w18_qp_12 Q: 25

A police car has a two-tone siren emitting sound of frequencies of 700 Hz and 1000 Hz .

The police car is travelling at a speed of 40.0 m s^{-1} towards a stationary observer. The speed of sound in the air is 340 m s^{-1} .

What is the difference between the two frequencies of the sound that is heard by the observer?

- A** 268 Hz
 - B** 300 Hz
 - C** 335 Hz
 - D** 340 Hz
-

834. 9702_w18_qp_13 Q: 24

A bat flies directly towards a fixed ultrasound detector at a speed of 25.0 ms^{-1} emitting pulses of ultrasound of frequency 40.0 kHz .

The speed of sound in air is 330 ms^{-1} .

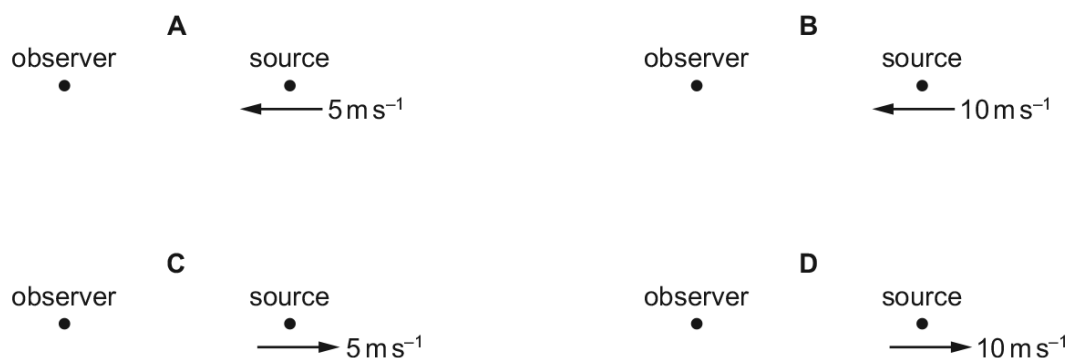
Which frequency does the ultrasound detector record?

- A** 37.0 kHz **B** 37.2 kHz **C** 43.0 kHz **D** 43.3 kHz

835. 9702_m17_qp_12 Q: 25

A source of sound waves is travelling as shown.

In which situation would the stationary observer detect the largest decrease in the observed frequency?



836. 9702_s17_qp_11 Q: 25

A car travelling in a straight line at a speed of 30 ms^{-1} passes near a stationary observer while sounding its horn. The true frequency of sound from the horn is 400 Hz .

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

What is the change in the frequency of the sound heard by the observer as the car passes?

- A** 39 Hz **B** 66 Hz **C** 72 Hz **D** 78 Hz

837. 9702_s17_qp_12 Q: 25

An ambulance travels along a straight road at a speed of 30.0 ms^{-1} . Its siren emits sound of frequency 2000 Hz . The speed of sound in the air is 340 ms^{-1} . The ambulance passes a man standing at the side of the road.

What is the frequency of the sound heard by the man as the ambulance moves towards him and as the ambulance moves away from him?

	frequency heard as ambulance moves towards man / Hz	frequency heard as ambulance moves away from man / Hz
A	1820	2180
B	1840	2190
C	2180	1820
D	2190	1840

838. 9702_s17_qp_13 Q: 24

A high-speed train approaches a stationary observer at a speed of 80 ms^{-1} . The train's horn emits a sound of frequency 250 Hz .

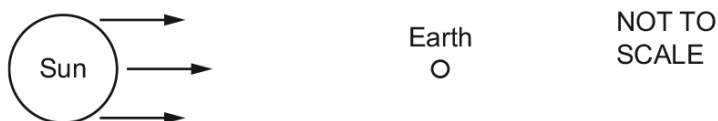
The speed of sound is 340 ms^{-1} .

What is the observed frequency of the sound from the horn?

- A** 190 Hz **B** 200 Hz **C** 310 Hz **D** 330 Hz

839. 9702_w17_qp_11 Q: 25

Light of a particular wavelength λ_s is emitted from the Sun. At any instant, a band of wavelengths ranging from less than λ_s to more than λ_s is observed on the Earth. This is caused by the Doppler effect.



What could be the explanation for this Doppler effect?

- A** The Sun is moving at right-angles to a line joining the Sun and the Earth.
B The Sun is moving away from the Earth.
C The Sun is moving towards the Earth.
D The Sun is rotating.

840. 9702_w17_qp_12 Q: 25

A train that is moving in a straight line along a railway track has a whistle that continuously emits sound of frequency f .

A woman standing by the side of the track hears sound of frequency $0.85f$.

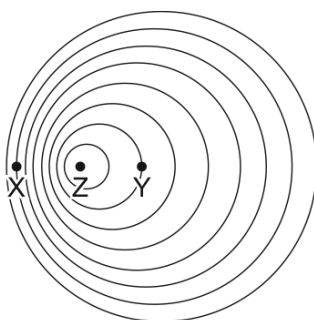
The speed of sound in the air is 340 m s^{-1} .

What is the velocity of the train?

- A 51 m s^{-1} away from the woman
- B 51 m s^{-1} towards the woman
- C 60 m s^{-1} away from the woman
- D 60 m s^{-1} towards the woman

841. 9702_w17_qp_13 Q: 25

A source of sound of frequency F at point Z is moving at a steady speed. The pattern of the emitted wavefronts is shown.



Which row describes the frequencies of the sound heard by stationary observers at X and Y?

	frequency heard at X	frequency heard at Y
A	$<F$	$<F$
B	$<F$	$>F$
C	$>F$	$<F$
D	$>F$	$>F$

842. 9702_w17_qp_13 Q: 26

A car travelling at a steady speed in a straight line passes close to a stationary observer. The observer measures the frequency of the sound from the engine.

As the car approaches, the observed frequency is 220 Hz. When the car moves away, the observed frequency is 180 Hz.

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

What is the speed of the car?

- A** 8.5 ms^{-1} **B** 31 ms^{-1} **C** 34 ms^{-1} **D** 38 ms^{-1}
-

843. 9702_m16_qp_12 Q: 20

With which types of wave can the Doppler shift be observed?

- A** all types of wave
B light and sound waves only
C sound waves and water waves only
D sound waves only
-

844. 9702_m16_qp_12 Q: 21

A distant star is receding from the Earth with a speed of $1.40 \times 10^7 \text{ ms}^{-1}$. It emits light of frequency $4.57 \times 10^{14} \text{ Hz}$. The speed of light is $3.00 \times 10^8 \text{ ms}^{-1}$.

The Doppler effect formula can be used with light waves.

What will be the frequency of this light when detected on Earth?

- A** $2.04 \times 10^{13} \text{ Hz}$
B $4.37 \times 10^{14} \text{ Hz}$
C $4.57 \times 10^{14} \text{ Hz}$
D $4.79 \times 10^{14} \text{ Hz}$
-

845. 9702_s16_qp_12 Q: 23

A source of sound of frequency 1000 Hz moves away from a stationary observer at a speed of 30.0 ms^{-1} . The speed of sound is 330 ms^{-1} .

What is the frequency of the sound heard by the observer?

- A** 909 Hz **B** 917 Hz **C** 1090 Hz **D** 1100 Hz
-

846. 9702_s16_qp_13 Q: 24

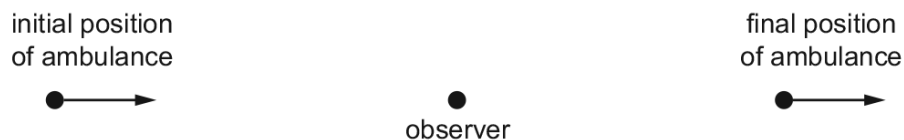
When a car travelling with constant velocity passes a stationary observer, the observer hears a change in the frequency of the sound emitted by the car.

Which statement is correct?

- A** The change in frequency is greater as the car moves away than as it approaches.
- B** The greater the speed of the car, the greater the change in observed frequency.
- C** The observed frequency is lower as the car moves towards the observer and higher as the car moves away from the observer.
- D** The volume of the sound heard by the observer does not change as the car approaches.

847. 9702_w16_qp_11 Q: 26

The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1} . The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.



Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

- A** 49 Hz
- B** 84 Hz
- C** 91 Hz
- D** 98 Hz

848. 9702_w16_qp_12 Q: 25

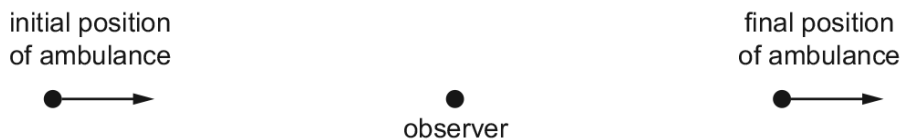
A man standing next to a stationary train hears sound of frequency 400 Hz emitted from the train's horn. The train then moves directly away from the man and sounds its horn when it has a speed of 50 m s^{-1} . The speed of sound is 340 m s^{-1} .

What is the difference in frequency of the sound heard by the man on the two occasions?

- A** 51 Hz
- B** 69 Hz
- C** 349 Hz
- D** 469 Hz

849. 9702_w16_qp_13 Q: 26

The warning signal on an ambulance has a frequency of 600 Hz. The speed of sound is 330 m s^{-1} . The ambulance is travelling with a constant velocity of 25 m s^{-1} towards an observer.



Which overall change in observed frequency takes place between the times at which the ambulance is a long way behind the observer and when it is a long way in front of the observer?

- A** 49 Hz **B** 84 Hz **C** 91 Hz **D** 98 Hz

8.5 Electromagnetic spectrum

850. 9702_m20_qp_12 Q: 25

What is the order of magnitude of the wavelengths of microwaves and X-rays?

	wavelength of microwaves / m	wavelength of X-rays / m
A	10^{-6}	10^3
B	10^{-2}	10^3
C	10^{-6}	10^{-10}
D	10^{-2}	10^{-10}

851. 9702_s20_qp_11 Q: 26

What are the names of the electromagnetic waves that have wavelengths in a vacuum of 100 pm and of $100 \mu\text{m}$?

	wavelength 100 pm	wavelength $100 \mu\text{m}$
A	γ -rays	infrared
B	γ -rays	red light
C	X-rays	infrared
D	X-rays	red light

852. 9702_s20_qp_12 Q: 26

The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma-ray	X-ray	infrared	microwave	radio wave
B	radio wave	microwave	infrared	X-ray	gamma-ray
C	radio wave	microwave	ultraviolet	infrared	X-ray
D	X-ray	infrared	ultraviolet	microwave	radio wave

853. 9702_s20_qp_13 Q: 26

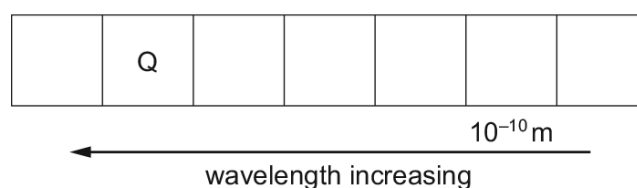
The table lists possible wavelengths of four different electromagnetic waves.

Which row is correct?

	type of wave	approximate wavelength / m
A	infrared	10^{-5}
B	radio	10^{-3}
C	ultraviolet	10^{-12}
D	X-rays	10^{-7}

854. 9702_m19_qp_12 Q: 26

The diagram shows the principal regions of the electromagnetic spectrum, with some details labelled. The diagram is not to scale.



What is a typical order of magnitude of the wavelength of the radiation in region Q?

- A** 10^{-7} m **B** 10^{-5} m **C** 10^{-2} m **D** 10^0 m

855. 9702_s19_qp_12 Q: 27

The electromagnetic spectrum consists of waves with different wavelengths.

Which row correctly identifies regions of the electromagnetic spectrum?

	10^{-10} m	10^{-8} m	10^{-5} m	10^{-2} m
A	microwaves	X-rays	ultraviolet	infrared
B	infrared	microwaves	X-rays	ultraviolet
C	microwaves	infrared	ultraviolet	X-rays
D	X-rays	ultraviolet	infrared	microwaves

856. 9702_s19_qp_13 Q: 25

Infrared laser light is used for the transmission of data along optic fibres.

What is a typical wavelength of infrared radiation?

- A** 5×10^{-5} m **B** 5×10^{-7} m **C** 2×10^{-9} m **D** 2×10^{-11} m

857. 9702_w19_qp_11 Q: 25

An electromagnetic wave has a wavelength of 138 pm in a vacuum.

To which region of the electromagnetic spectrum does this wave belong?

- A** radio wave
B microwave
C visible light
D X-ray

858. 9702_w19_qp_12 Q: 24

Two electromagnetic waves have wavelengths of 5.0×10^{-7} m and 5.0×10^{-2} m.

Which row identifies the regions of the electromagnetic spectrum to which the waves belong?

	wavelength 5.0×10^{-7} m	wavelength 5.0×10^{-2} m
A	ultraviolet	infrared
B	visible	microwave
C	ultraviolet	microwave
D	visible	infrared

859. 9702_m18_qp_12 Q: 23

The table lists possible orders of magnitude of the wavelengths of some of the principal radiations of the electromagnetic spectrum.

Which row shows the correct orders of magnitude of the wavelengths?

	wavelength / m			
	microwaves	infra-red	ultraviolet	X-rays
A	10^{-6}	10^{-10}	10^{-12}	10^{-14}
B	10^{-4}	10^{-8}	10^{-10}	10^{-12}
C	10^{-2}	10^{-6}	10^{-8}	10^{-10}
D	10^2	10^{-4}	10^{-6}	10^{-8}

860. 9702_s18_qp_11 Q: 21

Which region of the electromagnetic spectrum includes waves with a frequency of 10^7 MHz?

- A** infra-red waves
- B** radio waves
- C** ultraviolet waves
- D** X-rays

861. 9702_s18_qp_11 Q: 23

What can be deduced from a table of wavelengths of the waves in the electromagnetic spectrum?

- A** Green light has a shorter wavelength than X-rays.
- B** Red light has a shorter wavelength than green light.
- C** The wavelength range for radio waves is less than that for infra-red waves.
- D** The wavelength range for X-rays is less than that for radio waves.

862. 9702_s18_qp_12 Q: 22

Two lasers emit light in a vacuum. One laser emits red light and the other emits green light.

Which property of the two laser beams **must** be different?

- A amplitude
 - B frequency
 - C intensity
 - D speed
-

863. 9702_w18_qp_11 Q: 25

A telescope detects and analyses some electromagnetic radiation of wavelength 2 cm.

Which type of telescope is it?

- A microwave telescope
 - B optical telescope
 - C radio telescope
 - D X-ray telescope
-

864. 9702_w18_qp_12 Q: 26

A surveyor's device emits a pulse of light. The light is reflected from a wall 150 m away.

What is the time taken for the pulse to travel from the device to the wall and then back to the device?

- A 0.05 ns B 0.10 ns C 0.50 μ s D 1.0 μ s
-

865. 9702_w18_qp_13 Q: 25

An electromagnetic wave has a wavelength of 1.0×10^{-7} m.

To which region of the electromagnetic spectrum does this wave belong?

- A infra-red
 - B ultraviolet
 - C visible
 - D X-ray
-

866. 9702_m17_qp_12 Q: 26

M and N are two electromagnetic waves.

The ratio

$$\frac{\text{wavelength of M}}{\text{wavelength of N}} = 10^5.$$

What could M and N be?

	M	N
A	microwaves	visible light
B	microwaves	γ -rays
C	γ -rays	microwaves
D	visible light	microwaves

867. 9702_s17_qp_11 Q: 26

Which list shows electromagnetic waves in order of increasing frequency?

- A** radio waves $\rightarrow$ gamma rays $\rightarrow$ ultraviolet $\rightarrow$ infra-red
B radio waves $\rightarrow$ infra-red $\rightarrow$ ultraviolet $\rightarrow$ gamma rays
C ultraviolet $\rightarrow$ gamma rays $\rightarrow$ radio waves $\rightarrow$ infra-red
D ultraviolet $\rightarrow$ infra-red $\rightarrow$ radio waves $\rightarrow$ gamma rays

868. 9702_s17_qp_12 Q: 26

Three different electromagnetic waves P, Q and R have the frequencies shown.

	frequency / Hz
P	3×10^{10}
Q	3×10^{13}
R	6×10^{14}

Which row identifies P, Q and R?

	P	Q	R
A	infra-red	visible	ultraviolet
B	microwave	infra-red	visible
C	ultraviolet	X-ray	gamma ray
D	visible	ultraviolet	X-ray

869. 9702_s17_qp_13 Q: 25

Which row shows a correct frequency in Hz for each of the four principal radiations?

	X-rays	ultraviolet	microwaves	infra-red
A	10^{10}	10^{14}	10^{18}	10^{15}
B	10^{14}	10^{18}	10^{15}	10^{10}
C	10^{15}	10^{10}	10^{14}	10^{18}
D	10^{18}	10^{15}	10^{10}	10^{14}

870. 9702_w17_qp_11 Q: 4

What is a typical value of the wavelength of a microwave travelling in a vacuum?

- A** 3 000 000 pm
B 30 nm
C 30 000 μm
D 3000 mm

871. 9702_w17_qp_11 Q: 26

What is the order of magnitude of the frequencies of electromagnetic waves in the visible spectrum?

- A** 10^{10} Hz **B** 10^{12} Hz **C** 10^{14} Hz **D** 10^{16} Hz

872. 9702_w17_qp_12 Q: 26

Orange light in a vacuum has a wavelength of 600 nm.

What is the frequency of this light?

- A** 180 Hz **B** 5.0×10^5 Hz **C** 1.8×10^{11} Hz **D** 5.0×10^{14} Hz

873. 9702_w17_qp_13 Q: 27

Which frequency of electromagnetic radiation could be ultraviolet?

- A** 1.0×10^6 Hz
B 1.0×10^9 Hz
C 1.0×10^{12} Hz
D 1.0×10^{15} Hz

874. 9702_w17_qp_13 Q: 28

An electromagnetic wave travels in a straight line through a vacuum. The wave has a frequency of 6.0 THz.

What is the number of wavelengths in a distance of 1.0 m along the wave?

- A** 5.0×10^{-5} **B** 2.0×10^1 **C** 2.0×10^4 **D** 5.0×10^7

875. 9702_s16_qp_11 Q: 23

Which electromagnetic waves have the wavelengths of 10^{-2} m, 10^{-5} m, 10^{-10} m and 10^{-13} m?

	10^{-2} m	10^{-5} m	10^{-10} m	10^{-13} m
A	infra-red	microwaves	visible light	X-rays
B	microwaves	infra-red	X-rays	gamma rays
C	microwaves	visible light	ultraviolet	gamma rays
D	radio waves	microwaves	ultraviolet	X-rays

876. 9702_s16_qp_12 Q: 24

Each of the principal radiations of the electromagnetic spectrum has a range of wavelengths.

Which wavelength is correctly linked to its radiation?

	wavelength / m	radiation
A	10^{-9}	gamma ray
B	10^{-5}	microwave
C	10^{-8}	ultraviolet
D	10^{-14}	X-ray

877. 9702_w16_qp_11 Q: 23

The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

878. 9702_w16_qp_13 Q: 23

The table shows the wavelengths of five electromagnetic waves.

Which row correctly identifies the principal radiation for each of these wavelengths?

	10^{-14} m	10^{-10} m	10^{-6} m	10^{-2} m	10^2 m
A	gamma ray	X-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	X-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	X-ray
D	X-ray	infra-red	ultraviolet	microwave	radio wave

879. 9702_s15_qp_11 Q: 27

An electromagnetic wave has a wavelength that is numerically of the same order of magnitude as the diameter of a nucleus.

In which region of the electromagnetic spectrum does the wave occur?

- A** gamma ray
- B** X-ray
- C** visible light
- D** infra-red

Paper 1 Multiple Choice Answers: Waves

Question	Paper	Q. No.	Answer
721	9702_m20_qp_12	21	B
722	9702_s20_qp_11	22	A
723	9702_s20_qp_11	23	A
724	9702_s20_qp_12	22	C
725	9702_s20_qp_13	22	B
726	9702_m19_qp_12	1	A
727	9702_m19_qp_12	23	C
728	9702_s19_qp_11	27	D
729	9702_s19_qp_12	23	A
730	9702_s19_qp_12	24	D
731	9702_s19_qp_13	21	C
732	9702_s19_qp_13	22	C
733	9702_w19_qp_11	21	C
734	9702_w19_qp_12	20	D
735	9702_w19_qp_12	21	D
736	9702_w19_qp_13	25	A
737	9702_m18_qp_12	21	D
738	9702_s18_qp_11	20	B
739	9702_s18_qp_13	20	C
740	9702_s18_qp_13	21	D
741	9702_w18_qp_11	21	D
742	9702_w18_qp_12	22	D
743	9702_w18_qp_13	21	D
744	9702_m17_qp_12	22	C
745	9702_m17_qp_12	24	C
746	9702_s17_qp_12	22	C
747	9702_s17_qp_13	21	B
748	9702_s16_qp_11	22	A
749	9702_s16_qp_13	23	B
750	9702_s16_qp_13	25	D
751	9702_w16_qp_12	23	A
752	9702_s15_qp_11	25	B
753	9702_s15_qp_11	26	D
754	9702_s15_qp_12	24	C
755	9702_s15_qp_12	25	B
756	9702_s15_qp_13	26	D
757	9702_m20_qp_12	22	A
758	9702_s20_qp_12	21	A
759	9702_s20_qp_13	23	D
760	9702_s19_qp_11	22	A
761	9702_s19_qp_11	23	A
762	9702_w19_qp_11	22	C
763	9702_w19_qp_12	26	B
764	9702_w19_qp_13	21	C
765	9702_w19_qp_13	22	B
766	9702_w19_qp_13	27	A

Paper 1 Multiple Choice Answers: Waves (continued)

Question	Paper	Q. No.	Answer
767	9702_m18_qp_12	22	A
768	9702_s18_qp_11	22	B
769	9702_s18_qp_11	24	C
770	9702_w18_qp_11	22	C
771	9702_w18_qp_12	23	B
772	9702_w18_qp_13	22	B
773	9702_m17_qp_12	23	A
774	9702_s17_qp_11	22	B
775	9702_s17_qp_11	23	B
776	9702_s17_qp_12	23	B
777	9702_s17_qp_13	22	A
778	9702_w17_qp_11	22	B
779	9702_w17_qp_12	22	D
780	9702_w17_qp_12	23	D
781	9702_w17_qp_13	22	C
782	9702_w17_qp_13	23	D
783	9702_m16_qp_12	22	B
784	9702_s16_qp_12	25	C
785	9702_w16_qp_11	25	D
786	9702_w16_qp_12	24	B
787	9702_w16_qp_13	25	D
788	9702_s15_qp_11	24	D
789	9702_s15_qp_11	28	B
790	9702_m20_qp_12	23	B
791	9702_s20_qp_11	24	B
792	9702_s20_qp_12	23	A
793	9702_s20_qp_13	24	B
794	9702_m19_qp_12	22	D
795	9702_m19_qp_12	24	D
796	9702_s19_qp_11	4	D
797	9702_s19_qp_11	24	C
798	9702_s19_qp_12	25	D
799	9702_s19_qp_12	28	C
800	9702_s19_qp_13	23	B
801	9702_w19_qp_12	22	C
802	9702_w19_qp_13	23	B
803	9702_m18_qp_12	25	B
804	9702_s18_qp_12	23	D
805	9702_s18_qp_12	26	C
806	9702_s18_qp_13	22	B
807	9702_s18_qp_13	24	B
808	9702_w18_qp_11	23	A
809	9702_w18_qp_13	23	B
810	9702_s17_qp_11	24	B
811	9702_s17_qp_12	24	A
812	9702_s17_qp_13	23	C

Paper 1 Multiple Choice Answers: Waves (continued)

Question	Paper	Q. No.	Answer
813	9702_w17_qp_12	24	B
814	9702_w17_qp_13	24	A
815	9702_sl6_qp_12	22	A
816	9702_sl5_qp_13	25	C
817	9702_m20_qp_12	24	D
818	9702_s20_qp_11	25	B
819	9702_s20_qp_12	25	D
820	9702_s20_qp_13	25	D
821	9702_m19_qp_12	25	D
822	9702_sl9_qp_11	25	D
823	9702_sl9_qp_11	26	B
824	9702_sl9_qp_12	26	B
825	9702_sl9_qp_13	24	D
826	9702_w19_qp_11	24	A
827	9702_w19_qp_12	23	C
828	9702_w19_qp_13	24	B
829	9702_m18_qp_12	24	C
830	9702_sl8_qp_12	27	D
831	9702_sl8_qp_13	23	D
832	9702_w18_qp_11	24	D
833	9702_w18_qp_12	25	D
834	9702_w18_qp_13	24	D
835	9702_m17_qp_12	25	D
836	9702_sl7_qp_11	25	C
837	9702_sl7_qp_12	25	D
838	9702_sl7_qp_13	24	D
839	9702_w17_qp_11	25	D
840	9702_w17_qp_12	25	C
841	9702_w17_qp_13	25	C
842	9702_w17_qp_13	26	C
843	9702_m16_qp_12	20	A
844	9702_m16_qp_12	21	B
845	9702_sl6_qp_12	23	B
846	9702_sl6_qp_13	24	B
847	9702_w16_qp_11	26	C
848	9702_w16_qp_12	25	A
849	9702_w16_qp_13	26	C
850	9702_m20_qp_12	25	D
851	9702_s20_qp_11	26	C
852	9702_s20_qp_12	26	A
853	9702_s20_qp_13	26	A
854	9702_m19_qp_12	26	C
855	9702_sl9_qp_12	27	D
856	9702_sl9_qp_13	25	A
857	9702_w19_qp_11	25	D
858	9702_w19_qp_12	24	B

Paper 1 Multiple Choice Answers: Waves (continued)

Question	Paper	Q. No.	Answer
859	9702_m18_qp_12	23	C
860	9702_s18_qp_11	21	A
861	9702_s18_qp_11	23	D
862	9702_s18_qp_12	22	B
863	9702_w18_qp_11	25	A
864	9702_w18_qp_12	26	D
865	9702_w18_qp_13	25	B
866	9702_m17_qp_12	26	A
867	9702_s17_qp_11	26	B
868	9702_s17_qp_12	26	B
869	9702_s17_qp_13	25	D
870	9702_w17_qp_11	4	C
871	9702_w17_qp_11	26	C
872	9702_w17_qp_12	26	D
873	9702_w17_qp_13	27	D
874	9702_w17_qp_13	28	C
875	9702_s16_qp_11	23	B
876	9702_s16_qp_12	24	C
877	9702_w16_qp_11	23	A
878	9702_w16_qp_13	23	A
879	9702_s15_qp_11	27	A

Chapter 8

Waves

8.1 Progressive waves

129. 9702_w20_qp_21 Q: 5

A progressive wave Y passes a point P. The variation with time t of the displacement x for the wave at P is shown in Fig. 5.1.

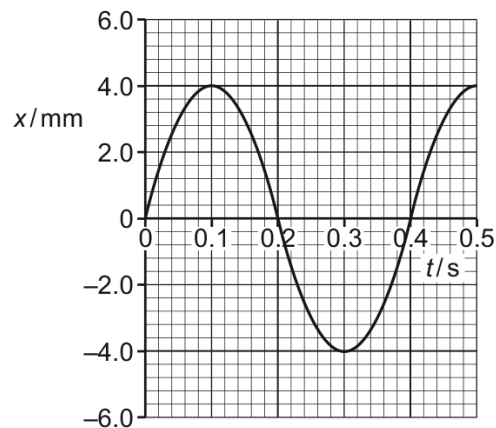


Fig. 5.1

The wave has a wavelength of 8.0 cm.

- (a) Determine the speed of the wave.

speed = ... ms^{-1} [2]

- (b) A second wave Z has wavelength 8.0 cm and amplitude 2.0 mm at point P. Waves Y and Z have the same speed.

For the waves at point P, calculate the ratio

$$\frac{\text{intensity of wave Z}}{\text{intensity of wave Y}}$$

ratio = ... [3]

[Total: 5]

130. 9702_w15_qp_21 Q: 2

The signal from a microwave detector is recorded on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 2.1.

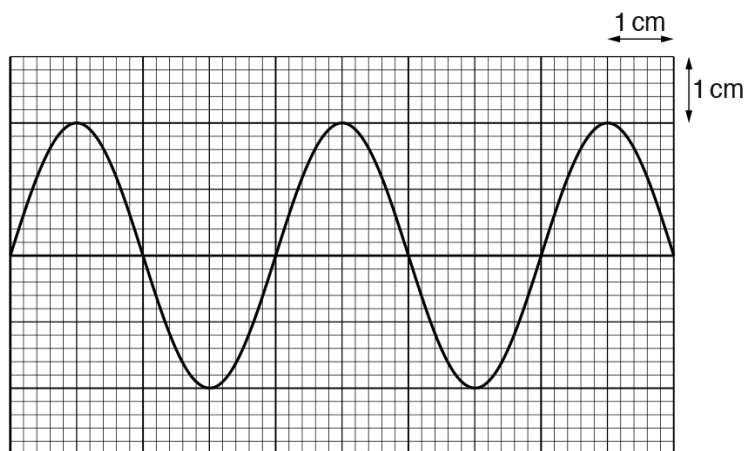


Fig. 2.1

The time-base setting on the c.r.o. is 50 ps cm^{-1} .

(a) Using Fig. 2.1, determine the wavelength of the microwaves.

wavelength = ... m [4]

(b) The signal from a radio wave detector is recorded on the same c.r.o.
The wavelength of the radio waves is $1.5 \times 10^3 \text{ m}$.

Determine the time-base setting required to display the same number of oscillations on the c.r.o. as shown in Fig. 2.1.

time-base setting = ... unit..... [2]

8.2 Transverse and longitudinal waves

131. 9702_w18_qp_22 Q: 4

- (a) Sound waves are longitudinal waves. By reference to the direction of propagation of energy, state what is meant by a *longitudinal* wave.

.....
[1]

- (b) A stationary sound wave in air has amplitude A . In an experiment, a detector is used to determine A^2 . The variation of A^2 with distance x along the wave is shown in Fig. 4.1.

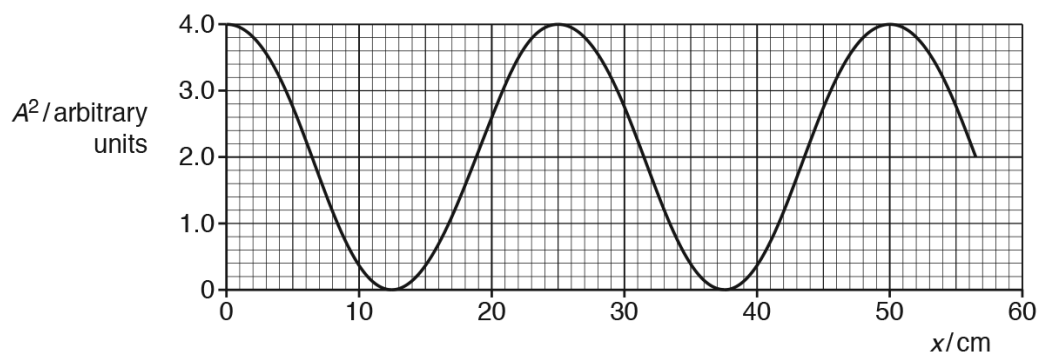


Fig. 4.1

- (i) State the phase difference between the vibrations of an air particle at $x = 25\text{ cm}$ and the vibrations of an air particle at $x = 50\text{ cm}$.

phase difference = ... ° [1]

- (ii) The speed of the sound in the air is 330 ms^{-1} . Determine the frequency of the sound wave.

frequency = ... Hz [3]

- (iii) Determine the ratio

$$\frac{\text{amplitude } A \text{ of wave at } x = 20\text{ cm}}{\text{amplitude } A \text{ of wave at } x = 25\text{ cm}}$$

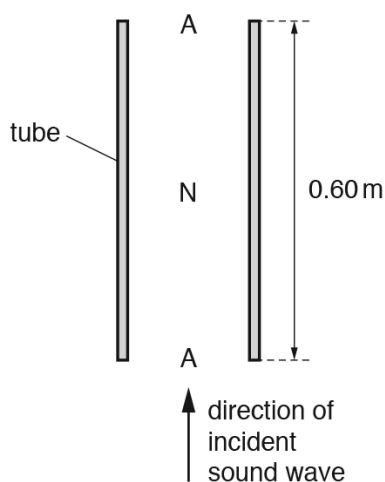
ratio = ... [2]

[Total: 7]

8.3 Determination of frequency and wavelength of sound waves

132. 9702_s19_qp_23 Q: 5

A vertical tube of length 0.60 m is open at both ends, as shown in Fig. 5.1.

**Fig. 5.1**

An incident sinusoidal sound wave of a single frequency travels up the tube. A stationary wave is then formed in the air column in the tube with antinodes A at both ends and a node N at the midpoint.

- (a) Explain how the stationary wave is formed from the incident sound wave.

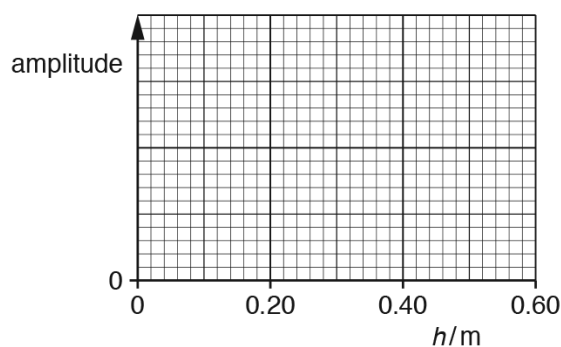
.....

.....

.....

.....[2]

- (b) On Fig. 5.2, sketch a graph to show the variation of the amplitude of the stationary wave with height h above the bottom of the tube.

**Fig. 5.2**

[2]

(c) For the stationary wave, state:

- (i) the direction of the oscillations of an air particle at a height of 0.15 m above the bottom of the tube

.....[1]

- (ii) the phase difference between the oscillations of a particle at a height of 0.10 m and a particle at a height of 0.20 m above the bottom of the tube.

phase difference = ... ° [1]

(d) The speed of the sound wave is 340 m s^{-1} .

Calculate the frequency of the sound wave.

frequency = ... Hz [2]

(e) The frequency of the sound wave is gradually increased.

Determine the frequency of the wave when a stationary wave is next formed.

frequency = ... Hz [1]

[Total: 9]

133. 9702_w19_qp_22 Q: 5

- (a) State what is meant by the *wavelength* of a progressive wave.

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

- (b) A cathode-ray oscilloscope (CRO) is used to analyse a sound wave. The screen of the CRO is shown in Fig. 5.1.

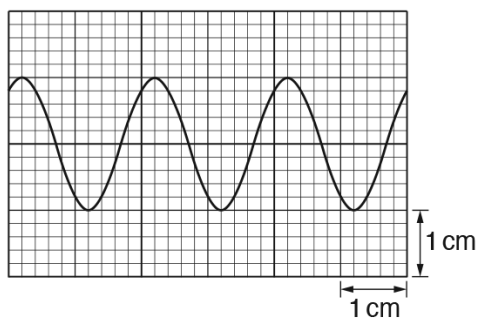


Fig. 5.1

The time-base setting of the CRO is 2.5 ms cm^{-1} .

Determine the frequency of the sound wave.

frequency = ... Hz [2]

- (c) The source emitting the sound in (b) is at point A. Waves travel from the source to point C along two different paths, AC and ABC, as shown in Fig. 5.2.

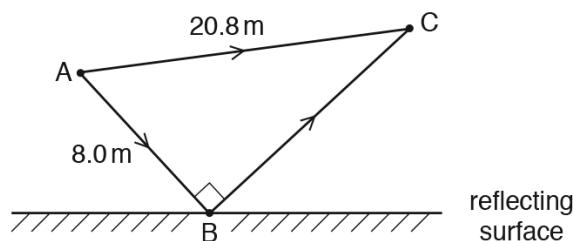


Fig. 5.2 (not to scale)

Distance AB is 8.0 m and distance AC is 20.8 m. Angle ABC is 90° . Assume that there is no phase change of the sound wave due to the reflection at point B. The wavelength of the waves is 1.6 m.

- (i) Show that the waves meeting at C have a path difference of 6.4 m.

[1]

- (ii) Explain why an intensity maximum is detected at point C.

.....

 [2]

- (iii) Determine the difference between the times taken for the sound to travel from the source to point C along the two different paths.

time difference = ... s [2]

- (iv) The wavelength of the sound is gradually increased. Calculate the wavelength of the sound when an intensity maximum is next detected at point C.

wavelength = ... m [1]

[Total: 9]

134. 9702_s17_qp_22 Q: 5

(a) Define the *frequency* of a sound wave.

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

(b) A sound wave travels through air. Describe the motion of the air particles relative to the direction of travel of the sound wave.

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

- (c) The sound wave emitted from the horn of a stationary car is detected with a microphone and displayed on a cathode-ray oscilloscope (c.r.o.), as shown in Fig. 5.1.

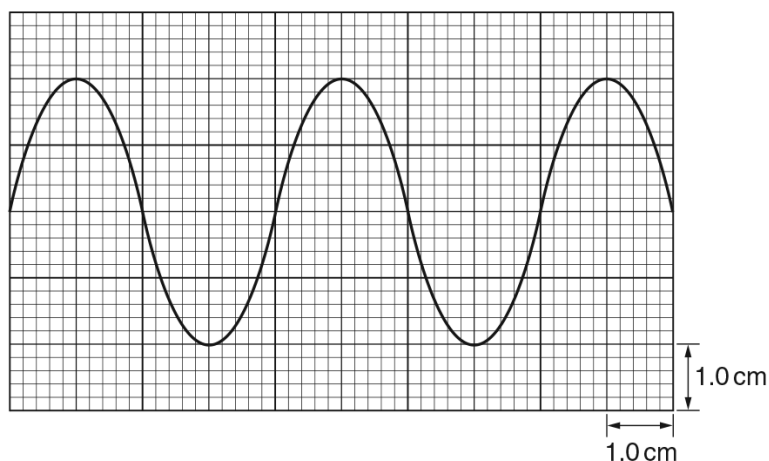


Fig. 5.1

The y -axis setting is 5.0 mV cm^{-1} .
The time-base setting is 0.50 ms cm^{-1} .

- (i) Use Fig. 5.1 to determine the frequency of the sound wave.

frequency = ... Hz [2]

- (ii) The horn of the car sounds continuously. Describe the changes to the trace seen on the c.r.o. as the car travels at constant speed

1. directly towards the stationary microphone,

.....
.....

2. directly away from the stationary microphone.

.....
.....

[3]

[Total: 7]

8.4 Doppler effect

135. 9702_m20_qp_22 Q: 2

A dolphin is swimming under water at a constant speed of 4.50 m s^{-1} .

- (a) The dolphin emits a sound as it swims directly towards a stationary submerged diver. The frequency of the sound heard by the diver is 9560 Hz . The speed of sound in the water is 1510 m s^{-1} .

Determine the frequency, to three significant figures, of the sound emitted by the dolphin.

frequency = ... Hz [2]

- (b) The dolphin strikes the bottom of a floating ball so that the ball rises vertically upwards from the surface of the water, as illustrated in Fig. 2.1.

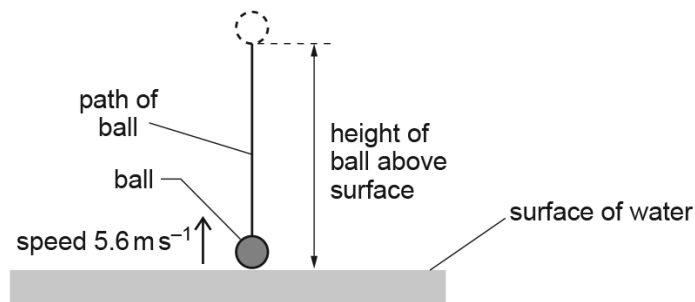


Fig. 2.1

The ball leaves the water surface with speed 5.6 m s^{-1} .

Assume that air resistance is negligible.

- (i) Calculate the maximum height reached by the ball above the surface of the water.

height = ... m [2]

- (ii) The ball leaves the water at time $t = 0$ and reaches its maximum height at time $t = T$.

On Fig. 2.2, sketch a graph to show the variation of the speed of the ball with time t from $t = 0$ to $t = T$. Numerical values are **not** required.

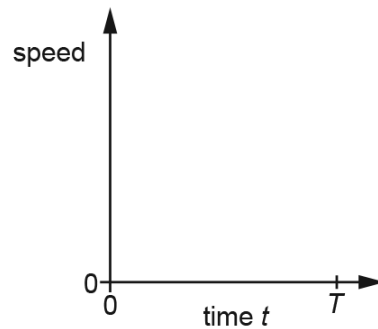


Fig. 2.2

[1]

- (iii) The mass of the ball is 0.45 kg.

Use your answer in (b)(i) to calculate the change in gravitational potential energy of the ball as it rises from the surface of the water to its maximum height.

change in gravitational potential energy = ... J [2]

- (iv) State and explain the variation in the magnitude of the acceleration of the ball as it falls back towards the surface of the water if air resistance is **not** negligible.

.....

.....

.....

.....

..... [2]

[Total: 9]

136. 9702_s19_qp_22 Q: 2

- (a) State Newton's second law of motion.

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

- (b) A car of mass 850 kg tows a trailer in a straight line along a horizontal road, as shown in Fig. 2.1.

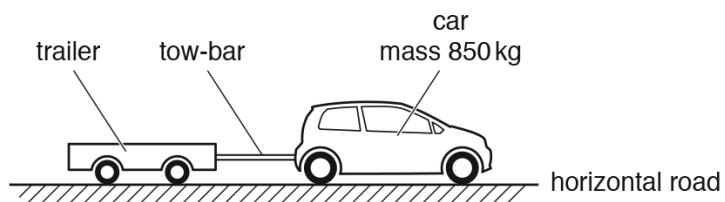


Fig. 2.1

The car and the trailer are connected by a horizontal tow-bar.

The variation with time t of the velocity v of the car for a part of its journey is shown in Fig. 2.2.

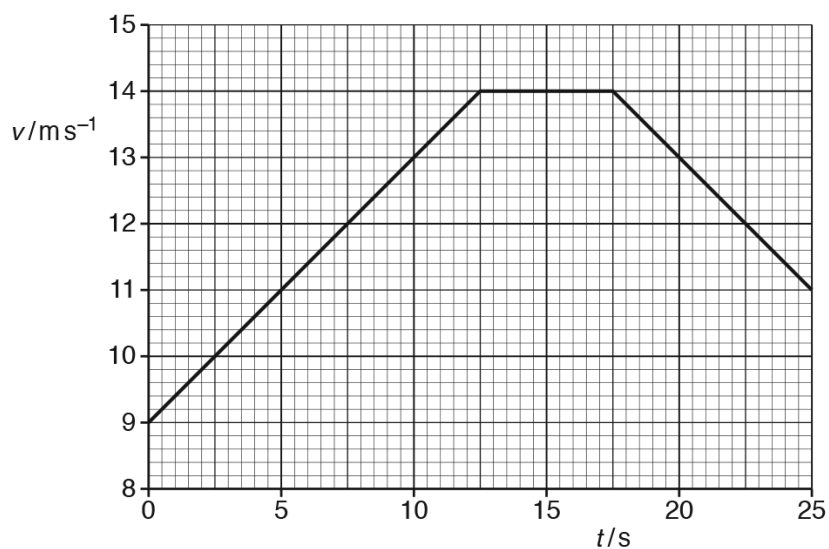


Fig. 2.2

- (i) Calculate the distance travelled by the car from time $t = 0$ to $t = 10$ s.

distance = ... m [2]

- (ii) At time $t = 10$ s, the resistive force acting on the car due to air resistance and friction is 510 N. The tension in the tow-bar is 440 N.

For the car at time $t = 10$ s:

1. use Fig. 2.2 to calculate the acceleration

acceleration = ... ms^{-2} [2]

2. use your answer to calculate the resultant force acting on the car

resultant force = ... N [1]

3. show that a horizontal force of 1300 N is exerted on the car by its engine

[1]

4. determine the useful output power of the engine.

output power = ... W [2]

- (c) A short time later, the car in (b) is travelling at a constant speed and the tension in the tow-bar is 480 N.

The tow-bar is a solid metal rod that obeys Hooke's law. Some data for the tow-bar are listed below.

Young modulus of metal = 2.2×10^{11} Pa

original length of tow-bar = 0.48 m

cross-sectional area of tow-bar = 3.0×10^{-4} m²

Determine the extension of the tow-bar.

extension = ... m [3]

- (d) The driver of the car in (b) sees a pedestrian standing directly ahead in the distance. The driver operates the horn of the car from time $t = 15$ s to $t = 17$ s. The frequency of the sound heard by the pedestrian is 480 Hz. The speed of the sound in the air is 340 ms⁻¹.

Use Fig. 2.2 to calculate the frequency of the sound emitted by the horn.

frequency = ... Hz [2]

[Total: 14]

137. 9702_w19_qp_21 Q: 3

A small remote-controlled model aircraft has two propellers, each of diameter 16 cm. Fig. 3.1 is a side view of the aircraft when hovering.

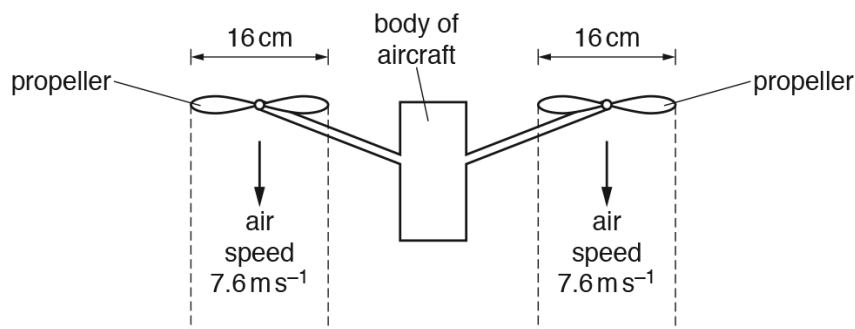


Fig. 3.1

Air is propelled vertically downwards by each propeller so that the aircraft hovers at a fixed position. The density of the air is 1.2 kg m^{-3} . Assume that the air from each propeller moves with a constant speed of 7.6 m s^{-1} in a uniform cylinder of diameter 16 cm. Also assume that the air above each propeller is stationary.

- (a) Show that, in a time interval of 3.0 s, the mass of air propelled downwards by **one** propeller is 0.55 kg.

[3]

- (b) Calculate:

- (i) the increase in momentum of the mass of air in (a)

increase in momentum = ... N s [1]

- (ii) the downward force exerted on this mass of air by the propeller.

force = ... N [1]

(c) State:

- (i) the upward force acting on **one** propeller

force = ... N [1]

- (ii) the name of the law that explains the relationship between the force in (b)(ii) and the force in (c)(i).

..... [1]

(d) Determine the mass of the aircraft.

mass = ... kg [1]

- (e) In order for the aircraft to hover at a very high altitude (height), the propellers must propel the air downwards with a greater speed than when the aircraft hovers at a low altitude. Suggest the reason for this.

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

- (f) When the aircraft is hovering at a high altitude, an electric fault causes the propellers to stop rotating. The aircraft falls vertically downwards. When the aircraft reaches a constant speed of 22 m s^{-1} , it emits sound of frequency 3.0 kHz from an alarm. The speed of the sound in the air is 340 m s^{-1} .

Determine the frequency of the sound heard by a person standing vertically below the falling aircraft.

frequency = ... Hz [2]

[Total: 11]

138. 9702_s18_qp_22 Q: 3

A child on a sledge slides down a steep hill and then travels in a straight line up an ice-covered slope, as illustrated in Fig. 3.1.

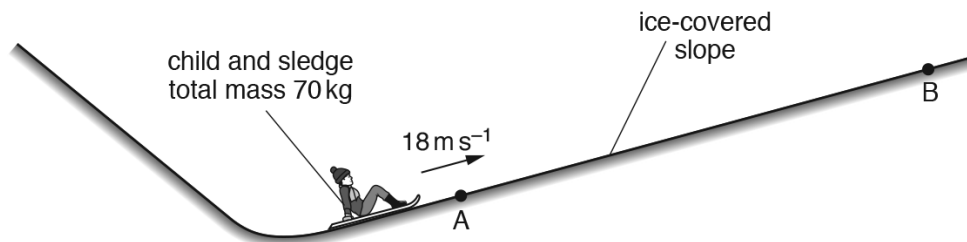


Fig. 3.1 (not to scale)

The sledge passes point A with speed 18 m s^{-1} at time $t = 0$ and then comes to rest at point B. The child applies a brake to the sledge at point B. The brake does not keep the sledge stationary and it immediately slides back down the slope towards A.

The variation with time t of the velocity v of the sledge from $t = 0$ to $t = 24 \text{ s}$ is shown in Fig. 3.2.

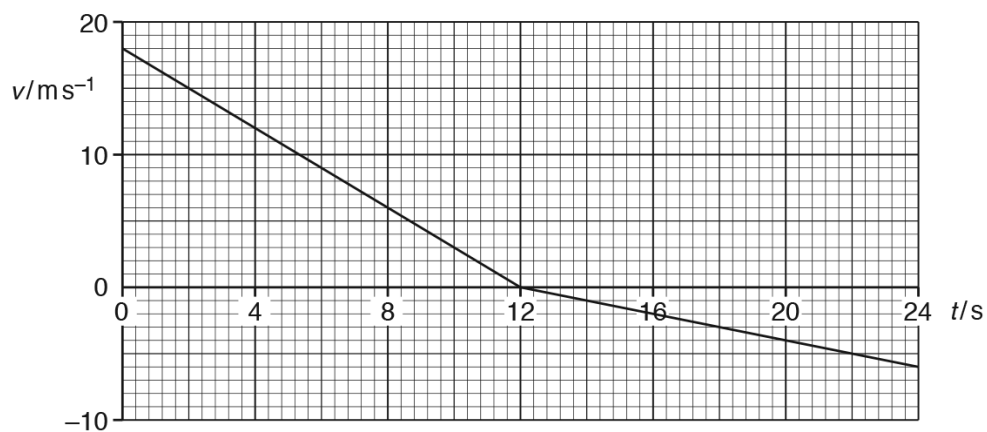


Fig. 3.2

(a) State the time taken for the sledge to travel from A to B.

time = ... s [1]

- (b) Determine the displacement of the sledge up the slope from point A at time $t = 24$ s.

displacement = ...m [3]

- (c) Show that the acceleration of the sledge as it moves from B back towards A is 0.50 ms^{-2} .

[2]

- (d) The child and sledge have a total mass of 70 kg. The component of the total weight of the child and sledge that acts down the slope is 80 N.

Determine

- (i) the frictional force on the sledge as it moves from B towards A,

frictional force = ... N [2]

- (ii) the angle θ of the slope to the horizontal.

$\theta =$ $^{\circ}$ [2]

- (e) The child on the sledge blows a whistle between $t = 4.0\text{ s}$ and $t = 8.0\text{ s}$. The whistle emits sound of frequency 900 Hz . The speed of the sound in the air is 340 ms^{-1} . A man standing at point A hears the sound.

Use Fig. 3.2 to

- (i) determine the initial frequency of the sound heard by the man,

initial frequency = ... Hz [2]

- (ii) describe and explain qualitatively the variation, if any, in the frequency of the sound heard by the man.

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

[Total: 13]

139. 9702_s18_qp_23 Q: 2

- (a) State what is meant by *work done*.

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

- (b) A diver releases a solid sphere of radius 16 cm from the sea bed. The sphere moves vertically upwards towards the surface of the sea.

The weight of the sphere is 20 N. The upthrust acting on the sphere is 170 N. The upthrust remains constant as the sphere moves upwards.

- (i) Calculate the density of the material of the sphere.

density = ... kg m^{-3} [2]

- (ii) Briefly explain the origin of the upthrust acting on the sphere.

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

- (iii) Calculate the acceleration of the sphere as it is released from rest.

acceleration = ... m s^{-2} [2]

- (iv) The viscous (drag) force D acting on the sphere is given by

$$D = kr^2v^2$$

where r is the radius of the sphere and v is its speed.
The constant k is equal to 810 kg m^{-3} .

Determine the constant (terminal) speed reached by the sphere.

speed = ... m s^{-1} [3]

- (v) The diver releases a different sphere that moves with a constant speed of 6.30 m s^{-1} directly towards a stationary ship. The sphere emits sound of frequency 4850 Hz . The ship detects sound of frequency 4870 Hz as the sphere moves towards it.

Determine, to three significant figures, the speed of the sound in the water.

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

[Total: 11]

140. 9702_m17_qp_22 Q: 4

- (a) State what is meant by the *Doppler effect*.

.....

[2]

- (b) A child sits on a rotating horizontal platform in a playground. The child moves with a constant speed along a circular path, as illustrated in Fig. 4.1.

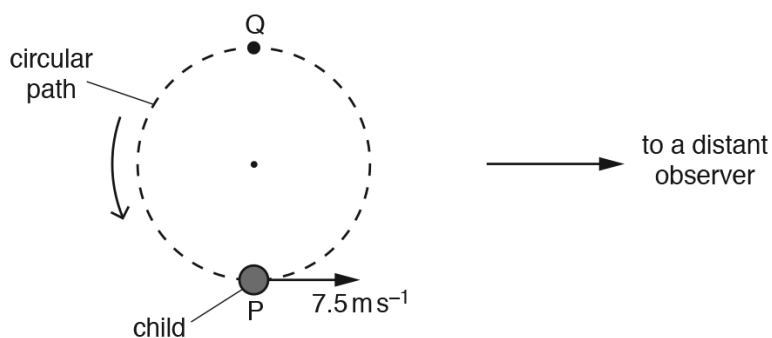


Fig. 4.1

An observer is standing a long distance away from the child. During one particular revolution, the child, moving at a speed of 7.5 m s^{-1} , starts blowing a whistle at point P and stops blowing it at point Q on the circular path.

The whistle emits sound of frequency 950 Hz . The speed of sound in air is 330 m s^{-1} .

- (i) Determine the maximum frequency of the sound heard by the distant observer.

maximum frequency = ... Hz [2]

- (ii) Describe the variation in the frequency of the sound heard by the distant observer.

.....

[2]

[Total: 6]

141. 9702_s17_qp_21 Q: 5

(a) Describe the Doppler effect.

.....

.....

.....[1]

(b) A car travels with a constant velocity along a straight road. The car horn with a frequency of 400 Hz is sounded continuously. A stationary observer on the roadside hears the sound from the horn at a frequency of 360 Hz.
The speed of sound is 340 m s^{-1} .

Determine the magnitude v , and the direction, of the velocity of the car relative to the observer.

$v = \dots\dots\dots \text{m s}^{-1}$

direction [3]

[Total: 4]

142. 9702_w17_qp_23 Q: 4

- (a) By reference to the direction of propagation of energy, explain what is meant by a *longitudinal* wave.

.....
[1]

- (b) A car horn emits a sound wave of frequency 800 Hz. A microphone and a cathode-ray oscilloscope (c.r.o.) are used to analyse the sound wave. The waveform displayed on the c.r.o. screen is shown in Fig. 4.1.

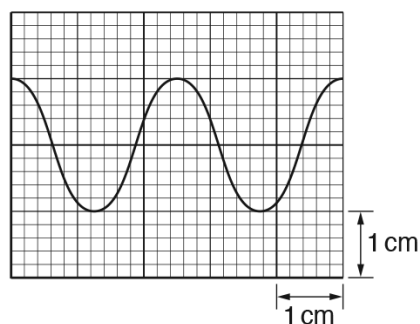


Fig. 4.1

Determine the time-base setting, in s cm^{-1} , of the c.r.o.

time-base setting = ... s cm^{-1} [3]

- (c) The intensity I of the sound at a distance r from the car horn in (b) is given by the expression

$$I = \frac{k}{r^2}$$

where k is a constant.

Fig. 4.2 shows the car in (b) on a road.

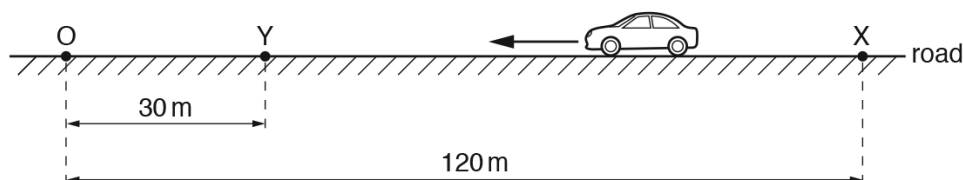


Fig. 4.2

An observer stands at point O. Initially the car is parked at point X which is 120 m away from point O. The car then moves directly towards the observer and stops at point Y, a distance of 30 m away from O.

The car horn continuously emits sound when the car is moving between points X and Y.

- (i) The sound wave at point O has amplitude A_X when the car is at X and has amplitude A_Y when the car is at Y.

Calculate the ratio $\frac{A_Y}{A_X}$.

ratio = ...[3]

- (ii) When the car is parked at X, the frequency of the sound from the horn that is detected by the observer is 800 Hz. As the car moves from X to Y, the maximum change in the detected frequency is 16 Hz. The speed of the sound in air is 330 ms^{-1} .

Determine, to two significant figures,

1. the minimum wavelength of the sound detected by the observer,

wavelength = ... m [2]

2. the maximum speed of the car.

speed = ... ms^{-1} [2]

[Total: 11]

143. 9702_s16_qp_22 Q: 4

- (a) By reference to the direction of the propagation of energy, state what is meant by a *longitudinal* wave and by a *transverse* wave.

longitudinal:

.....

.....

transverse:

.....

.....

[2]

- (b) The intensity of a sound wave passing through air is given by

$$I = K v \rho f^2 A^2$$

where I is the intensity (power per unit area),

K is a constant without units,

v is the speed of sound,

ρ is the density of air,

f is the frequency of the wave

and A is the amplitude of the wave.

Show that both sides of the equation have the same SI base units.

- (c) (i) Describe the *Doppler effect*.

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

- (ii) A distant star is moving away from a stationary observer.

State the effect of the motion on the light observed from the star.

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

- (d) A car travels at a constant speed towards a stationary observer. The horn of the car sounds at a frequency of 510 Hz and the observer hears a frequency of 550 Hz. The speed of sound in air is 340 m s^{-1} .

Calculate the speed of the car.

speed = ... m s^{-1} [3]

[Total: 10]

144. 9702_w16_qp_21 Q: 4

- (a) State what is meant by the *frequency* of a progressive wave.

.....

[2]

- (b) A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of the sound emitted by a loudspeaker. The trace produced on the screen of the c.r.o. is shown in Fig. 4.1.

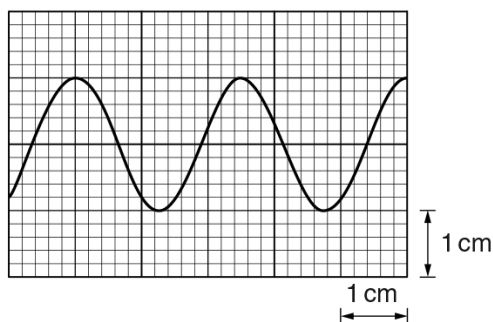


Fig. 4.1

The time-base setting of the c.r.o. is $250 \mu\text{s cm}^{-1}$.

Show that the frequency of the sound wave is 1600 Hz.

[2]

- (c) The loudspeaker in (b) emits the sound in all directions. A person attaches the loudspeaker to a string and then swings the loudspeaker at a constant speed in a horizontal circle above his head.

An observer, standing a large distance away from the loudspeaker, hears sound of maximum frequency 1640 Hz. The speed of sound in air is 330 m s^{-1} .

- (i) Determine the speed of the loudspeaker.

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

- (ii) Describe and explain, qualitatively, the variation in the frequency of the sound heard by the observer.

.....

.....

.....

.....

.....[2]

[Total: 8]

145. 9702_w16_qp_23 Q: 4

- (a) State what is meant by the *frequency* of a progressive wave.

.....

[2]

- (b) A cathode-ray oscilloscope (c.r.o.) is used to determine the frequency of the sound emitted by a loudspeaker. The trace produced on the screen of the c.r.o. is shown in Fig. 4.1.

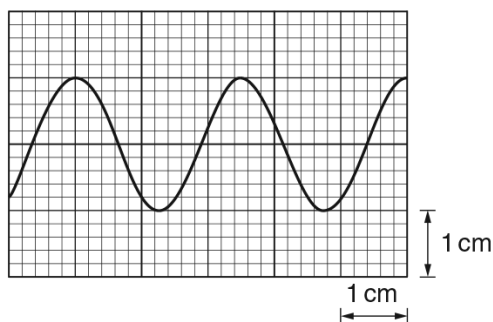


Fig. 4.1

The time-base setting of the c.r.o. is $250 \mu\text{s cm}^{-1}$.

Show that the frequency of the sound wave is 1600 Hz.

[2]

- (c) The loudspeaker in (b) emits the sound in all directions. A person attaches the loudspeaker to a string and then swings the loudspeaker at a constant speed in a horizontal circle above his head.

An observer, standing a large distance away from the loudspeaker, hears sound of maximum frequency 1640 Hz. The speed of sound in air is 330 m s^{-1} .

- (i) Determine the speed of the loudspeaker.

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

- (ii) Describe and explain, qualitatively, the variation in the frequency of the sound heard by the observer.

.....

.....

.....

.....

.....[2]

[Total: 8]

8.5 Electromagnetic spectrum

146. 9702_w20_qp_23 Q: 1

- (a) An electromagnetic wave has a wavelength of $85\text{ }\mu\text{m}$.

(i) State the wavelength, in m, of the wave.

wavelength = ... m [1]

(ii) Calculate the frequency, in THz, of the wave.

frequency = ... THz [2]

(iii) State the name of the region of the electromagnetic spectrum that contains this wave.

..... [1]

- (b) The current I in a coil of wire produces a magnetic field. The energy E stored in the magnetic field is given by

$$E = \frac{I^2 L}{2}$$

where L is a constant.

The manufacturer of the coil states that the value of L , in SI base units, is $7.5 \times 10^{-6} \pm 5\%$.
The current I in the coil is measured as $(0.50 \pm 0.02)\text{ A}$.

The values of L and I are used to calculate E .

Determine the percentage uncertainty in the value of E .

percentage uncertainty = ... % [2]

[Total: 6]

128. 9702_w15_qp_22 Q: 3

- (a) (i) $k = F/x$ **or** 1 / gradient C1
 $(k = 4.4 / (5.4 \times 10^{-2}) =) 81 \text{ (81.48) N m}^{-1}$ A1 [2]
- (ii) work done = area under line **or** $\frac{1}{2}Fx$ **or** $\frac{1}{2}kx^2$ C1
 $(= 0.5 \times 4.4 \times 5.4 \times 10^{-2} =) 0.12 \text{ (0.119) J}$ A1 [2]
- (b) (i) kinetic energy/ E_k of trolley/T (and block) changes to EPE/strain energy/elastic energy of spring B1
EPE changes to KE of trolley/T and KE of block **or** to give lower KE to trolley B1 [2]
- (ii) change in momentum = $m(v + u)$ C1
 $= 0.25 (0.75 + 1.2) = 0.49 \text{ (0.488) N s}$ A1 [2]

129. 9702_w20_qp_21 Q: 5

	Answer	Mark
(a)	$v = \lambda / T$ or $v = f\lambda$ and $f = 1 / T$	C1
	$v = 8.0 \times 10^{-2} / 0.40$ $= 0.20 \text{ m s}^{-1}$	A1
(b)	$I \propto A^2$	C1
	ratio = $2^2 / 4^2$	C1
	$= 0.25$	A1

130. 9702_w15_qp_21 Q: 2

- (a) $ps = 10^{-12} \text{ (s)}$ **or** $T = 4 \times 50 \times 10^{-12} \text{ (s)}$ B1
 $v = f\lambda$ **or** $v = \lambda / T$ C1
 $\lambda = 3.0 \times 10^8 \times 4 \times 50 \times 10^{-12}$ C1
 $= 0.06(0) \text{ m}$ A1 [4]
- (b) $1500 = 3.0 \times 10^8 \times 4 \times \text{time-base setting}$ **or** $T = 5 \times 10^{-6} \text{ s}$ C1
time-base setting = $1.3 \text{ (1.25) } \mu\text{s cm}^{-1}$ A1 [2]

131. 9702_w18_qp_22 Q: 4

	Answer	Mark
(a)	vibration(s)/oscillation(s) (of particles) parallel to direction of propagation of energy	B1
(b)(i)	phase difference = 180°	A1
(b)(ii)	$v = f\lambda$	C1
	$\lambda/2 = 25 \text{ (cm) or } 0.25 \text{ (m)}$	C1
	$f = 330/0.50$ $= 660 \text{ Hz}$	A1
(b)(iii)	(readings from graph =) 2.6 and 4.0	C1
	ratio = $(2.6/4.0)^{1/2}$ $= 0.81$	A1

132. 9702_s19_qp_23 Q: 5

	Answer	Mark
(a)	(incident) wave reflects at end/top of tube	B1
	(incident) wave and reflected wave interfere/superpose	B1
(b)	line has maximum value of amplitude at $h = 0$ and $h = 0.60 \text{ m}$ only	B1
	line has minimum/zero value of amplitude at $h = 0.30 \text{ m}$ only	B1
(c)(i)	vertical/along length of tube/along axis of tube	B1
(c)(ii)	phase difference = 0	A1
(d)	$v = f\lambda$	C1
	$v = 340 / (2 \times 0.60)$ $= 280 \text{ Hz}$	A1
(e)	$f = 340 / 0.60$ $= 570 \text{ Hz}$	A1

133. 9702_w19_qp_22 Q: 5

	Answer	Mark
(a)	distance moved by wavefront/energy during one cycle/oscillation/period (of source) or minimum distance between two wavefronts or distance between two adjacent wavefronts	B1
(b)	$(T=) 2.0 \times 2.5 (= 5.0 \text{ ms})$ or $2.0 \times 2.5 \times 10^{-3} (= 5.0 \times 10^{-3} \text{ s})$	C1
	$f = 1 / (5.0 \times 10^{-3})$ $= 200 \text{ Hz}$	A1
(c)(i)	(path difference $=$) $8.0 + (20.8^2 - 8.0^2)^{0.5} - 20.8 = 6.4 \text{ (m)}$	A1
(c)(ii)	- path difference $= 4\lambda$ - waves (meet at C) in phase - constructive interference (of waves) any two points, one mark each	B2
(c)(iii)	$v = 200 \times 1.6$ $= 320 \text{ (ms}^{-1}\text{)}$	C1
	$\Delta t = 6.4 / 320$ or $27.2 / 320 - 20.8 / 320$ $= 0.020 \text{ s}$	A1
(c)(iv)	$3\lambda = 6.4$ $\lambda = 2.1 \text{ m}$	A1

134. 9702_s17_qp_22 Q: 5

	Answer	Mark
(a)	frequency is the number of vibrations/oscillations per unit time or the number of wavefronts passing a point per unit time	B1
(b)	vibrations/oscillation of the air particles are parallel to the direction of it (the direction of travel of the sound wave)	B1
(c)(i)	$T = 2(0) \text{ (ms)}$	C1
	$f = 500 \text{ Hz}$	A1
(c)(ii)	1. amplitude increases (time) period decreases 2. amplitude decreases (time) period increases any 3 points	B3

135. 9702_m20_qp_22 Q: 2

	Answer	Mark
(a)	$f_0 = f_s v / (v - v_s)$ $9560 = f \times 1510 / (1510 - 4.50)$	C1
	$f = 9530 \text{ Hz}$	A1
(b)(i)	$v^2 = u^2 + 2as$ height $= 5.6^2 / (2 \times 9.81)$	C1
	$= 1.6 \text{ m}$	A1
(b)(ii)	downward sloping straight line starting from a point on the speed axis and ending at point (T, 0)	B1

	Answer	Mark
(b)(iii)	$(\Delta)E = mg(\Delta)h$ $= 0.45 \times 9.81 \times 1.6$	C1
	$= 7.1 \text{ J}$	A1
(b)(iv)	air resistance increases (and weight constant)	B1
	(resultant force decreases so) acceleration decreases	B1

136. 9702_s19_qp_22 Q: 2

	Answer	Mark
(a)	(resultant) force proportional/equal to/is rate of change of momentum	B1
(b)(i)	distance = area under graph or $s = \frac{1}{2}(u + v)t$ $= \frac{1}{2} \times (9 + 13) \times 10$	C1
	or $s = ut + \frac{1}{2}at^2$ $= (9 \times 10) + (\frac{1}{2} \times 0.40 \times 10^2)$ or $s = vt - \frac{1}{2}at^2$ $= (13 \times 10) - (\frac{1}{2} \times 0.40 \times 10^2)$ or $v^2 = u^2 + 2as$ $13^2 = 9^2 + (2 \times 0.40 \times s)$	
	distance = 110 m	A1

	Answer	Mark
(b)(ii)	1. $a = \text{gradient}$ or $a = (v - u)/t$ or $a = \Delta v / (\Delta)t$ e.g. $a = (14 - 9) / 12.5$ or $(13 - 9) / 10$	C1
	$a = 0.40 \text{ m s}^{-2}$	A1
	2. resultant force = 850×0.40 $= 340 \text{ N}$	A1
	3. $(F =) 510 + 440 + 340 = 1300 \text{ (N)}$	A1
	4. $P = Fv$	C1
	$= 1300 \times 13$ $= 1.7 \times 10^4 \text{ W}$	A1
(c)	$E = \sigma / \epsilon$	C1
	$E = (F/A) / (\Delta L / L)$ or $E = FL / A\Delta L$	C1
	$\Delta L = (480 \times 0.48) / (3.0 \times 10^{-4} \times 2.2 \times 10^{11})$ $= 3.5 \times 10^{-6} \text{ m}$	A1
(d)	$f_o = f_s v / (v - v_s)$ $480 = f_s \times 340 / (340 - 14)$	C1
	$f_s = 460 \text{ Hz}$	A1

137. 9702_w19_qp_21 Q: 3

	Answer	Mark
(a)	$\rho = m / V$	C1
	$V = \pi \times (0.16 / 2)^2 \times 7.6 \times 3.0 \text{ (= 0.458 m}^3\text{)}$	C1
	$m = \pi \times (0.16 / 2)^2 \times 7.6 \times 3.0 \times 1.2 = 0.55 \text{ kg}$	A1
(b)(i)	$\Delta p = 0.55 \times 7.6$ $= 4.2 \text{ N s}$	A1
(b)(ii)	$F = 4.2 / 3.0 \text{ or } 0.55 \times 7.6 / 3.0$ $= 1.4 \text{ N}$	A1
(c)(i)	$F = 1.4 \text{ N}$	A1
(c)(ii)	Newton's third law (of motion)	B1
(d)	$2 \times 1.4 = m \times 9.81$ $m = 0.29 \text{ kg}$	A1
(e)	the density of air is less at high altitude	B1
(f)	$f_o = f_s v / (v - v_s)$ $= 3000 \times 340 / (340 - 22)$	C1
	$= 3200 \text{ Hz}$	A1

138. 9702_s18_qp_22 Q: 3

	Answer	Mark
(a)	time = 12s	A1
(b)	distance (up slope) = $\frac{1}{2} \times 12 \times 18 \text{ (= 108)}$	C1
	distance (down slope) = $\frac{1}{2} \times 12 \times 6 \text{ (= 36)}$	C1
	displacement from A = $108 - 36$ $= 72\text{m}$	A1
(c)	$v = u + at \text{ or } a = \text{gradient or } a = \Delta v / (\Delta)t$	C1
	$a = 6 / 12 = 0.50 \text{ (ms}^{-2}\text{) (other points from the line may be used)}$	A1
	or	
	$v^2 = u^2 + 2as \text{ and } u = 0$ or $v^2 = 2as$	(C1)
	$a = 6.0^2 / (2 \times 36) = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)
	or	
	$s = ut + \frac{1}{2}at^2 \text{ and } u = 0$ or $s = \frac{1}{2}at^2$	(C1)
	$a = 2 \times 36 / 12^2 = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)
	or	
	$s = vt - \frac{1}{2}at^2$	(C1)
	$a = 2 \times (6 \times 12 - 36) / 12^2 = 0.50 \text{ (ms}^{-2}\text{)}$	(A1)

	Answer	Mark
(d)(i)	$F = 70 \times 0.50 (= 35)$	C1
	frictional force $= 80 - 35$	A1
	$= 45 \text{ N}$	
(d)(ii)	$\sin \theta = 80 / (70 \times 9.81)$	C1
	$\theta = 6.7^\circ$	A1
(e)(i)	$f_0 = (900 \times 340) / (340 + 12)$	C1
	$= 870 \text{ Hz}$	A1
(e)(ii)	speed/velocity (of sledge) decreases and (so) frequency increases	B1

139. 9702_s18_qp_23 Q: 2

	Answer	Mark
(a)(i)	(work =) force $\times$ distance moved in the direction of the force	B1
(b)(i)	$\rho = m/V$	C1
	$= (20/9.81) / (4/3 \times \pi \times 0.16^3)$	A1
	$= 120 \text{ kg m}^{-3}$	
(b)(ii)	the pressure on the lower surface (of sphere) is greater than the pressure on the upper surface (of sphere)	B1
(b)(iii)	$a = (170 - 20) / (20/9.81)$	C1
	$= 74 \text{ ms}^{-2}$	A1
(b)(iv)	$D = 170 - 20 (= 150)$	C1
	$810 \times (0.16^2) \times v^2 = 150$	C1
	$v = 2.7 \text{ ms}^{-1}$	A1
(b)(v)	$4870 = (4850 \times v) / (v - 6.30)$	C1
	$v = 1530 \text{ ms}^{-1}$	A1

140. 9702_m17_qp_22 Q: 4

	Answer	Mark
(a)	change in frequency when source moves relative to observer	M1
	refers to 'change in <u>observed</u> / <u>apparent</u> frequency'	A1
(b)(i)	$f = (950 \times 330) / (330 - 7.5)$	C1
	$= 970 \text{ (972) Hz}$	A1
(b)(ii)	frequency decreases	M1
	from greater than 950 Hz / from 970 (972) Hz / to less than 950 Hz / to 930 (929) Hz / by 40 (43) Hz	A1

141. 9702_s17_qp_21 Q: 5

	Answer	Mark
(a)	observed frequency is different to source frequency when source moves relative to observer	B1
(b)	$360 = (400 \times 340) / (340 \pm v)$	C1
	$v = 38 \text{ (37.8) m s}^{-1}$	A1
	away (from the observer)	B1

142. 9702_w17_qp_23 Q: 4

	Answer	Mark
(a)	displacement of particles/vibration(s)/oscillation(s) is parallel to/along the direction of energy/propagation	B1
(b)	period = $1 / 800$ ($= 1.25 \times 10^{-3} \text{ s}$)	C1
	time-base setting = $1.25 \times 10^{-3} / 2.5$	C1
	$= 5.0 \times 10^{-4} \text{ s cm}^{-1}$	A1
(c)(i)	$I \propto A^2$	C1
	$(I_X / I_Y) [r_Y / r_X]^2 = [A_X / A_Y]^2$	C1
	ratio $A_Y / A_X = 120 / 30$ $= 4.0$	A1

	Answer	Mark
(c)(ii)	1. $v = f \lambda$	C1
	minimum $\lambda = 330 / (800 + 16) = 0.40 \text{ m}$	A1
	2. $f_o / f_s = v / (v - v_s)$ $816 / 800 = 330 / (330 - v_s)$	C1
	$v_s = 6.5 \text{ m s}^{-1}$	A1

143. 9702_s16_qp_22 Q: 4

- (a) longitudinal: vibrations/oscillations (of the particles/wave) are parallel to the direction **or** in the same direction (of the propagation of energy) B1
- transverse: vibrations/oscillations (of the particles/wave) are perpendicular to the direction (of the propagation of energy) B1 [2]
- (b) LHS: intensity = power/area units: $\text{kg m s}^{-2} \times \text{m} \times \text{s}^{-1} \times \text{m}^{-2}$ or $\text{kg m}^2 \text{s}^{-3} \times \text{m}^{-2}$ B1
- RHS: units: $\text{m s}^{-1} \times \text{kg m}^{-3} \times \text{s}^{-2} \times \text{m}^2$ M1
- LHS and RHS both kg s^{-3} A1 [3]
- (c) (i) change/difference in the observed/apparent frequency when the source is moving (relative to the observer) B1 [1]
- (ii) wavelength increases/frequency decreases/red shift B1 [1]
- (d) observed frequency = $v f_s / (v - v_s)$ C1
- $550 = (340 \times 510) / (340 - v_s)$ C1
- $v_s = 25 \text{ (24.7) m s}^{-1}$ A1 [3]

144. 9702_w16_qp_21 Q: 4

- (a) the number of oscillations per unit time of the source/of a point on the wave/of a particle (in the medium) M1
 or A1 [2]
 the number of wavelengths/wavefronts per unit time (M1)
 passing a (fixed) point (A1)
- (b) T or period = $2.5 \times 250 \text{ } (\mu\text{s})$ (= 625 μs) M1
 frequency = $1/(6.25 \times 10^{-4})$ or $1/(2.5 \times 250 \times 10^{-6}) = 1600 \text{ Hz}$ A1 [2]
- (c) (i) for maximum frequency: $f_o = f_s v / (v - v_s)$
 $1640 = (1600 \times 330) / (330 - v_s)$ C1
 $v_s = 8(.0) \text{ m s}^{-1}$ (8.049 m s^{-1}) A1 [2]
- (ii) loudspeaker moving towards observer causes rise in/higher frequency B1
 loudspeaker moving away from observer causes fall in/lower frequency B1 [2]
 or
 repeated rise and fall/higher and then lower frequency (M1)
 caused by loudspeaker moving towards and away from observer (A1)

145. 9702_w16_qp_23 Q: 4

- (a) the number of oscillations per unit time of the source/of a point on the wave/of a particle (in the medium) M1
 or A1 [2]
 the number of wavelengths/wavefronts per unit time (M1)
 passing a (fixed) point (A1)
- (b) T or period = $2.5 \times 250 \text{ } (\mu\text{s})$ (= 625 μs) M1
 frequency = $1/(6.25 \times 10^{-4})$ or $1/(2.5 \times 250 \times 10^{-6}) = 1600 \text{ Hz}$ A1 [2]
- (c) (i) for maximum frequency: $f_o = f_s v / (v - v_s)$
 $1640 = (1600 \times 330) / (330 - v_s)$ C1
 $v_s = 8(.0) \text{ m s}^{-1}$ (8.049 m s^{-1}) A1 [2]
- (ii) loudspeaker moving towards observer causes rise in/higher frequency B1
 loudspeaker moving away from observer causes fall in/lower frequency B1 [2]
 or
 repeated rise and fall/higher and then lower frequency (M1)
 caused by loudspeaker moving towards and away from observer (A1)

146. 9702_w20_qp_23 Q: 1

	Answer	Mark
(a)(i)	wavelength = 8.5×10^{-5} m	A1
(a)(ii)	$f = v / \lambda$ or c / λ	C1
	$= 3.0 \times 10^8 / 8.5 \times 10^{-5}$ ($= 3.5 \times 10^{12}$)	A1
	= 3.5 THz	
(a)(iii)	infrared	B1
(b)	(implied) percentage uncertainty in $I = 4\%$ or (implied) fractional uncertainty in $I = 0.04$	C1
	percentage uncertainty in $E = 5\% + (4\% \times 2)$	A1
	= 13%	

147. 9702_s20_qp_22 Q: 4

	Answer	Mark
(a)	progressive waves transfer energy or stationary waves do not transfer energy	B1
(b)(i)	0.32 m	A1
(b)(ii)	$v = \lambda / T$ or $v = f\lambda$ and $f = 1 / T$	C1
	$v = 0.32 / 0.020$ or 50×0.32	A1
	= 16 m s^{-1}	
(b)(iii)	450° or 90°	A1
(b)(iv)	(P has) maximum downward displacement at 0.005 s	B1
	returns to original position/point (at 0.010 s)	B1
(c)(i)	(position where) zero amplitude	B1
(c)(ii)	2	A1
(c)(iii)	180°	A1
(c)(iv)	string drawn between X and Y with one antinode midway along the string	B1

148. 9702_w20_qp_21 Q: 6

	Answer	Mark
(a)	the waves (of the same type) move in opposite directions and overlap	B1
	the waves have the same (speed and) frequency/wavelength	B1
(b)(i)	zero amplitude	B1
(b)(ii)	distance = 6.0×4	A1
	= 24 cm	
(b)(iii)	180°	A1

Chapter 6

Waves

118. 9702_s21_qp_41 Q: 4

Outline the **use** of ultrasound to obtain diagnostic information about internal body structures.

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..... [5]

119. 9702_s21_qp_43 Q: 4

Outline the **use** of ultrasound to obtain diagnostic information about internal body structures.

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..... [5]

120. 9702_w21_qp_42 Q: 11

- (a) A piezoelectric transducer containing a quartz crystal is used to obtain diagnostic information about internal structures.

Describe the function of the quartz crystal.

.....

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.....

..... [3]

- (b) (i) Define *specific acoustic impedance*.

.....

.....

..... [2]

- (ii) Describe, qualitatively, how the specific acoustic impedances of two materials affect the intensity reflection coefficient at a boundary between the materials.

.....

.....

.....

..... [2]

[Total: 7]

121. 9702_m20_qp_42 Q: 4

- (a) (i) Explain why ultrasound used in medical diagnosis is emitted in pulses.

.....

 [2]

- (ii) Explain the principles of the **detection** of ultrasound waves used in medical diagnosis.

.....

 [3]

- (b) The specific acoustic impedances Z of some media are given in Table 4.1.

Table 4.1

media	$Z/\text{kg m}^{-2}\text{s}^{-1}$
air	4.3×10^2
gel	1.5×10^6
soft tissue	1.6×10^6

- (i) The specific acoustic impedances of two media are Z_1 and Z_2 . The intensity reflection coefficient α for the boundary of these two media is given by:

$$\alpha = \frac{(Z_1 - Z_2)^2}{(Z_1 + Z_2)^2}.$$

Calculate, to three significant figures, the fraction of the ultrasound intensity that is reflected at a boundary between air and soft tissue.

$\alpha =$ [1]

- (ii) Use your value in (b)(i) to explain why gel is applied to the surface of the skin during an ultrasound scan.

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.....

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.....

..... [2]

[Total: 8]

122. 9702_s20_qp_41 Q: 4

- (a) (i) By reference to an ultrasound wave, explain what is meant by *specific acoustic impedance*.

.....

 [2]

- (ii) An ultrasound wave is incident normally on the boundary between two media. The media have specific acoustic impedances Z_1 and Z_2 .

State how the ratio

$$\frac{\text{intensity of ultrasound reflected from boundary}}{\text{intensity of ultrasound incident on boundary}}$$

depends on the relative magnitudes of Z_1 and Z_2 .

.....

 [2]

- (b) (i) State what is meant by the *attenuation* of an ultrasound wave.

.....
 [1]

- (ii) A parallel beam of ultrasound is passing through a medium.
 The incident intensity I_0 is reduced to $0.35I_0$ on passing through a thickness of 0.046 m of the medium.

Calculate the linear attenuation coefficient μ of the ultrasound beam in the medium.

$$\mu = \dots\dots\dots \text{m}^{-1} \quad [2]$$

[Total: 7]

123. 9702_s20_qp_42 Q: 5

(a) Explain the principles of the **detection** of ultrasound waves for medical diagnosis.

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..... [4]

(b) By reference to specific acoustic impedance, explain why there is very little transmission of ultrasound waves from air into skin.

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.....

.....

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.....

..... [3]

[Total: 7]

124. 9702_s20_qp_43 Q: 4

- (a) (i) By reference to an ultrasound wave, explain what is meant by *specific acoustic impedance*.

.....

 [2]

- (ii) An ultrasound wave is incident normally on the boundary between two media. The media have specific acoustic impedances Z_1 and Z_2 .

State how the ratio

$$\frac{\text{intensity of ultrasound reflected from boundary}}{\text{intensity of ultrasound incident on boundary}}$$

depends on the relative magnitudes of Z_1 and Z_2 .

.....

 [2]

- (b) (i) State what is meant by the *attenuation* of an ultrasound wave.

.....
 [1]

- (ii) A parallel beam of ultrasound is passing through a medium.
 The incident intensity I_0 is reduced to $0.35I_0$ on passing through a thickness of 0.046 m of the medium.

Calculate the linear attenuation coefficient μ of the ultrasound beam in the medium.

$$\mu = \dots\dots\dots \text{m}^{-1} \quad [2]$$

[Total: 7]

125. 9702_s19_qp_42 Q: 4

- (a) State what is meant by the *specific acoustic impedance* of a medium.

.....

[2]

- (b) A parallel beam of ultrasound of intensity I_0 is incident on the boundary between two media A and B, as illustrated in Fig. 4.1.

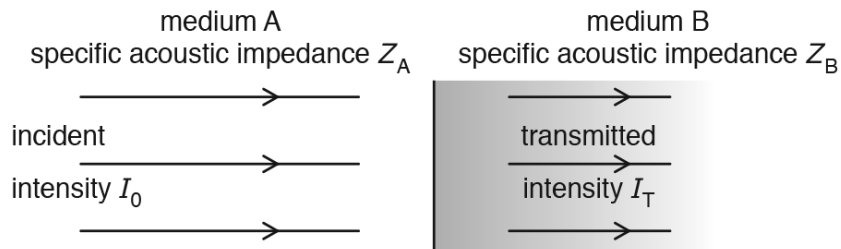


Fig. 4.1

The two media A and B have specific acoustic impedances Z_A and Z_B respectively. The intensity of the beam transmitted through the boundary is I_T .

State how the ratio

$$\frac{\text{intensity } I_T \text{ of transmitted beam}}{\text{intensity } I_0 \text{ of incident beam}}$$

depends on the relative magnitudes of Z_A and Z_B .

.....

[2]

- (c) The linear absorption (attenuation) coefficient μ of medium B is 23 m^{-1} .

Calculate the thickness of medium B required to reduce the intensity of the ultrasound beam to 34% of its initial intensity in medium B.

thickness = ... m [3]

[Total: 7]

126. 9702_w19_qp_42 Q: 5

- (a) (i) State what is meant by the *specific acoustic impedance* of a medium.

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

- (ii) The density of a sample of bone is 1.8 g cm^{-3} and the speed of ultrasound in the bone is $4.1 \times 10^3 \text{ m s}^{-1}$.

Calculate the specific acoustic impedance Z_B of the sample of bone.

$$Z_B = \dots\dots\dots \text{ kg m}^{-2} \text{ s}^{-1} \quad [1]$$

- (b) A parallel beam of ultrasound passes normally through a layer of fat and of muscle, as illustrated in Fig. 5.1.

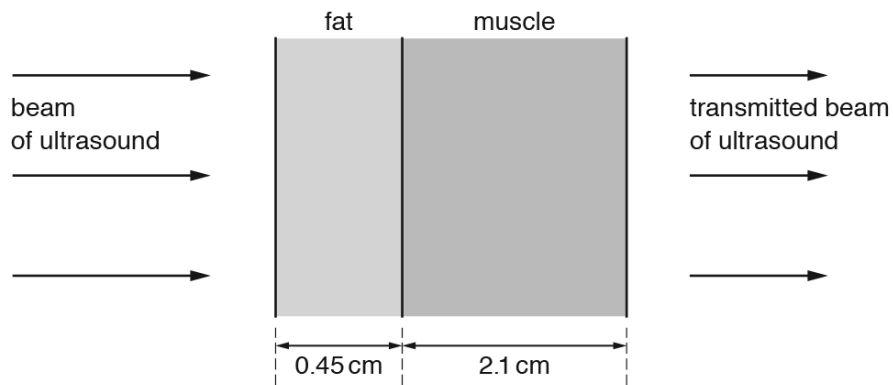


Fig. 5.1 (not to scale)

The fat has thickness 0.45 cm and the muscle has thickness 2.1 cm.

Data for fat and for muscle are given in Fig. 5.2.

	specific acoustic impedance $Z/10^6 \text{ kg m}^{-2} \text{ s}^{-1}$	linear attenuation (absorption) coefficient μ/cm^{-1}
fat	1.3	0.24
muscle	1.7	0.23

Fig. 5.2

The intensity reflection coefficient α at a boundary between two media of specific acoustic impedances Z_1 and Z_2 is given by the expression

$$\alpha = \frac{(Z_2 - Z_1)^2}{(Z_2 + Z_1)^2}.$$

Calculate the fraction of the intensity of the ultrasound that is **transmitted** through the boundary between the fat and the muscle.

fraction transmitted = ... [1]

- (c) (i) State what is meant by *attenuation* of an ultrasound wave.

.....

 [2]

- (ii) Data for linear attenuation coefficients are given in Fig. 5.2.

Determine the ratio

$$\frac{\text{intensity of ultrasound transmitted through the medium}}{\text{intensity of ultrasound entering the medium}}$$

for:

1. the layer of fat of thickness 0.45 cm

ratio = ...

2. the layer of muscle of thickness 2.1 cm.

ratio = ... [3]

- (d) Use your answers in (b) and (c)(ii) to determine the fraction of the intensity entering the layer of fat that is transmitted through the layer of muscle.

fraction transmitted = ... [1]

[Total: 10]

-[6]

-[2

- $Z_1 \approx Z_2$
-
- $Z_1 \gg Z_2$ or $Z_1 \ll Z_2$
-
- [2]

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128. 9702_s18_qp_41 Q: 4

Piezo-electric transducers are used for the generation of ultrasonic waves.

- (a) State one other use, apart from in ultrasound, of piezo-electric transducers.

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

- (b) Explain the main principles behind the **use** of ultrasound to obtain diagnostic information about internal body structures.

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.....[6]

[Total: 7]

129. 9702_s18_qp_43 Q: 4

Piezo-electric transducers are used for the generation of ultrasonic waves.

(a) State one other use, apart from in ultrasound, of piezo-electric transducers.

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

(b) Explain the main principles behind the **use** of ultrasound to obtain diagnostic information about internal body structures.

.....
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.....[6]

[Total: 7]

(a) Explain the main principles behind the **use** of ultrasound to obtain diagnostic information about internal body structures.

.....[6]

.....[2]

Discuss qualitatively how the relative magnitudes of the two specific acoustic impedances affect the reflected intensity.

.....[2]

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- (a) Explain the main principles behind the **use** of ultrasound to obtain diagnostic information about internal body structures.

.....[6]

- (b) (i) Define *specific acoustic impedance*.

.....[2]

- (ii) The fraction of the incident intensity of an ultrasound beam that is reflected at a boundary between two media depends on the specific acoustic impedances Z_1 and Z_2 of the media.

Discuss qualitatively how the relative magnitudes of the two specific acoustic impedances affect the reflected intensity.

.....[2

[Total: 10]

132. 9702_m17_qp_42 Q: 4

Explain the main principles of the **generation** of ultrasound waves for medical use.

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.....[4]

[Total: 4]

- (b) A parallel beam of ultrasound has intensity I_0 as it enters a muscle of thickness 4.6 cm, as illustrated in Fig. 4.1.

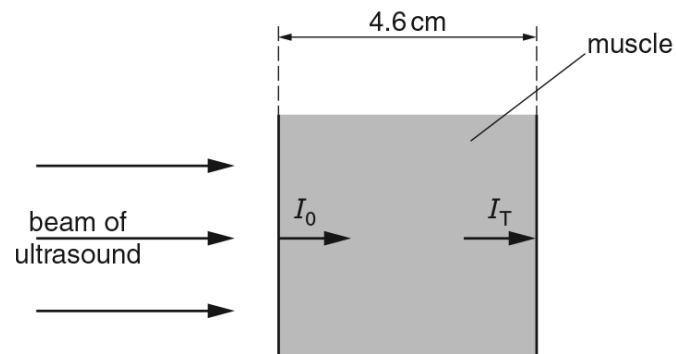


Fig. 4.1

The intensity of the beam just before it leaves the muscle is I_T .
The ratio I_0/I_T is found to be 2.9.

Calculate the linear attenuation (absorption) coefficient μ of the ultrasound in the layer of muscle.

$$\mu = \dots\dots\dots \text{ cm}^{-1} \text{ [3]}$$

[Total: 9]

134. 9702 w17 qp 42 Q: 4

(a) Explain the principles behind the **generation** of ultrasound waves for diagnosis in medicine.

.....[5]

(b) Ultrasound frequencies as high as 10 MHz are used in medical diagnosis. Suggest one advantage of the use of high-frequency ultrasound rather than lower-frequency ultrasound.

.....[1]

[Total: 6]

135. 9702_m16_qp_42 Q: 6

A parallel beam of ultrasound is incident normally on the surface of a layer of fat of thickness 1.1 cm, as shown in Fig. 6.1.

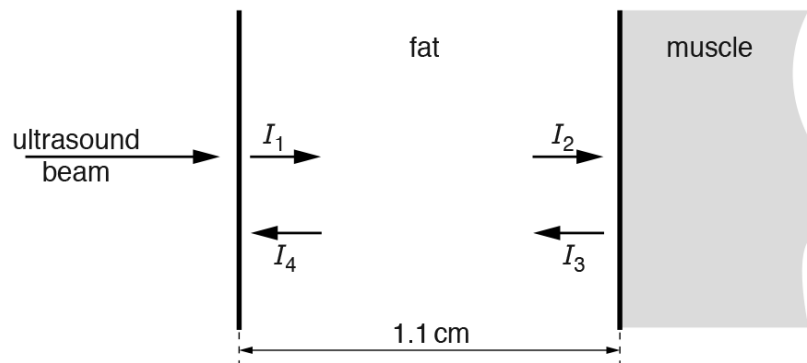


Fig. 6.1

For the ultrasound,

I_1 is the intensity just after entering the surface of the fat layer,

I_2 is the intensity incident on the fat-muscle boundary,

I_3 is the intensity reflected from the fat-muscle boundary,

I_4 is the intensity received back at the surface of the fat layer.

Some data for the fat are given in Fig. 6.2.

specific acoustic impedance Z	$1.4 \times 10^6 \text{ kg m}^{-2} \text{ s}^{-1}$
density ρ	940 kg m^{-3}
absorption (attenuation) coefficient μ	48 m^{-1}

Fig. 6.2

- (a) Calculate the time interval between a short pulse of ultrasound initially entering the layer of fat and then returning back to the surface of the fat layer.

time = ... s [3]

- (b) Calculate the ratio $\frac{I_2}{I_1}$.

ratio = ...[2]

- (c) Intensity I_4 is 0.33% of intensity I_1 .

Determine the ratio $\frac{I_3}{I_2}$.

ratio = ...[2]

- (d) The specific acoustic impedance of the muscle is greater than that of the fat.

State the effect, if any, on the value of the ratio $\frac{I_3}{I_2}$ of an increase in the difference between the specific acoustic impedance of the muscle and that of the fat.

.....

.....[1]

[Total: 8]

136. 9702_w16_qp_42 Q: 5

Ultrasound may be used to obtain information about internal body structures.

(a) Suggest why the ultrasound from the transducer is pulsed.

.....

 [2]

(b) (i) State what is meant by *specific acoustic impedance*.

.....

 [2]

(ii) A parallel beam of ultrasound of intensity I_0 is incident normally on the boundary between two media, as shown in Fig. 5.1.

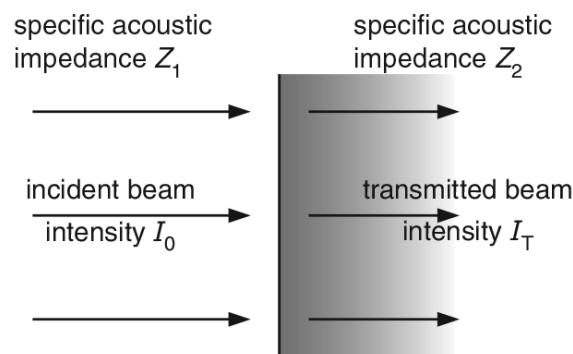


Fig. 5.1

The media have specific acoustic impedances Z_1 and Z_2 .

The intensity of the ultrasound beam transmitted across the boundary is I_T .

Explain the significance of the magnitudes of Z_1 and of Z_2 on the ratio I_T/I_0 .

.....

 [2]

[Total: 6]

116. 9702_s17_MS_41 Q: 2

	Answer	Marks
(a)	e.g. period = 3 / 2.5	C1
	frequency = 0.83 Hz	A1
(b)	light (damping)	B1
(c)	at 2.7 s, $A_0 = 1.5$ (cm)	B1
	energy = $\frac{1}{2} m \times 4\pi^2 f^2 A_0^2$	B1
	$= \frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (1.5 \times 10^{-2})^2$	C1
	$= 5.51 \times 10^{-4}$ (J)	
	at 7.5 s, $A_0 = 0.75$ (cm)	B1
	energy = $\frac{1}{4} \times 5.51 \times 10^{-4}$ or energy = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (0.75 \times 10^{-2})^2$	C1
	energy = 1.38×10^{-4} (J) change = $(5.51 \times 10^{-4} - 1.38 \times 10^{-4}) = 4.13$ J	A1

117. 9702_s17_MS_43 Q: 2

	Answer	Marks
(a)	e.g. period = 3 / 2.5	C1
	frequency = 0.83 Hz	A1
(b)	light (damping)	B1
(c)	at 2.7 s, $A_0 = 1.5$ (cm)	B1
	energy = $\frac{1}{2} m \times 4\pi^2 f^2 A_0^2$	B1
	$= \frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (1.5 \times 10^{-2})^2$	C1
	$= 5.51 \times 10^{-4}$ (J)	
	at 7.5 s, $A_0 = 0.75$ (cm)	B1
	energy = $\frac{1}{4} \times 5.51 \times 10^{-4}$ or energy = $\frac{1}{2} \times 0.18 \times 4\pi^2 \times 0.83^2 \times (0.75 \times 10^{-2})^2$	C1
	energy = 1.38×10^{-4} (J) change = $(5.51 \times 10^{-4} - 1.38 \times 10^{-4}) = 4.13$ J	A1

118. 9702_s21_MS_41 Q: 4

	Answer	Marks
	(ultrasound) pulse	B1
	reflected at boundaries	B1
	gel is used to minimise reflection at skin or generated <u>and</u> detected by quartz crystal	B1
	time delay between generation and detection gives information about depth	B1
	intensity (of reflected wave) gives information about nature of boundary	B1

119. 9702_s21_MS_43 Q: 4

	Answer	Marks
	(ultrasound) pulse	B1
	reflected at boundaries	B1
	gel is used to minimise reflection at skin or generated <u>and</u> detected by quartz crystal	B1
	time delay between generation and detection gives information about depth	B1
	intensity (of reflected wave) gives information about nature of boundary	B1

120. 9702_w21_MS_42 Q: 11

	Answer	Marks
(a)	generates <u>ultrasound</u>	B1
	detects <u>reflected</u> ultrasound	B1
	applied p.d. causes crystal to vibrate or vibrations cause crystal to generate an e.m.f.	B1
(b)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
(b)(ii)	difference between (the specific acoustic impedances)	C1
	- if similar/same then reflection coefficient is zero/very low - if very different then reflection coefficient is (nearly) 1 - the lower the difference means lower the reflection coefficient (<i>any one point</i>)	A1

121. 9702_m20_MS_42 Q: 4

	Answer	Marks
(a)(i)	Any 2 from: - allows the reflected signal to be distinguished from the emitted signal - detection occurs in the time between emitted pulses (reflection of ultrasound) detected by same probe / transducer / crystal - cannot emit and detect at same time (hence pulses)	B2
(a)(ii)	piezo-electric crystal	B1
	ultrasound makes crystal vibrate / resonate	B1
	vibration produces (alternating) e.m.f. / p.d. across crystal	B1
(b)(i)	$= (1.6 \times 10^6 - 4.3 \times 10^2)^2 / (1.6 \times 10^6 + 4.3 \times 10^2)^2$ $= 0.999$	B1
(b)(ii)	without the gel most of the ultrasound is reflected	B1
	Z values more similar / α reduces so less (ultrasound) is reflected / more (ultrasound) is transmitted	B1

122. 9702_s20_MS_41 Q: 4

	Answer	Marks
(a)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
(a)(ii)	the greater the difference between Z_1 and Z_2 , the closer the ratio is to 1 or if difference between Z_1 and Z_2 large, ratio is close to 1	B1
	the closer together Z_1 and Z_2 , the closer the ratio is to 0 or if difference between Z_1 and Z_2 small, ratio close to 0	B1
(b)(i)	loss of intensity/amplitude/power (of the wave)	B1
(b)(ii)	$I = I_0 e^{-\mu x}$	C1
	$0.35 = e^{-0.046\mu}$ $\mu = 23 \text{ m}^{-1}$	A1

123. 9702_s20_MS_42 Q: 5

	Answer	Marks
(a)	pulses of ultrasound	B1
	ultrasound incident on quartz crystal	B1
	waves make crystal oscillate	B1
	oscillations (of crystal) generates an e.m.f. (across the crystal)	B1
(b)	specific acoustic impedances of air and skin are very different	B1
	intensity reflection coefficient depends on difference between acoustic impedance	B1
	most ultrasound reflected so little transmission	B1

124. 9702_s20_MS_43 Q: 4

	Answer	Marks
(a)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
(a)(ii)	the greater the difference between Z_1 and Z_2 , the closer the ratio is to 1 or if difference between Z_1 and Z_2 large, ratio is close to 1	B1
	the closer together Z_1 and Z_2 , the closer the ratio is to 0 or if difference between Z_1 and Z_2 small, ratio close to 0	B1
(b)(i)	loss of intensity/amplitude/power (of the wave)	B1
(b)(ii)	$I = I_0 e^{-\mu x}$	C1
	$0.35 = e^{-0.046\mu}$ $\mu = 23 \text{ m}^{-1}$	A1

125. 9702_s19_MS_42 Q: 4

	Answer	Marks
(a)	product of density and speed	M1
	speed of sound in medium	A1
(b)	Any two from: - if $Z_A \gg Z_B$ then ratio is (nearly) zero or if $Z_B \gg Z_A$ then ratio is (nearly) zero or if Z_B and Z_A are very different then ratio is (nearly) zero or the greater the difference the lower the ratio - if $Z_A \approx Z_B$ then ratio is (nearly) 1 or if $Z_A = Z_B$ then ratio is 1 or the smaller the difference the closer the ratio to 1 (not 'large') $I_T / I_0 = 1 - [(Z_A - Z_B)^2 / (Z_A + Z_B)^2]$	B2
(c)	$I = I_0 e^{-\mu x}$	C1
	$0.34 = \exp(-23 \times x)$	C1
	$x = 0.047 \text{ m}$	A1

126. 9702_w19_MS_42 Q: 5

	Answer	Marks
(a)(i)	product of density and speed	M1
	speed of sound in the medium	A1
(a)(ii)	$Z_B = 1.8 \times 10^3 \times 4.1 \times 10^3$ $= 7.4 \times 10^6 \text{ kg m}^2 \text{ s}^{-1}$	A1
(b)	$\alpha = (1.7 - 1.3)^2 / (1.7 + 1.3)^2 = 0.018$ fraction = 0.98	A1
(c)(i)	reduction in power/intensity (of wave)	M1
	as the wave passes through the medium	A1
(c)(ii)	1. ratio = $e^{-\mu x}$	C1
	= 0.90	A1
	2. ratio = 0.62	A1
(d)	fraction = $0.898 \times 0.617 \times 0.98$ = 0.54	A1

127. 9702_m18_MS_42 Q: 5

	Answer	Marks
(a)	<u>pulses</u> of ultrasound	B1
	reflected at boundaries (between media)	B1
	reflected pulses detected by (ultrasound) generator	B1
	Any three from:	
	(reflected signal) processed and displayed	(B1)
	time delay (between transmission and receipt) gives information about depth (of boundary)	(B1)
	intensity of reflected pulse gives information about (nature of) <u>boundary</u>	(B1)
	gel used to minimise reflection at skin / maximise transmission into skin	(B1)
	degree of reflection depends upon impedances of two media (at boundary)	(B1)
		B3
(b)(i)	product of density and speed	M1
	of sound in the medium	A1
(b)(ii)	(Z_1 about equal to Z_2) coefficient very small / nearly 0	B1
	(Z_1 very different to Z_2) coefficient nearly 1	B1

128. 9702_s18_MS_41 Q: 4

	Answer	Marks
(a)	e.g. microphone weighing scales/pressure sensor lighters/spark generation watches/clocks/regulation of time	B1
(b)	<u>pulses</u> (of ultrasound)	B1
	reflected at boundaries (between media)	B1
	(reflected pulses) detected by (ultrasound) generator	B1
	Any three from:	B3
	- time delay (between transmission and receipt) gives information about depth (of boundary) - intensity of reflected pulse gives information about (nature of) <u>boundary</u> - gel used to minimise reflection at skin/maximise transmission into skin - degree of reflection depends upon impedances of two media (at boundary)	

129. 9702_s18_MS_43 Q: 4

	Answer	Marks
(a)	e.g. microphone weighing scales/pressure sensor lighters/spark generation watches/clocks/regulation of time	B1
(b)	<u>pulses</u> (of ultrasound)	B1
	reflected at boundaries (between media)	B1
	(reflected pulses) detected by (ultrasound) generator	B1
	Any three from:	B3
	- time delay (between transmission and receipt) gives information about depth (of boundary) - intensity of reflected pulse gives information about (nature of) <u>boundary</u> - gel used to minimise reflection at skin/maximise transmission into skin - degree of reflection depends upon impedances of two media (at boundary)	

130. 9702_w18_MS_41 Q: 4

	Answer	Marks
(a)	pulses (of ultrasound from generator)	B1
	reflected at boundaries (between media)	B1
	time delay (between transmission and receipt) gives information about depth	B1
	intensity of reflected pulse gives information about nature (of tissues)/type (of tissues)/boundary	B1
	Any two from: • (reflected pulses) detected by the (ultrasound) generator • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	B2
(b)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
(b)(ii)	Z_1 about equal to Z_2 results in negligible/no reflection	B1
	$Z_1 \gg Z_2$ (or $Z_1 \ll Z_2$) results in mostly reflection	B1

131. 9702_w18_MS_43 Q: 4

	Answer	Marks
(a)	pulses (of ultrasound from generator)	B1
	reflected at boundaries (between media)	B1
	time delay (between transmission and receipt) gives information about depth	B1
	intensity of reflected pulse gives information about nature (of tissues)/type (of tissues)/boundary	B1
	Any two from: • (reflected pulses) detected by the (ultrasound) generator • gel used to minimise reflection at skin/maximise transmission into skin • degree of reflection depends upon impedances of two media (at boundary)	B2
(b)(i)	product of density and speed	M1
	speed of ultrasound in medium	A1
(b)(ii)	Z_1 about equal to Z_2 results in negligible/no reflection	B1
	$Z_1 \gg Z_2$ (or $Z_1 \ll Z_2$) results in mostly reflection	B1

132. 9702_m17_MS_42 Q: 4

	Answer	Marks
	piezo-electric / quartz crystal / transducer	B1
	alternating p.d. applied across crystal / transducer	B1
	causes crystal to vibrate / resonate	B1
	crystal resonates at ultrasound frequencies / crystal's natural frequency is in the ultrasound range / alternating p.d. is in ultrasound frequency range	B1

133. 9702_s17_MS_42 Q: 4

	Answer	Marks
(a)	pulse (of ultrasound)	B1
	* produced by quartz crystal/piezo-electric crystal	
	* gel/coupling medium (on skin) used to reduce reflection at skin	
	reflected from boundaries (between media)	B1
	reflected pulse/wave detected by (ultrasound) transmitter	B1
	reflected wave processed and displayed	B1
	* intensity of reflected pulse/wave gives information about boundary	
	* time delay gives information about depth of boundary	
	<i>max. 2 of additional detail points marked *</i>	B2
(b)	$I_T = I_0 \exp(-\mu x)$	C1
	$2.9 = \exp(4.6\mu)$	C1
	$\mu = 0.23 \text{ cm}^{-1}$	A1

134. 9702_w17_MS_42 Q: 4

	Answer	Marks
(a)	quartz/piezo-electric and crystal/transducer	B1
	p.d. across crystal causes it to distort	B1
	applying <u>alternating</u> p.d. causes oscillations/vibrations	B1
	when applied frequency is natural frequency, crystal resonates	B1
	natural frequency of crystal is in ultrasound range	B1
(b)	small(er) structures can be resolved/observed/identified	B1

135. 9702_m16_MS_42 Q: 6

(a) speed = Z/ρ
 $= 1.4 \times 10^6 / 940 (=1490)$ C1
time = $(1.1 \times 10^{-2} \times 2) / 1490$ C1
 $= 1.5 \times 10^{-5} \text{ s}$ A1 [3]
(time of $7.4 \times 10^{-6} \text{ s}$ is one way only and scores 2/3 marks)
(use of speed of light is wrong physics and scores 0/3 marks)

- (b) $I = I_0 \exp(-\mu x)$ or $I_2 = I_1 \exp(-\mu x)$ C1
 ratio = $\exp(-48 \times 1.1 \times 10^{-2})$
 = 0.59 A1 [2]
- (c) $0.33/100 = 0.59 \times (I_3/I_2) \times 0.59$ C1
 ratio = 9.5×10^{-3} A1
 or
 $0.33/100 = \exp(-48 \times 2.2 \times 10^{-2}) \times (I_3/I_2)$ (C1)
 ratio = 9.5×10^{-3} (A1) [2]
- (d) ratio I_3/I_2 increases B1 [1]
 (accept: "there is an increase in the proportion of the intensity that is reflected")

136. 9702_w16_MS_42 Q: 5

- (a) transducer/transmitter can be also be used as the receiver
 or
 transducer both transmits and receives
 receives reflected pulses between the emitted pulses
 (needs to be pulsed) in order to measure/determine depth(s)
 (needs to be pulsed) to determine nature of boundaries
 Any three of the above marking points, 1 mark each B2 [2]
- (b) (i) product of speed of (ultra)sound and density (of medium) M1
 reference to speed of sound in medium A1 [2]
- (ii) if Z_1 and Z_2 are (nearly) equal, I_T/I_0 (nearly) equal to 1/unity/(very) little reflection/mostly transmission B1
 if $Z_1 \gg Z_2$ or $Z_1 \ll Z_2$ or the difference between Z_1 and Z_2 is (very) large, then I_T/I_0 is small/zero/mostly reflection/little transmission B1 [2]

137. 9702_m21_MS_42 Q: 5

	Answer	Marks
(a)(i)	amplitude of the carrier wave varies	M1
	in synchrony with the displacement of the (information) signal	A1
(a)(ii)	Any 2 from: - fewer transmitters needed / each transmitter can cover a greater distance - more stations can share waveband - transmitters and receivers are cheaper	B2

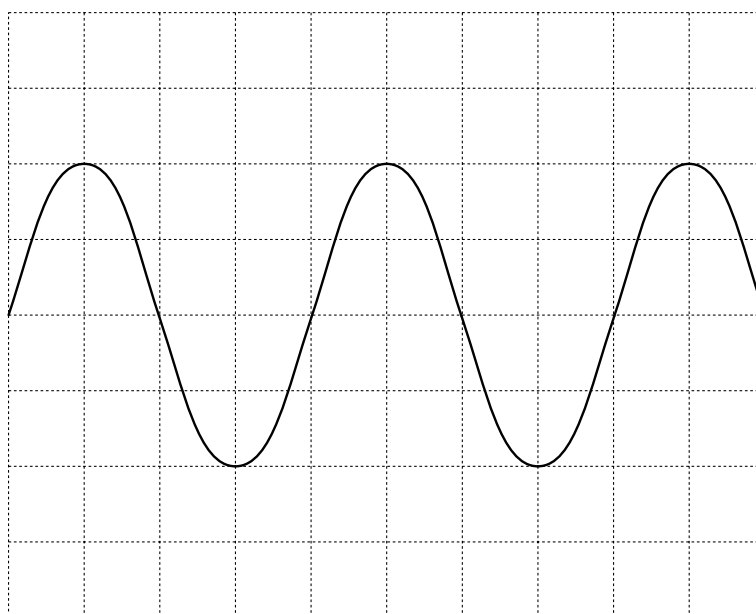
- 1 Which of the following summarises the change in wave characteristics on going from infra-red to ultraviolet in the electromagnetic spectrum?

9702/1/M/J/02/Q25

	frequency	speed (in a vacuum)
A	decreases	decreases
B	decreases	remains constant
C	increases	remains constant
D	increases	increases

- 2 The diagram shows a cathode-ray oscilloscope trace of a sound wave. The time-base is calibrated at 2.0 ms cm^{-1} .

9702/1/M/J/02/Q26



What is the frequency of the sound wave?

- A** 62.5 Hz **B** 125 Hz **C** 250 Hz **D** 500 Hz
- 3 Which statement correctly relates the intensity of a sound wave to the vibrations of the molecules?

9702/1/M/J/02/Q27

- A** intensity $\propto$ amplitude
B intensity $\propto$ (amplitude)²
C intensity $\propto$ displacement
D intensity $\propto$ (displacement)²

- 4 Which value is a possible wavelength for radiation in the microwave region of the electromagnetic spectrum?

9702/1/O/N/02/Q25

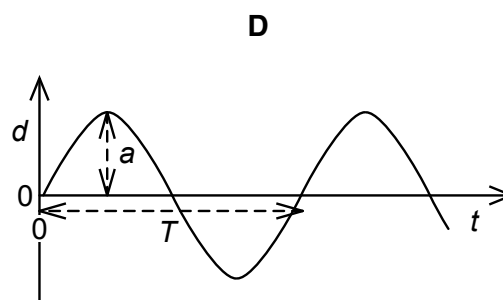
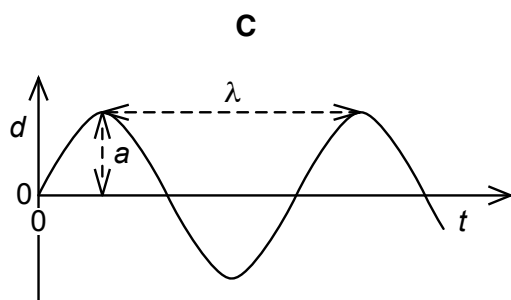
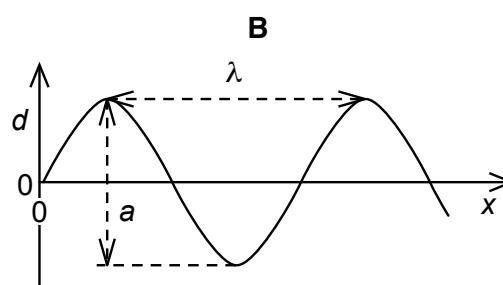
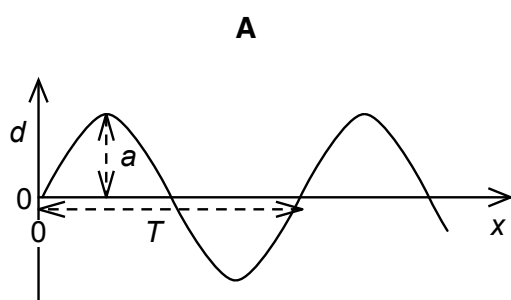
A $3 \times 10^{-2} \text{ m}$ **B** $3 \times 10^{-5} \text{ m}$ **C** $3 \times 10^{-8} \text{ m}$ **D** $3 \times 10^{-10} \text{ m}$

- 5 The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x .

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The labels on the graphs are intended to show the wavelength λ , the period T , and the amplitude a of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?



- 6 A wave of amplitude a has an intensity of 3.0 Wm^{-2} .

9702/1/O/N/02/Q27

What is the intensity of a wave of the same frequency that has an amplitude $2a$?

A 4.2 Wm^{-2} **B** 6.0 Wm^{-2} **C** 9.0 Wm^{-2} **D** 12 Wm^{-2}

- 7 Which of the following is true for all transverse waves?

9702/01/M/J/03/Q23

- A** They are all electromagnetic.
B They can all be polarised.
C They can all travel through a vacuum.
D They all involve the oscillation of atoms.

- 8 Electromagnetic waves of wavelength λ and frequency f travel at speed c in a vacuum.

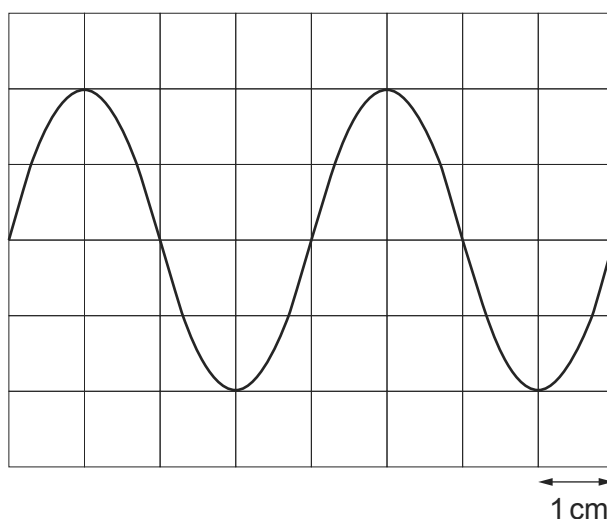
Which of the following describes the wavelength and speed of electromagnetic waves of frequency $f/2$?

9702/01/M/J/03/Q25

	wavelength	speed in a vacuum
A	$\lambda/2$	$c/2$
B	$\lambda/2$	c
C	2λ	c
D	2λ	$2c$

- 9 A sound wave is displayed on the screen of a cathode-ray oscilloscope. The time base of the c.r.o. is set at 2.5 ms/cm .

9702/01/M/J/03/Q26



What is the frequency of the sound wave?

- A** 50 Hz **B** 100 Hz **C** 200 Hz **D** 400 Hz

- 10 When the light from two lamps falls on a screen, no interference pattern can be obtained.

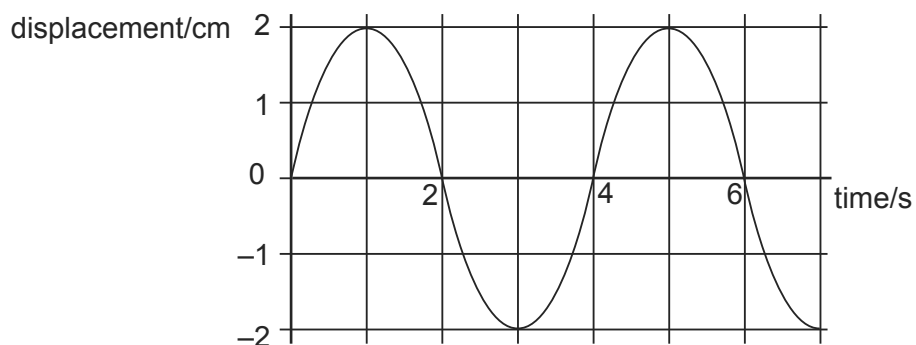
9702/01/M/J/03/Q27

Why is this?

- A** The lamps are not point sources.
B The lamps emit light of different amplitudes.
C The light from the lamps is not coherent.
D The light from the lamps is white.

- 11 The graph shows how the displacement of a particle in a wave varies with time.

9702/01/O/N/03/Q23



Which of the following is correct?

- A** The wave has an amplitude of 2 cm and could be either transverse or longitudinal.
- B** The wave has an amplitude of 2 cm and must be transverse.
- C** The wave has an amplitude of 4 cm and could be either transverse or longitudinal.
- D** The wave has an amplitude of 4 cm and must be transverse.

- 12 Which of the following applies to a progressive transverse wave?

9702/01/O/N/03/Q25

	transfers energy	can be polarised
A	no	no
B	no	yes
C	yes	no
D	yes	yes

- 13 Which observation indicates that sound waves are longitudinal?

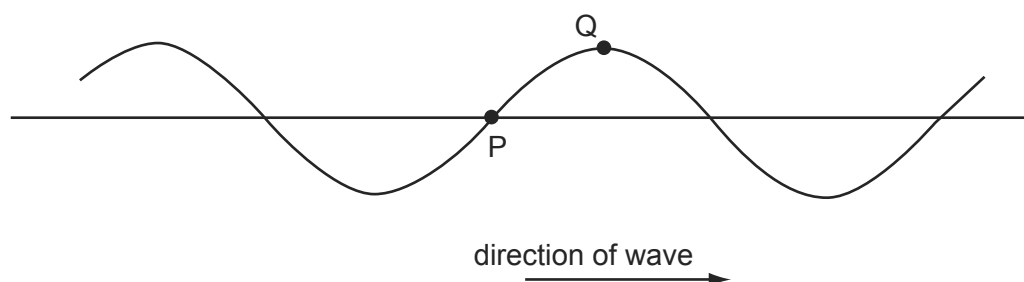
9702/01/M/J/04/Q24

- A** Sound can be reflected from a solid surface.
- B** Sound cannot be polarised.
- C** Sound is diffracted around corners.
- D** Sound is refracted as it passes from hot air to cold air.

- 14 The diagram shows a transverse wave on a rope. The wave is travelling from left to right.

At the instant shown, the points P and Q on the rope have zero displacement and maximum displacement respectively.

9702/01/M/J/04/Q25



Which of the following describes the direction of motion, if any, of the points P and Q at this instant?

	point P	point Q
A	downwards	stationary
B	stationary	downwards
C	stationary	upwards
D	upwards	stationary

- 15 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?

9702/01/M/J/04/Q26

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

- 16 What is the approximate range of frequencies of infra-red radiation?

9702/01/M/J/04/Q27

- A** $1 \times 10^3 \text{ Hz}$ to $1 \times 10^9 \text{ Hz}$
B $1 \times 10^9 \text{ Hz}$ to $1 \times 10^{11} \text{ Hz}$
C $1 \times 10^{11} \text{ Hz}$ to $1 \times 10^{14} \text{ Hz}$
D $1 \times 10^{14} \text{ Hz}$ to $1 \times 10^{17} \text{ Hz}$

- 17 A wave of amplitude 20 mm has intensity I_X . Another wave of the same frequency but of amplitude 5 mm has intensity I_Y .

9702/01/O/N/04/Q26

What is $\frac{I_X}{I_Y}$?

- A** 2 **B** 4 **C** 16 **D** 256

18 Which of the following is a longitudinal wave?

9702/01/O/N/04/Q24

- A** a light wave travelling through air
- B** a radio wave from a broadcasting station
- C** a ripple on the surface of water
- D** a sound wave travelling through air

19 What do **not** travel at the speed of light in a vacuum?

9702/01/M/J/05/Q23

- A** electrons
- B** microwaves
- C** radio waves
- D** X-rays

20 The number of wavelengths of visible light in one metre is of the order of

9702/01/M/J/05/Q24

- A** 10^4 .
- B** 10^6 .
- C** 10^8 .
- D** 10^{10} .

21 A health inspector is measuring the intensity of a sound. Near a loudspeaker his meter records an intensity I . This corresponds to an amplitude A of the sound wave. At another position the meter gives an intensity reading of $2I$.

9702/01/M/J/0/Q25

What is the corresponding sound wave amplitude?

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

22 A sound wave is set up in a long tube, closed at one end. The length of the tube is adjusted until the sound from the tube is loudest.

9702/01/M/J/0/Q26

What is the nature of the sound wave in the tube?

- A** longitudinal and progressive
- B** longitudinal and stationary
- C** transverse and progressive
- D** transverse and stationary

23 The frequency of a certain wave is 500 Hz and its speed is 340 m s^{-1} .

9702/01/M/J/06/Q25

What is the phase difference between the motions of two points on the wave 0.17 m apart?

- A** $\frac{\pi}{4}$ rad
- B** $\frac{\pi}{2}$ rad
- C** $\frac{3\pi}{4}$ rad
- D** π rad

- 24 Polarisation is a phenomenon associated with a certain type of wave.

9702/01/O/N/0/Q22

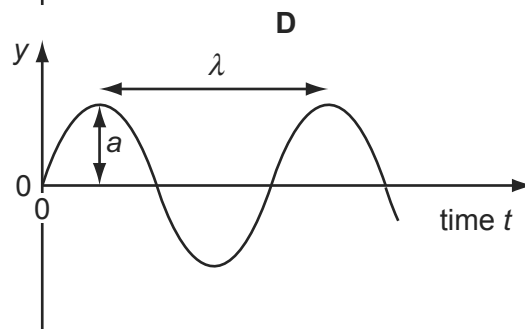
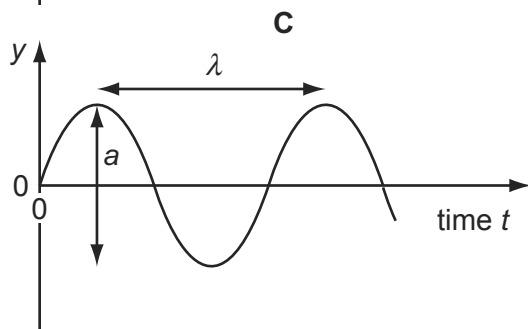
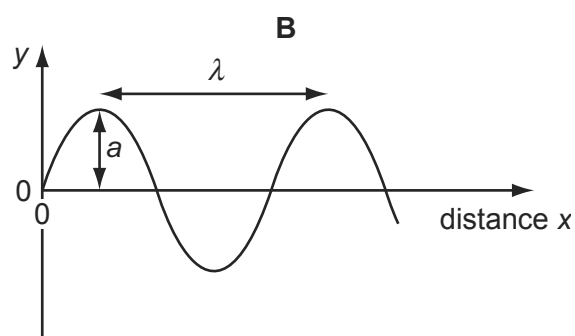
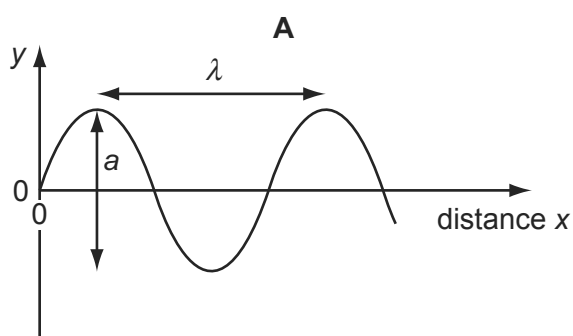
Which condition **must** be fulfilled if a wave is to be polarised?

- A It must be a light wave.
- B It must be a longitudinal wave.
- C It must be a radio wave.
- D It must be a transverse wave.

- 25 A sound wave has displacement y at distance x from its source at time t .

9702/01/O/N/0/Q23

Which graph correctly shows the amplitude a and the wavelength λ of the wave?



- 26 Which phenomenon is associated with transverse waves but **not** longitudinal waves?

9702/01/M/J/06/Q23

- A polarisation
- B reflection
- C refraction
- D superposition

- 27 The order of magnitude of the frequency of the longest-wavelength ultraviolet waves can be expressed as 10^x Hz.

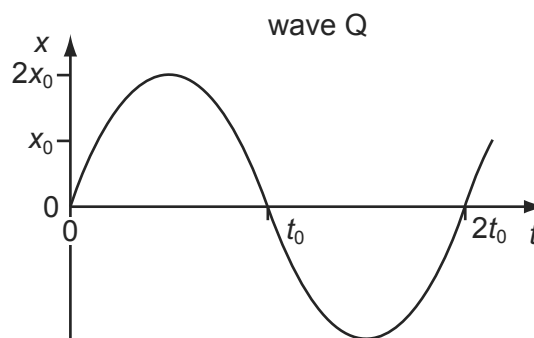
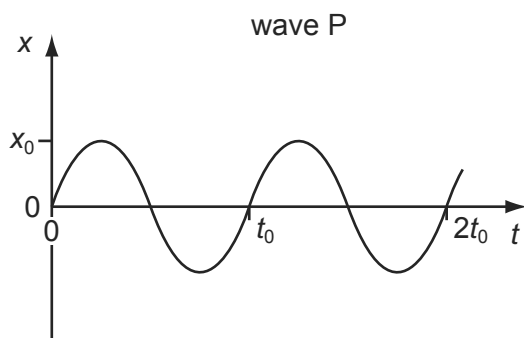
9702/11/O/N/09/Q23

What is the value of x ?

- A 13
- B 15
- C 17
- D 19

- 28 The intensity of a progressive wave is proportional to the square of the amplitude of the wave. It is also proportional to the square of the frequency. 9702/01/O/N/05/Q24

The variation with time t of displacement x of particles in a medium, when two progressive waves P and Q pass separately through the medium, are shown on the graphs.



The intensity of wave P is I_0 .

What is the intensity of wave Q?

- A** $\frac{1}{2}I_0$ **B** I_0 **C** $8I_0$ **D** $16I_0$
- 29 A sound wave of frequency 150 Hz travels in water at a speed of 1500 m s^{-1} . It then travels through the surface of the water and into air, where its speed is 300 m s^{-1} . 9702/01/O/N/05/Q25

Which line in the table gives the correct values for the wavelengths of the sound in water and in air?

	wavelength in water / m	wavelength in air / m
A	0.10	0.10
B	0.10	0.50
C	10	2.0
D	10	50

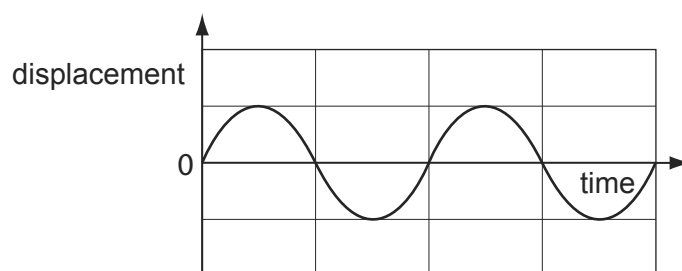
- 30 A wave motion is described by the oscillation of particles. 9702/01/O/N/06/Q24

What is the name given to the number of complete oscillations of a particle in one second?

- A** amplitude
B frequency
C wavelength
D wave speed

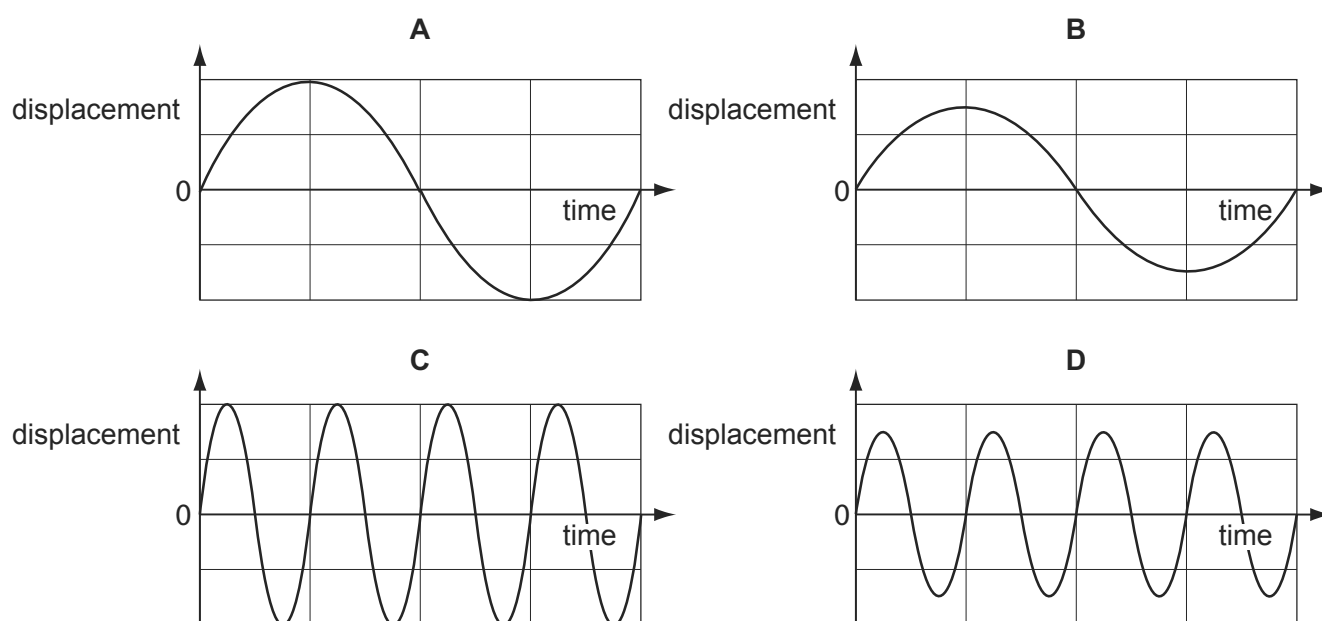
31 A displacement-time graph is shown for a particular wave.

9702/01/M/J/06/Q24



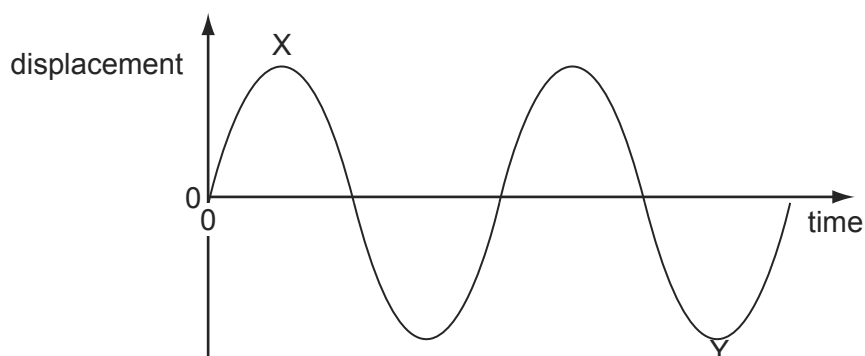
A second wave of similar type has twice the intensity and half the frequency.

When drawn on the same axes, what would the second wave look like?



32 A displacement-time graph for a transverse wave is shown in the diagram.

9702/01/O/N/06/Q25



The phase difference between X and Y can be expressed as $n\pi$.

What is the value of n ?

- A** 1.5 **B** 2.5 **C** 3.0 **D** 6.0

- 33 Continuous water waves are diffracted through a gap in a barrier in a ripple tank. 9702/01/O/N/06/Q26

Which change will cause the diffraction of the waves to increase?

- A increasing the frequency of the waves
- B increasing the width of the gap
- C reducing the wavelength of the waves
- D reducing the width of the gap

- 34 Which of the following types of wave can be polarised?

9702/01/M/J/07/Q21

- A a longitudinal progressive wave
- B a longitudinal stationary wave
- C a transverse stationary wave
- D a transverse sound wave

- 35 Sound wave X has intensity 10^{12} times greater than that of sound wave Y.

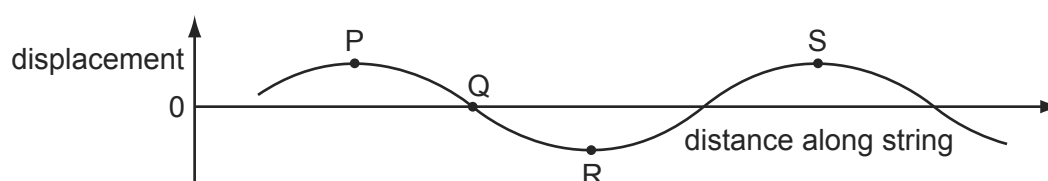
9702/01/M/J/07/Q22

By how much is the amplitude of X greater than the amplitude of Y?

- A 10^6 times
- B 3.16×10^6 times
- C 5×10^{11} times
- D 10^{12} times

- 36 The graph shows the shape at a particular instant of part of a transverse wave travelling along a string.

9702/01/M/J/07/Q23

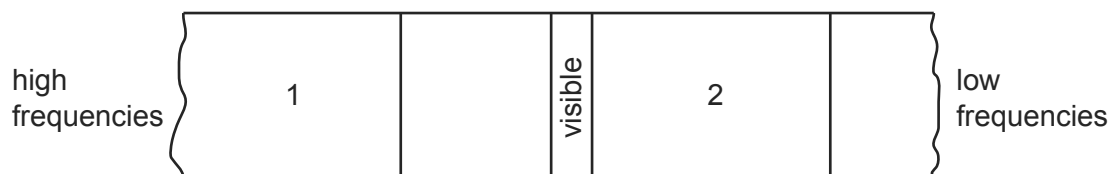


Which statement about the motion of points in the string is correct?

- A The speed at point P is a maximum.
- B The displacement at point Q is always zero.
- C The energy at point R is entirely kinetic.
- D The acceleration at point S is a maximum.

37 The diagram illustrates part of the electromagnetic spectrum.

9702/01/M/J/07/Q24



Which labels are correct for the regions marked 1 and 2?

	1	2
A	infrared	X-rays
B	microwaves	X-rays
C	ultraviolet	microwaves
D	X-rays	infrared

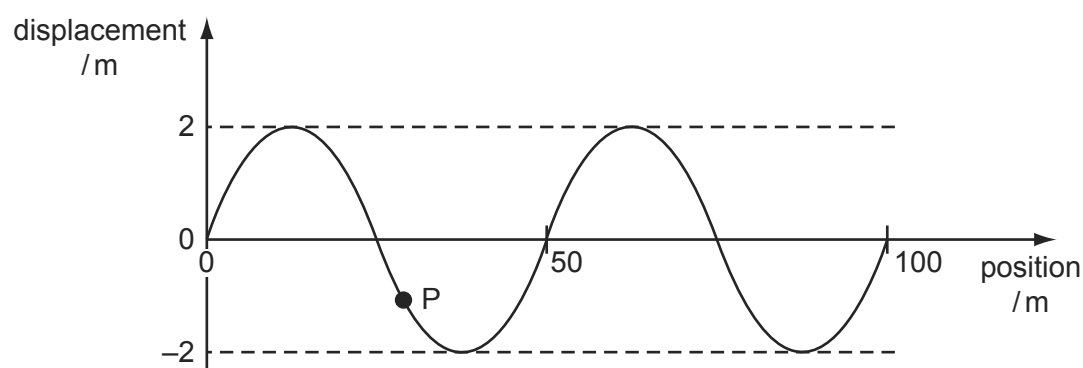
38 What is the relationship between the intensity I and the amplitude a of a wave?

9702/01/O/N/07/Q21

- A** $\frac{I}{a} = \text{constant}$
- B** $\frac{I}{a^2} = \text{constant}$
- C** $Ia = \text{constant}$
- D** $Ia^2 = \text{constant}$

39 The graph represents a sinusoidal wave in the sea, travelling at a speed of 8.0 m s^{-1} , at one instant of time. The maximum speed of the oscillating particles in the wave is $2\pi af$, where a is the amplitude and f is the frequency.

9702/01/O/N/07/Q23



An object P of mass $2.0 \times 10^{-3} \text{ kg}$ floats on the surface.

What is the maximum kinetic energy of P due to the wave? Assume that its motion is vertical.

- A** 0.026 mJ **B** 4.0 mJ **C** 39 mJ **D** 64 mJ

- 40 An electromagnetic wave has a frequency of 10^8 Hz.

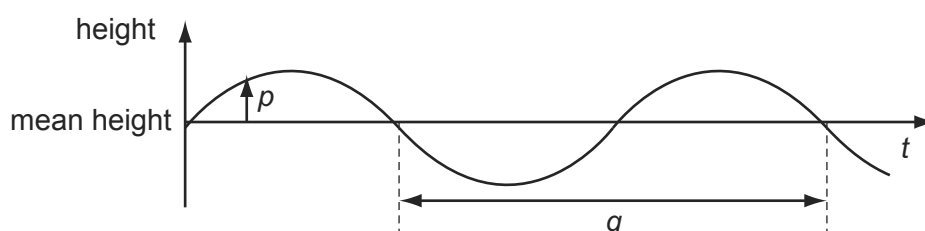
9702/01/O/N/07/Q22

In which region of the electromagnetic spectrum does the wave occur?

- A infra-red
- B radio
- C ultraviolet
- D visible

- 41 The graph shows how the height of a water surface at a point in a harbour varies with time t as waves pass the point.

9702/01/M/J/08/Q25



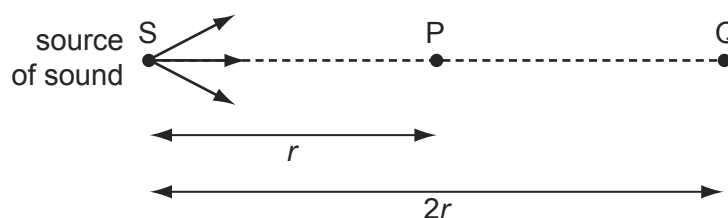
What are p and q ?

	p	q
A	displacement	wavelength
B	displacement	period
C	amplitude	wavelength
D	amplitude	period

- 42 The intensity I of a sound at a point P is inversely proportional to the square of the distance x of P from the source of the sound. That is

9702/01/M/J/08/Q26

$$I \propto \frac{1}{x^2}.$$



Air molecules at P, a distance r from S, oscillate with amplitude $8.0 \mu\text{m}$.

Point Q is situated a distance $2r$ from S.

What is the amplitude of oscillation of air molecules at Q?

- A $1.4 \mu\text{m}$
- B $2.0 \mu\text{m}$
- C $2.8 \mu\text{m}$
- D $4.0 \mu\text{m}$

- 43 Sound waves, emitted by a small loudspeaker, are reflected by a wall.

9702/01/M/J/08/Q27

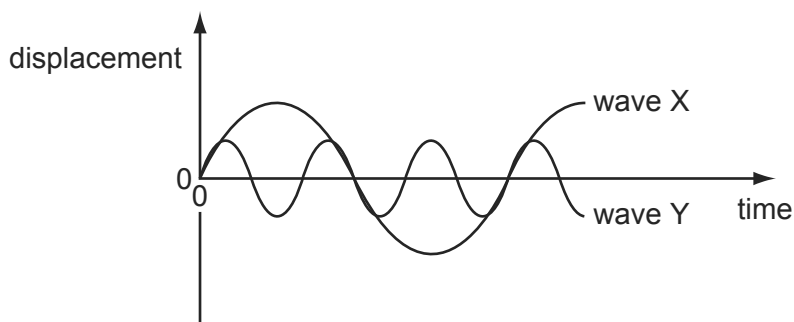
The frequency f of the waves is adjusted until a stationary wave is formed with the antinode nearest the wall at a distance x from the wall.

Which expression gives f in terms of x and the speed of sound c ?

- A** $f = \frac{4c}{x}$ **B** $f = \frac{2c}{x}$ **C** $f = \frac{c}{2x}$ **D** $f = \frac{c}{4x}$

- 44 The diagram shows two waves X and Y.

9702/01/O/N/08/Q24



Wave X has amplitude 8 cm and frequency 100 Hz.

What are the amplitude and frequency of wave Y?

	amplitude / cm	frequency / Hz
A	2	33
B	2	300
C	4	33
D	4	300

- 45 Light can exhibit all of the properties listed.

9702/01/O/N/08/Q25

Which property can sound **not** exhibit?

- A** interference
B polarisation
C refraction
D total internal reflection

- 46 The order of magnitude of the frequency of the longest-wavelength ultraviolet waves can be expressed as 10^x Hz.

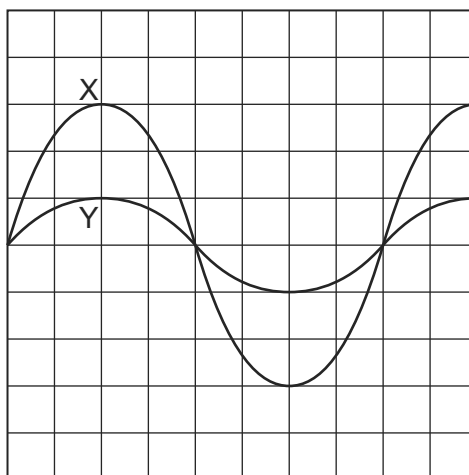
9702/12/O/N/09/Q22

What is the value of x ?

- A** 13 **B** 15 **C** 17 **D** 19

- 47 The diagram represents the screen of a cathode-ray oscilloscope displaying two sound waves labelled X and Y.

9702/01/O/N/08/Q26



What is the ratio $\frac{\text{intensity of sound wave X}}{\text{intensity of sound wave Y}}$?

- A** $\frac{9}{1}$ **B** $\frac{3}{1}$ **C** $\frac{\sqrt{3}}{1}$ **D** $\frac{1}{1}$

- 48 Which wave properties change when light passes from air into glass?

9702/01/M/J/09/Q23

- A** colour and speed
B frequency and wavelength
C speed and wavelength
D wavelength and colour

- 49 The light from two lasers passes through a vacuum. One laser emits red light and the other emits green light.

9702/11/O/N/09/Q24

Which property of the two laser beams must be different?

- A** amplitude
B frequency
C plane of polarisation
D speed

- 50 The amplitude of a wave is A and its intensity is I .

9702/12/O/N/10/Q23

Which amplitude is necessary for the intensity to be doubled to $2I$?

- A** A^2 **B** $\sqrt{A}$ **C** $\sqrt{2}A$ **D** $2A$

- 51 The light from two lasers passes through a vacuum. One laser emits red light and the other emits green light. 9702/12/O/N/09/Q23

Which property of the two laser beams must be different?

- A amplitude
- B frequency
- C plane of polarisation
- D speed

- 52 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m. 9702/11/M/J/10/Q22

Which type of wave are they most likely to be?

- A radio waves
- B microwaves
- C infra-red waves
- D ultraviolet waves

- 53 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m. 9702/13/M/J/10/Q23

Which type of wave are they most likely to be?

- A radio waves
- B microwaves
- C infra-red waves
- D ultraviolet waves

- 54 Electromagnetic waves from an unknown source in space were found to be significantly diffracted when passing through gaps of the order of 10^{-5} m. 9702/12/M/J/10/Q24

Which type of wave are they most likely to be?

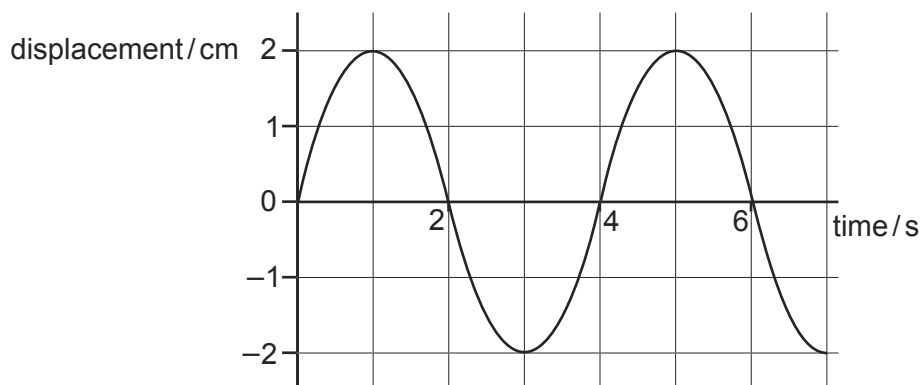
- A radio waves
- B microwaves
- C infra-red waves
- D ultraviolet waves

- 55 Which value is a possible wavelength for radiation in the ultra-violet region of the electromagnetic spectrum? 9702/12/O/N/10/Q24

- A 3×10^{-2} m B 3×10^{-5} m C 3×10^{-8} m D 3×10^{-10} m

56 The graph shows how the displacement of a particle in a wave varies with time.

9702/11/O/N/10/Q23



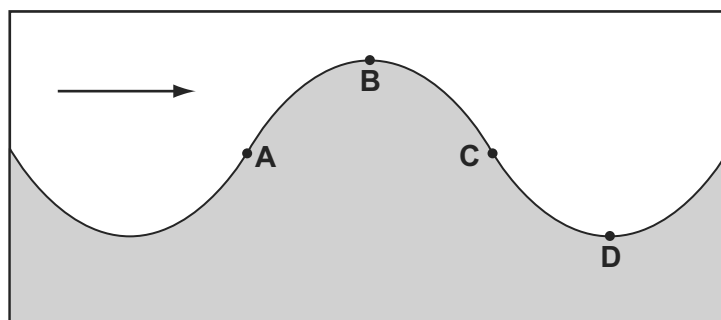
Which statement is correct?

- A** The wave has an amplitude of 2 cm and could be either transverse or longitudinal.
- B** The wave has an amplitude of 2 cm and must be transverse.
- C** The wave has an amplitude of 4 cm and could be either transverse or longitudinal.
- D** The wave has an amplitude of 4 cm and must be transverse.

57 The diagram shows a vertical cross-section through a water wave moving from left to right.

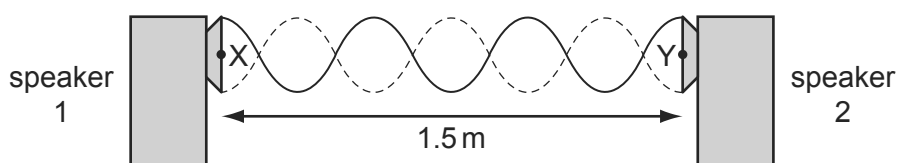
9702/11/O/N/10/Q24

At which point is the water moving upwards with maximum speed?



58 A stationary wave is produced by two loudspeakers emitting sound of the same frequency.

9702/11/O/N/10/Q26

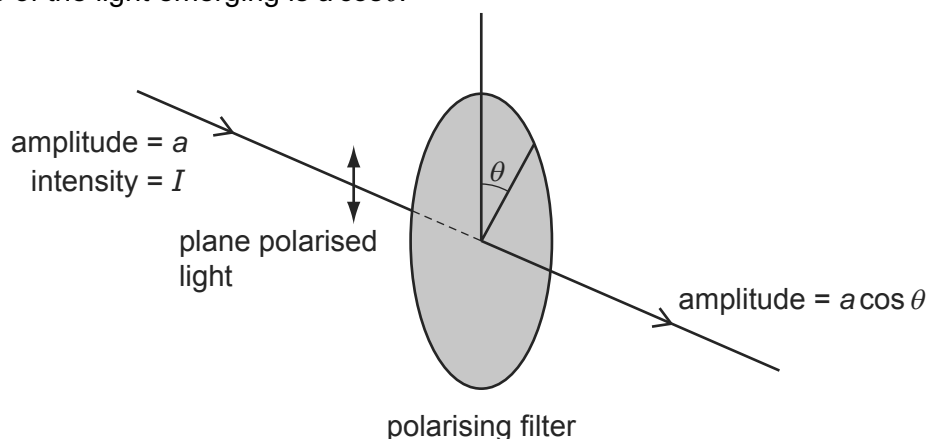


When a microphone is moved between X and Y, a distance of 1.5 m, six nodes and seven antinodes are detected.

What is the wavelength of the sound?

- A** 0.50 m
- B** 0.43 m
- C** 0.25 m
- D** 0.21 m

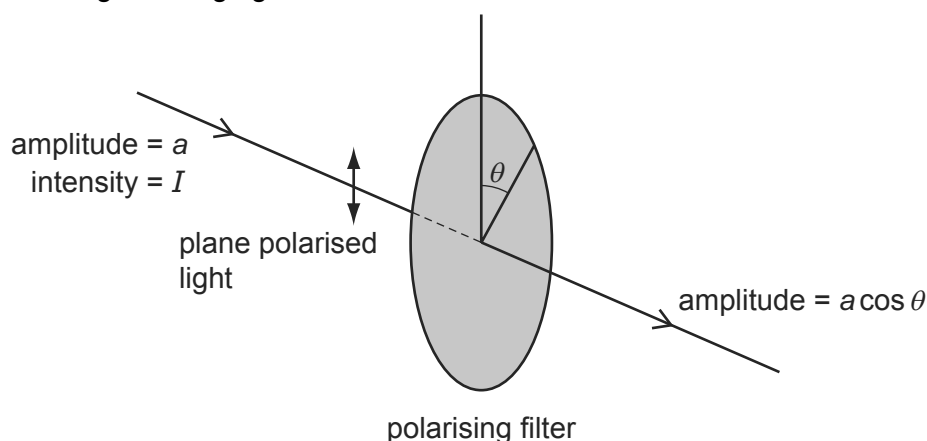
- 59 When plane-polarised light of amplitude a is passed through a polarising filter as shown, the amplitude of the light emerging is $a \cos \theta$. 9702/11/O/N/10/Q25



The intensity of the initial beam is I .

What is the intensity of the emerging light when θ is 60.0° ?

- A** $0.250 I$ **B** $0.500 I$ **C** $0.750 I$ **D** $0.866 I$
- 60 When plane-polarised light of amplitude a is passed through a polarising filter as shown, the amplitude of the light emerging is $a \cos \theta$. 9702/13/O/N/10/Q24



The intensity of the initial beam is I .

What is the intensity of the emerging light when θ is 60.0° ?

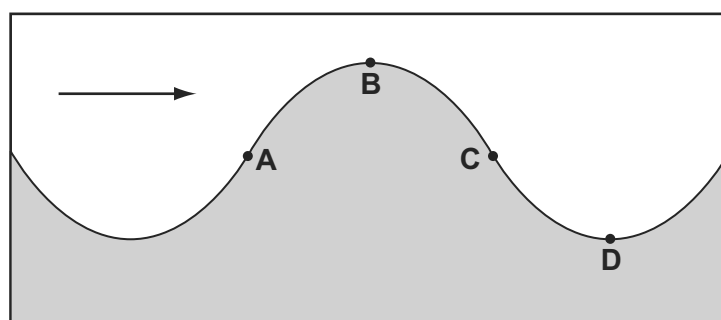
- A** $0.250 I$ **B** $0.500 I$ **C** $0.750 I$ **D** $0.866 I$
- 61 Which electromagnetic wave would cause the most significant diffraction effect for an atomic lattice of spacing around 10^{-10} m ? 9702/13/O/N/10/Q26

- A** infra-red
B microwave
C ultraviolet
D X-ray

- 62 The diagram shows a vertical cross-section through a water wave moving from left to right.

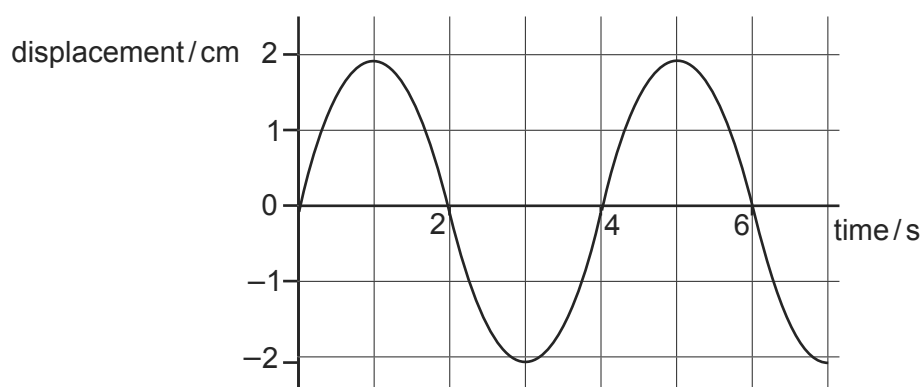
9702/13/O/N/10/Q25

At which point is the water moving upwards with maximum speed?



- 63 The graph shows how the displacement of a particle in a wave varies with time.

9702/13/O/N/10/Q27



Which statement is correct?

- A** The wave has an amplitude of 2 cm and could be either transverse or longitudinal.
 - B** The wave has an amplitude of 2 cm and must be transverse.
 - C** The wave has an amplitude of 4 cm and could be either transverse or longitudinal.
 - D** The wave has an amplitude of 4 cm and must be transverse.
- 64 Which statement about sound waves in air at constant temperature is correct?
- A** Amplitude is inversely proportional to velocity.
 - B** Frequency is inversely proportional to wavelength.
 - C** Velocity is proportional to wavelength.
 - D** Wavelength is proportional to amplitude.

9702/11/M/J/11/Q23

- 65 In which order of magnitude are the frequencies of electromagnetic waves in the visible spectrum?

9702/12/M/J/11/Q25

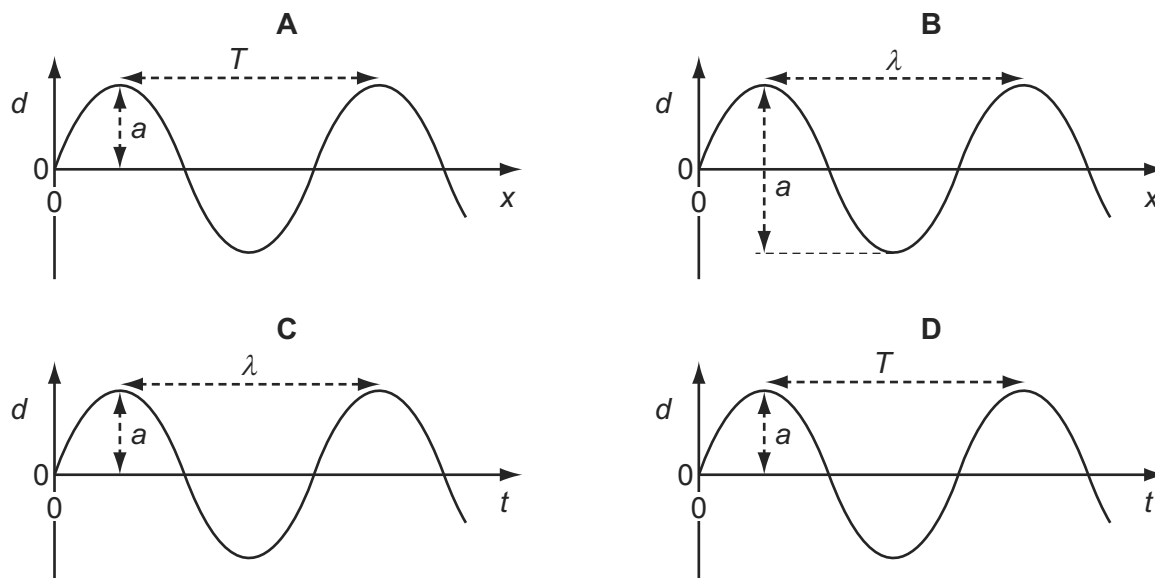
- A** 10^{12} Hz
- B** 10^{13} Hz
- C** 10^{14} Hz
- D** 10^{15} Hz

- 66 The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x .

9702/11/M/J/11/Q22

The labels on the graphs are intended to show the wavelength λ , the period T and the amplitude a of the wave, but only one graph is correctly labelled.

Which graph is correctly labelled?



- 67 A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

9702/11/M/J/11/Q24

$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

- A** $a \propto \frac{1}{r}$ **B** $a \propto \frac{1}{r^2}$ **C** $a \propto r$ **D** $a \propto r^2$

- 68 P is a source emitting infra-red radiation and Q is a source emitting ultra-violet radiation. The figures in the table are suggested values for the wavelengths emitted by P and Q.

9702/11/O/N/11/Q27

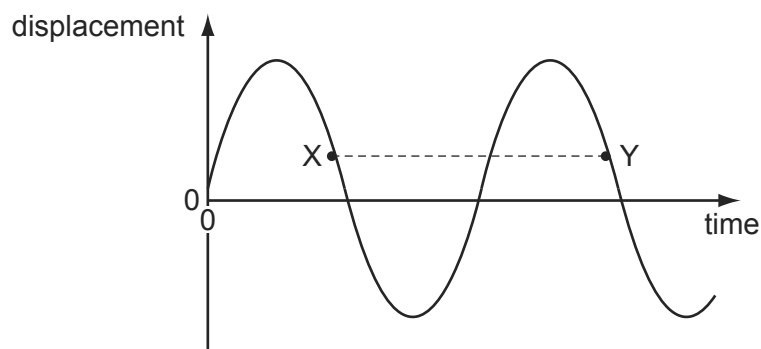
Which row is correct?

	wavelength emitted by P / m	wavelength emitted by Q / m
A	5×10^{-5}	5×10^{-8}
B	5×10^{-5}	5×10^{-10}
C	5×10^{-7}	5×10^{-8}
D	5×10^{-7}	5×10^{-10}

- 69 A transverse progressive wave is set up on a string.

9702/12/M/J/11/Q26

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

- 70 If a wave can be polarised, it **must** be

9702/12/M/J/11/Q27

- A** a longitudinal wave.
- B** an electromagnetic wave.
- C** a sound wave.
- D** a transverse wave.

- 71 A source of sound of constant power P is situated in an open space. The intensity I of sound at distance r from this source is given by

9702/13/M/J/11/Q22

$$I = \frac{P}{4\pi r^2}.$$

How does the amplitude a of the vibrating air molecules vary with the distance r from the source?

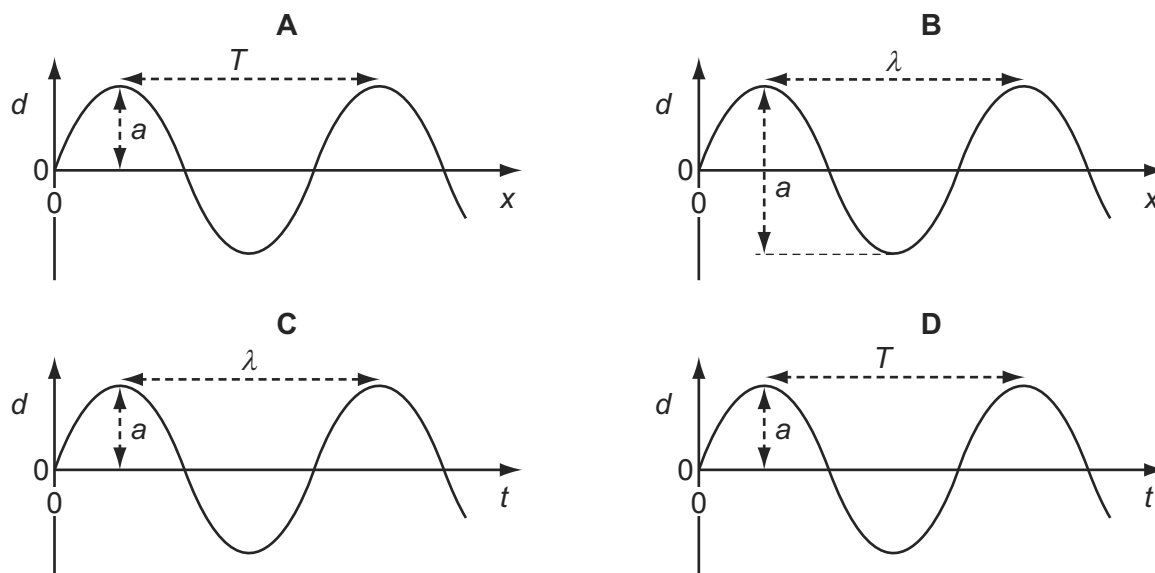
- A** $a \propto \frac{1}{r}$
- B** $a \propto \frac{1}{r^2}$
- C** $a \propto r$
- D** $a \propto r^2$

- 72 The four graphs represent a progressive wave on a stretched string. Graphs **A** and **B** show how the displacement d varies with distance x along the string at one instant. Graphs **C** and **D** show how the displacement d varies with time t at a particular value of x .

The labels on the graphs are intended to show the wavelength λ , the period T and the amplitude a of the wave, but only one graph is correctly labelled.

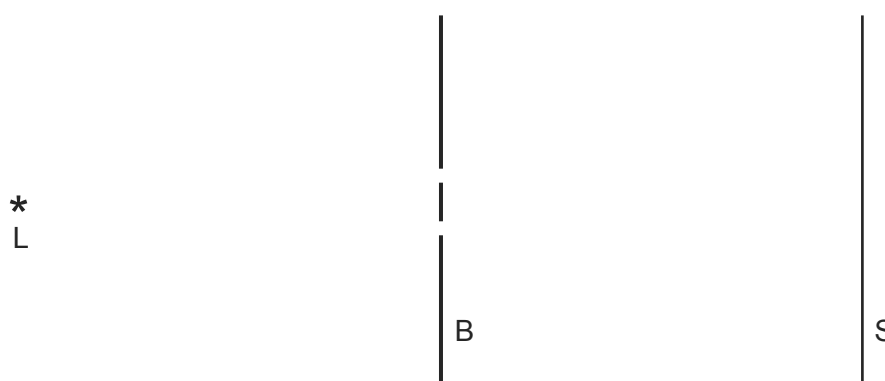
9702/13/M/J/11/Q23

Which graph is correctly labelled?



- 73 The diagram shows a view from above of a double slit interference demonstration. 9702/11/O/N/11/Q28

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 a point on the screen where the centre of the fringe pattern forms.

What is the intensity, at the same point, when one of the slits is covered up?

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

74 A wave that can be polarised must be

- A** longitudinal.
- B** progressive.
- C** stationary.
- D** transverse.

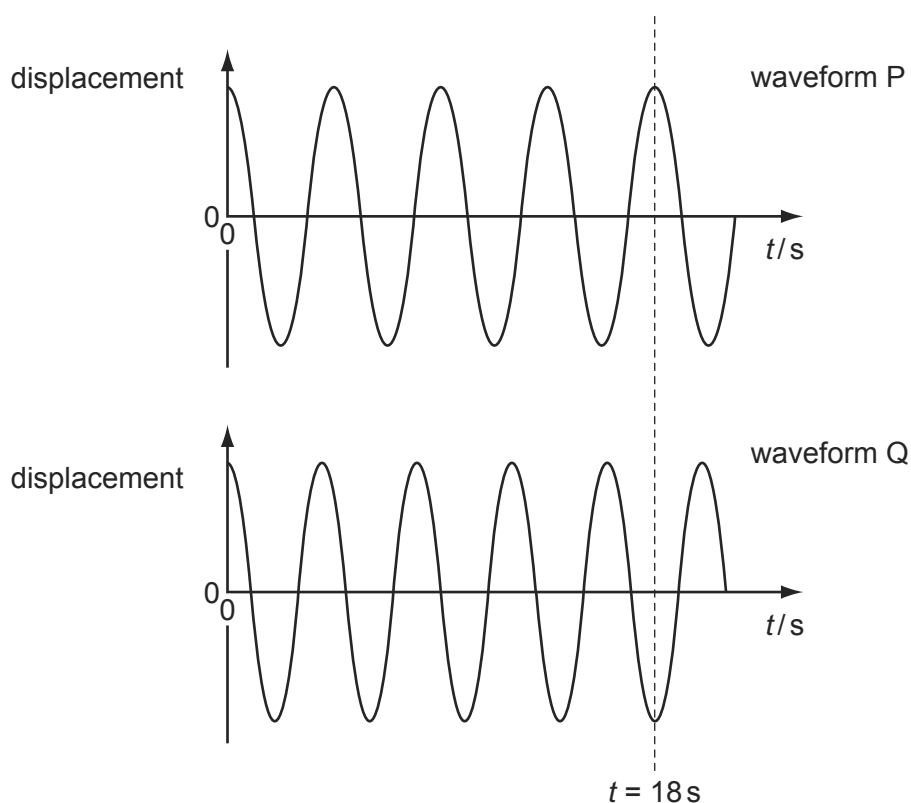
9702/12/O/N/11/Q25

75 Which statement about electromagnetic radiation is correct?

- A** Waves of wavelength 5×10^{-9} m are high-energy gamma rays.
- B** Waves of wavelength 3×10^{-8} m are ultra-violet waves.
- C** Waves of wavelength 5×10^{-7} m are infra-red waves.
- D** Waves of wavelength 9×10^{-7} m are light waves.

76 The diagram shows two sinusoidal waveforms.

9702/12/O/N/11/Q26



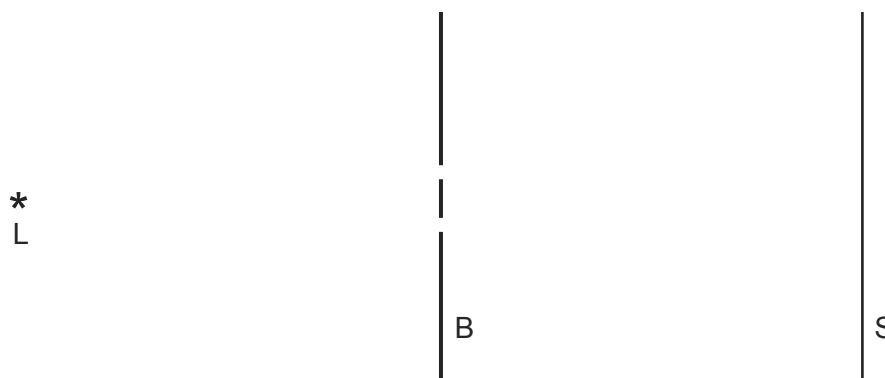
At time $t = 0$ the waves are in phase. At the dotted line, $t = 18$ s.

At which time is the phase difference between the two oscillations $\frac{1}{8}$ of a cycle?

- A** 4.0 s
- B** 4.5 s
- C** 8.0 s
- D** 9.0 s

- 77 The diagram shows a view from above of a double slit interference demonstration. 9702/13/O/N/11/Q27

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 a point on the screen where the centre of the fringe pattern forms.

What is the intensity, at the same point, when one of the slits is covered up?

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

- 78 P is a source emitting infra-red radiation and Q is a source emitting ultra-violet radiation. The figures in the table are suggested values for the wavelengths emitted by P and Q. 9702/13/O/N/11/Q28

Which row is correct?

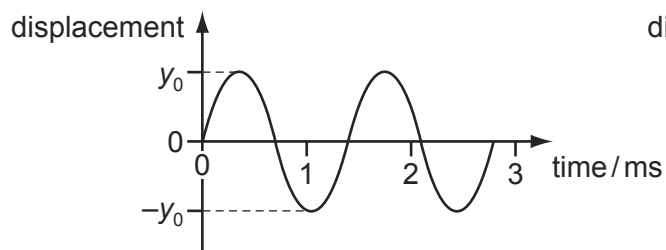
	wavelength emitted by P / m	wavelength emitted by Q / m
A	5×10^{-5}	5×10^{-8}
B	5×10^{-5}	5×10^{-10}
C	5×10^{-7}	5×10^{-8}
D	5×10^{-7}	5×10^{-10}

- 79 Which observation indicates that sound waves are longitudinal? 9702/11/M/J/12/Q28

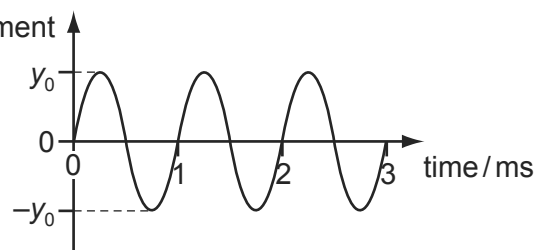
- A** Sound can be reflected from a solid surface.
B Sound cannot be polarised.
C Sound is diffracted around corners.
D Sound is refracted as it passes from hot air to cold air.

80 Two waves E and G are shown. The waves have the same speed.

9702/11/M/J/12/Q26



E



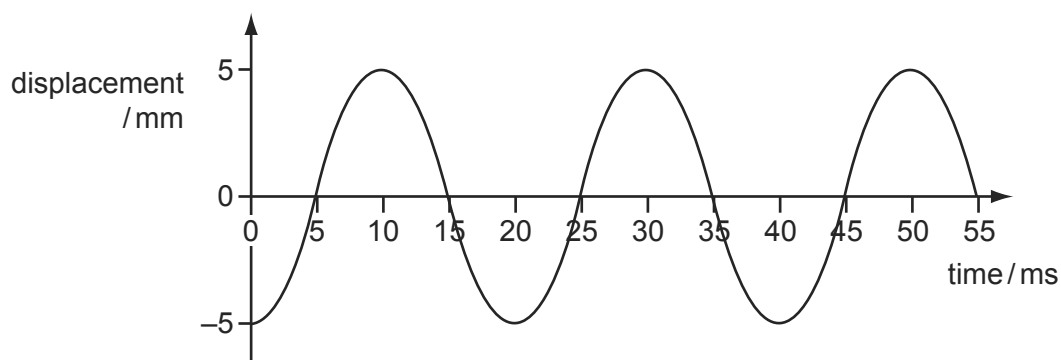
G

Which statement is correct?

- A** Wave E has a greater amplitude than wave G.
- B** Wave E has a greater intensity than wave G.
- C** Wave E has a smaller frequency than wave G.
- D** Wave E has a smaller wavelength than wave G.

81 The diagram shows a displacement-time graph for a progressive wave.

9702/11/M/J/12/Q27



What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

82 A surveyor's device emits a laser pulse.

9702/12/M/J/12/Q26

What is the time taken for the pulse to travel from the device to a wall 150 m away, where it is reflected, and then return to the device?

- A** 0.05 ns
- B** 0.10 ns
- C** 0.50 μ s
- D** 1.0 μ s

- 83 The period of an electromagnetic wave is 1.0 ns.

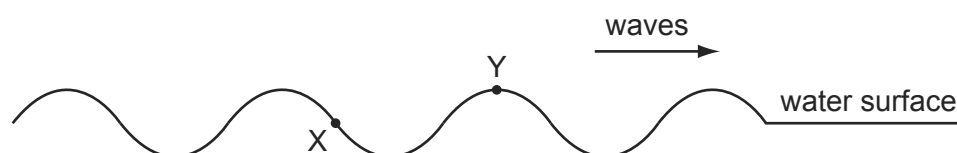
9702/12/M/J/12/Q27

What are the frequency and wavelength of the wave?

	frequency / Hz	wavelength / m
A	1.0	3.0×10^8
B	1.0×10^6	300
C	1.0×10^9	0.30
D	1.0×10^{12}	3.0×10^{-4}

- 84 X and Y are two points on the surface of water in a ripple tank. A source of waves of constant frequency begins to generate waves which then travel past X and Y, causing them to oscillate.

9702/12/M/J/12/Q28

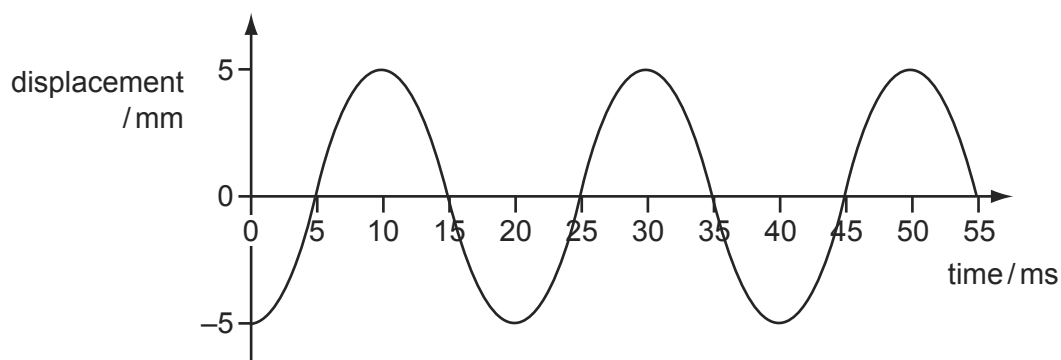


What is the phase difference between X and Y?

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

- 85 The diagram shows a displacement-time graph for a progressive wave.

9702/13/M/J/12/Q26

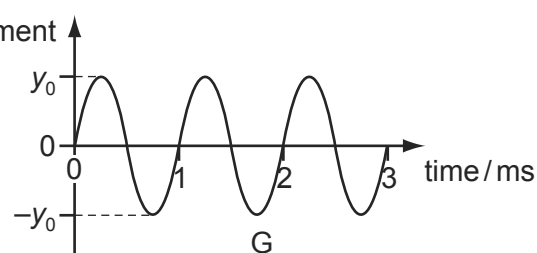
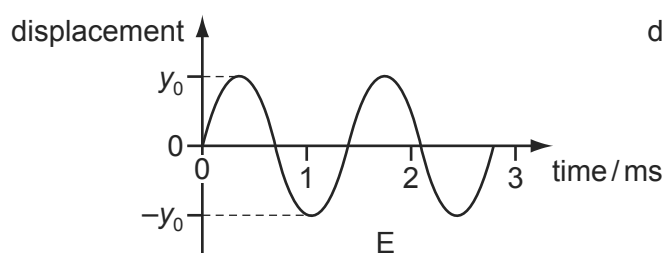


What are the amplitude and frequency of the wave?

	amplitude / mm	frequency / Hz
A	5	40
B	5	50
C	10	40
D	10	50

86 Two waves E and G are shown. The waves have the same speed.

9702/13/M/J/12/Q27



Which statement is correct?

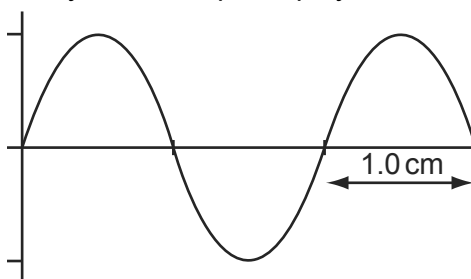
- A** Wave E has a greater amplitude than wave G.
- B** Wave E has a greater intensity than wave G.
- C** Wave E has a smaller frequency than wave G.
- D** Wave E has a smaller wavelength than wave G.

87 Which observation indicates that sound waves are longitudinal?

9702/13/M/J/12/Q29

- A** Sound can be reflected from a solid surface.
- B** Sound cannot be polarised.
- C** Sound is diffracted around corners.
- D** Sound is refracted as it passes from hot air to cold air.

88 The diagram shows a cathode-ray oscilloscope display of an electromagnetic wave. 9702/12/O/N/12/Q31



The time base setting is $0.20 \mu\text{s cm}^{-1}$.

Which statement is correct?

- A** The frequency of the wave is 2.5 MHz and it lies in the radio wave region of the electromagnetic spectrum.
- B** The frequency of the wave is 2.5 MHz and it lies in the microwave region of the electromagnetic spectrum.
- C** The frequency of the wave is 5.0 MHz and it lies in the radio wave region of the electromagnetic spectrum.
- D** The frequency of the wave is 5.0 MHz and it lies in the microwave region of the electromagnetic spectrum.