Multiple choice questions

Diffraction

Straight waves in a ripple tank approach a straight barrier which is parallel to the wave crests.
There is a gap of width *w* in the barrier. The wavelength is λ.
Use the following answer key for questions 50 and 51.

	λ (cm)	*w* (cm)
A.	0.5	2.0
B.	1.5	2.0
C.	2.5	2.0
D.	1.0	4.0
E.	1.5	4.0
F.	2.0	4.0

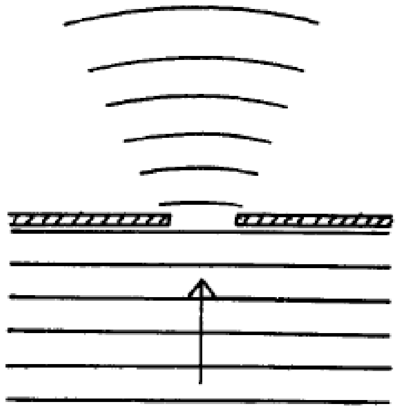
Example 1 1973 Question 50, 1 mark

In which case will the waves be most strongly diffracted?

Example 2 1973 Question 51, 1 mark

In which case will there be no nodal lines?

The diagram below shows sea waves approaching a gap in a sea-wall across a harbour of constant water depth.

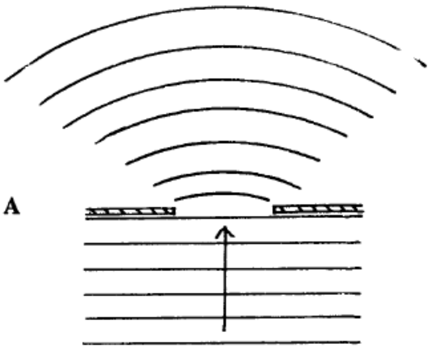


The gap is now doubled in width.

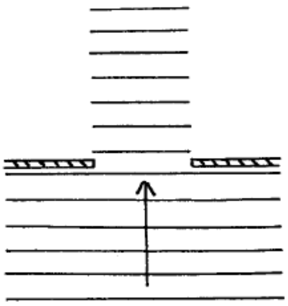
Example 3 1988 Question 40, 1 mark,

Which of the diagrams (**A** to **D)** below, represents what we would now expect to observe?

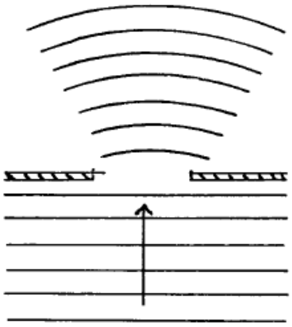
A



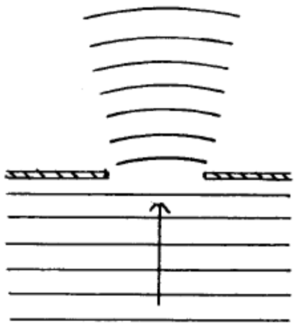
B



C

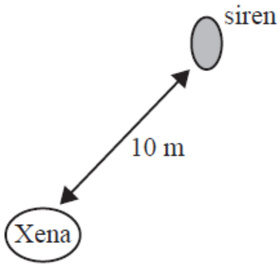


D

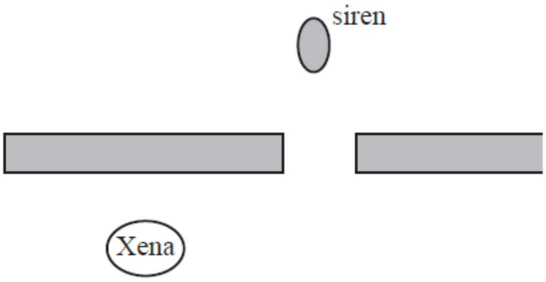


Example 4 2012 Question 8, 2 marks

A siren emits sounds of 500 Hz and 5000 Hz that alternate every second. The two frequencies have the same sound intensity level when Xena is standing 10 m from the siren, as shown below.



The siren is now placed on one side of a high wall with a narrow opening in it. Xena is standing on the other side of the wall. She is still 10 m from the siren. The situation is shown below.



Xena finds that both frequencies are softer than they were before the siren was placed on the other side of the wall. However, one of the frequencies is relatively much softer than the other frequency.
Which of the following statements is correct?

A. The 5000 Hz sound will be relatively softer because of diffraction effects.

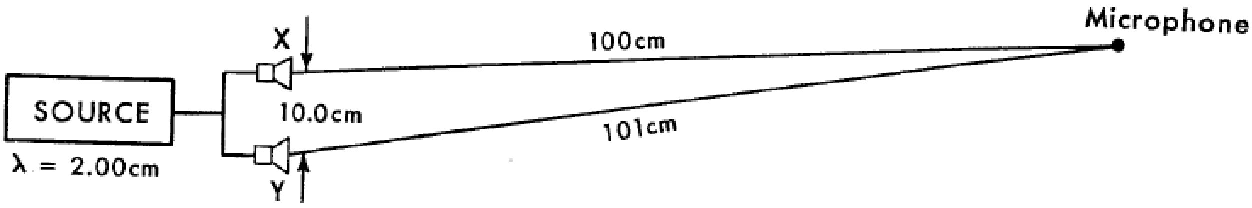
B. The 500 Hz sound will be relatively softer because of diffraction effects.

C. The 5000 Hz sound will be relatively softer because some of the higher-frequency sound will reflect off the front of the wall more than the lower-frequency sound.

D. The 500 Hz sound will be relatively softer because some of the lower-frequency sound will reflect off the front of the wall more than the higher-frequency sound.

Interference

The source is adjusted to produce sound of wavelength 2.00 cm, and the loudspeakers are placed 10.0 cm apart as shown below.



A microphone is placed at a point which is 100 cm from X and 101 cm from Y. The sound intensity there is measured.

Example 5 1977 Question 49, 1 mark 77%

Which of the following statements best describes the result?

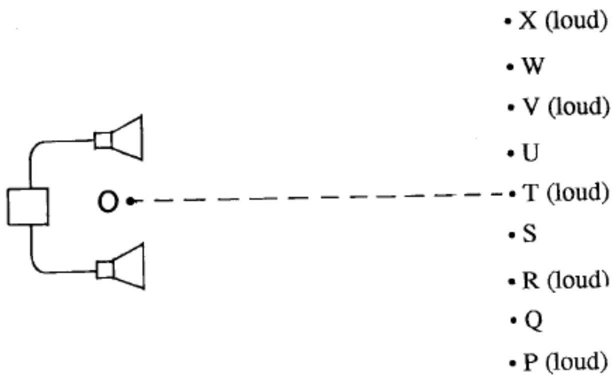
A. No sound will be detected.

B. There will be a detectable sound intensity which is constant in time.

C. There will be a detectable sound intensity which fluctuates slowly with time.

D. There is insufficient information to choose from A, B and C above.

Two loudspeakers, shown below, driven by a signal generator, emit sound of wavelength 0.60 metre. A student walks from point P to point X, and observes that the sound intensity alternates between loud (at points P, R, T, V and X) and very soft (at points Q, S, U and W). Point T is on the perpendicular bisector of the line joining the speakers and is a considerable distance from the loudspeakers. (O is the midpoint of the line joining the speakers.)



The student now walks very slowly towards the speakers along the line, TO.

Example 6 1989 Question 41, 1 mark

Which of the following statements (**A - E**) below best describes what the student would expect to hear?

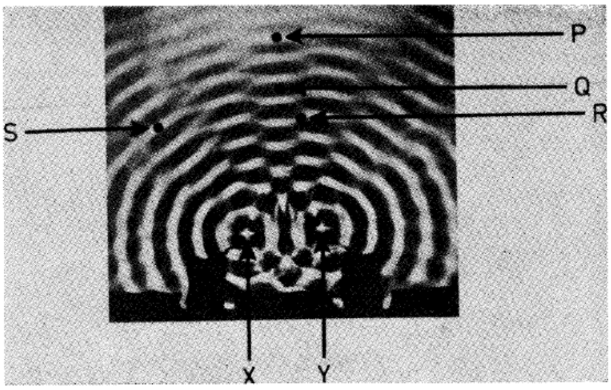
A. A sound of increasing frequency.

B. A sound of constant frequency but increasing volume.

C. A sound of decreasing frequency.

D. A series of 'louds' and 'softs'.

E. No sound at all (or a very soft note).



Two point sources, vibrating with the same frequency, produce an interference pattern in a ripple tank. The sources are in phase. Use the following key to answer questions 36 and 37.

A. This is a point on a resultant train of waves moving outwards from the region of the sources.

B. This is a point on a resultant train of waves moving inwards towards the sources.

C. This is a point on a standing (stationary) wave pattern.

D. At this point the water is relatively undisturbed.

Example 7 1978 Question 36, 1 mark

Which of the above statements best describes the point P?

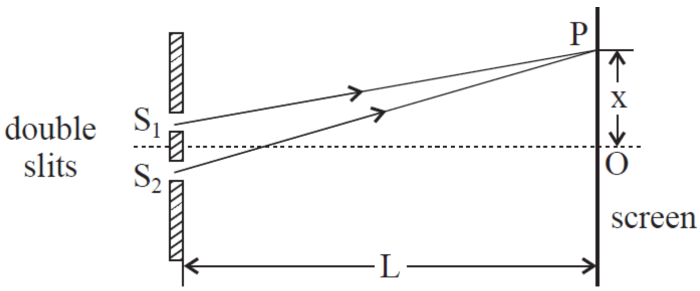
Example 8 1978 Question 37, 1 mark

Which of the above statements best describes the point R?

Young's Double slit interference

Example 9 QLD 2009 Question 8, 1 mark

The double-slit arrangement shown below was used to estimate the wavelength of monochromatic light.



The distance $PS_2 - PS_1$ is known. A maximum occurs at P. To find the wavelength of light, which
other measurement is required?

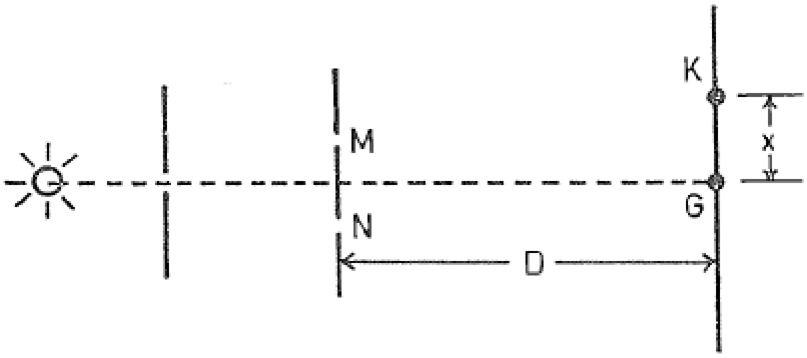
A. L

B. x

C. the distance S_1S_2

D. the number of maxima from O to P

Young's experiment is performed with light of wavelength, λ, using the apparatus shown in the diagram. *G is* equidistant from slits *M* and *N.*



On the screen one would expect to see in the vicinity of *G*

Example 10 1967 Question 61, 1 mark

A. a boundary between a bright and a dark band passing through *G*.

B. a dark band centred on *G*.

C. a bright band centred on *G*.

K is a point such that *NK - MK* = λ/2.

Example 11 1967 Question 62, 1 mark

One would expect to see in the vicinity of *K*

A. a boundary between a bright and a dark band passing through *K*.

B. a dark band centred on *K*.

C. a bright band centred on *K*.

An interference pattern is formed by passing intense yellow light ($\lambda = 5.7 \times 10^{-7}$ m) through a two slits 6×10^{-5} m apart. The pattern is observed on the screen 0.80 m from the slit. The width of the central maximum in the pattern is observed to be 0.10 m.

Example 12 1974 Question 59, 1 mark

Which of the following changes would result in the nodal lines being closer together?

A. Use a blue light source instead.

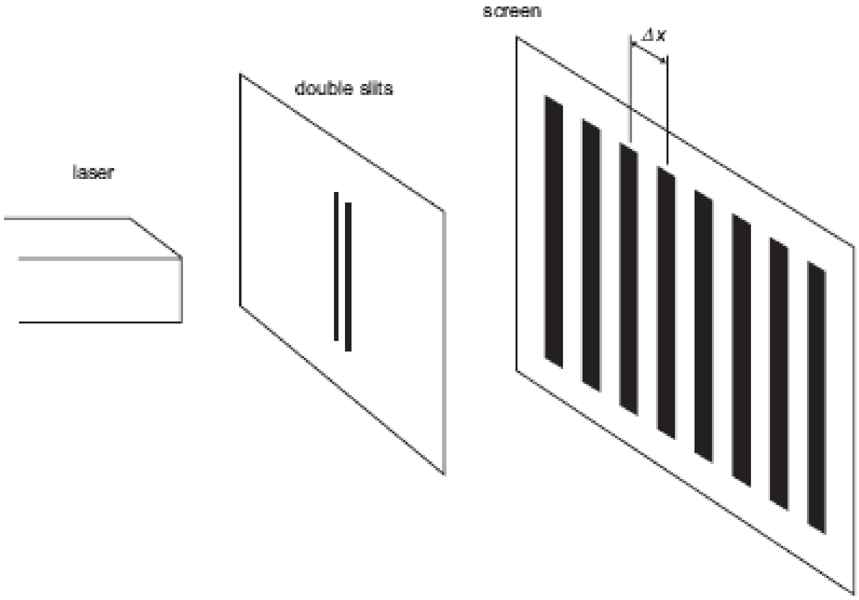
B. Decrease the intensity of the light source.

C. Use narrower slits.

D. Use two slits which are closer together.

E. Move the screen further from the slits.

A physics teacher has apparatus to show Young's double slit experiment. The apparatus is shown below. The pattern of bright and dark bands is observed on the screen.



Example 13   2005 Question 5, 2 marks

Which one of the following actions will **increase** the distance, *Δx*, between dark bands in this double slit interference pattern?

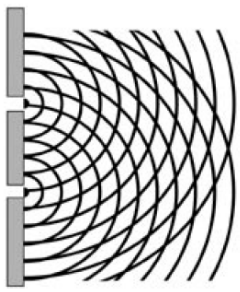
A. decrease the slit width

B. decrease the slit separation

C. decrease the slit-screen distance

D. decrease the wavelength of the light

In 1801, Thomas Young performed his now famous interference experiment. In this experiment the wave nature of light was demonstrated. The figure below is a drawing similar to the original sketch recorded by Young at the time. The dark circles represent wave crests, and the troughs are midway between these.



Example 14   2004 Sample Question 1, 2 marks

Which **one** or **more** of the following statements is true. Constructive interference occurs where:

A. crests overlap crests

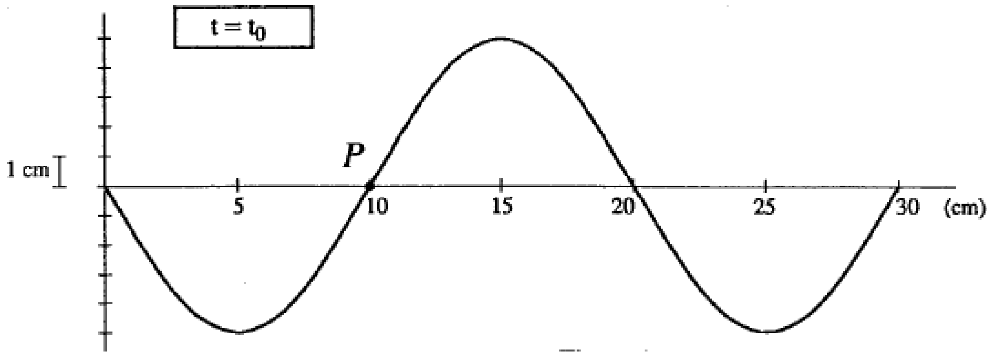
B. crests overlap troughs

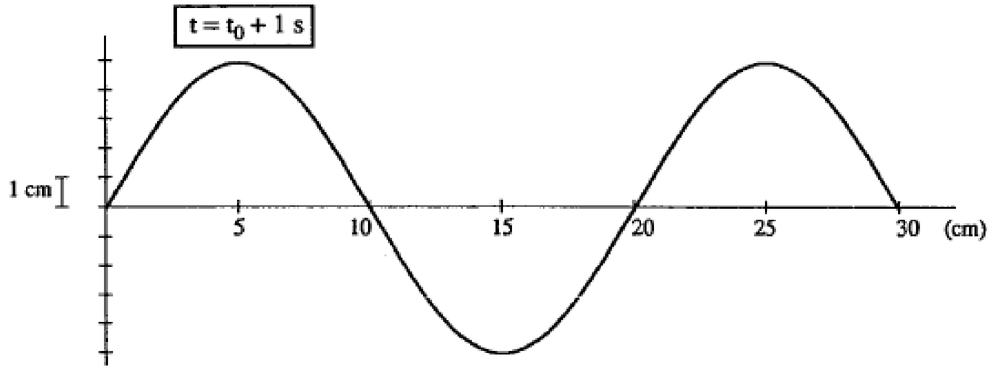
C. troughs overlap crests

D. troughs overlap troughs

Standing waves (in strings)

A travelling wave, moving to the right, is set up on a long string. The wave has a wavelength of 20 cm, and an amplitude of 5.0 cm. The first figure below shows a section of the string at a particular time t_0, and the second figure shows the same section 1.0 second later.





Example 15 1991 Question 40, 1 mark,

Which of the statements (**A - G**) below best describes the motion of the string at point P, at time t_0?

A. It is stationary, and will remain so.

B. It is stationary, and about to move up.

C. It is stationary, and about to move down.

D. It is moving upward.

E. It is moving downward.

F. It is moving to the right.

G. It is moving to the left.

Example 16 1991 Question 41, 1 mark,

If, instead, the wave shown in the figures was a stationary wave with the same amplitude, wavelength and frequency, which of the statements (**A - G**) above would best describe the motion of the string at point P?

Example 17 QLD 2015 Question 7, 1 mark

Standing waves may be created when two waves moving in opposite directions through the same medium interact. Which of the statements below is **false**?

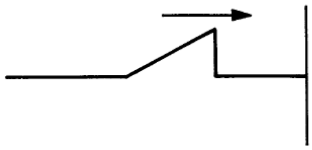
A. Standing waves can propagate energy.

B. Standing waves can occur in audio and optical phenomena.

C. The waves creating the standing wave have the same amplitude.

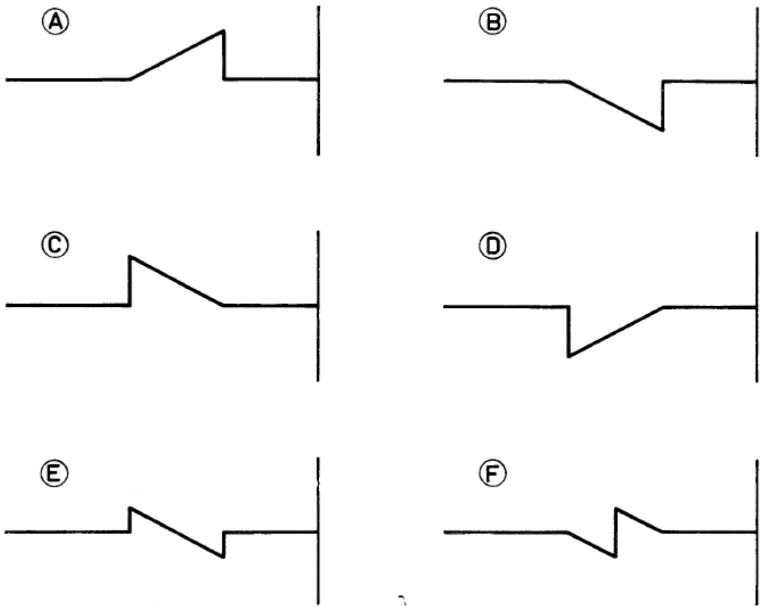
D. The waves creating the standing wave have the same wavelength.

A pulse in a rope approaches a solid wall and is reflected from it.

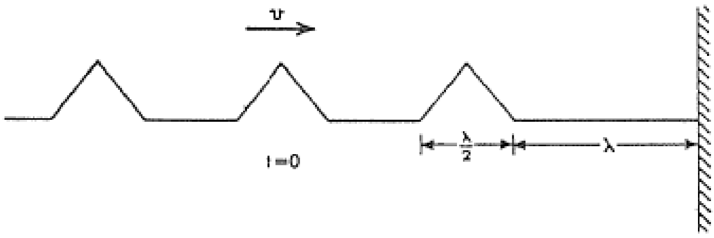


Example 18 1973 Question 49, 1 mark

Which of the following shows the pulse after reflection?



A wave pulse travels along a string towards the end of the string which is fixed. The pulse consists of three wavelengths as shown in the diagram. The wavelength is given by λ.



The velocity of the wave is *v.* At time *t* = 0 the leading wavefront is λ away from the end of the string.
Which of the wave patterns in the answer key represents the wave pulse at the following times?

Example 19 1977 Question 35, 1 mark

$t = \frac{\lambda}{v}$

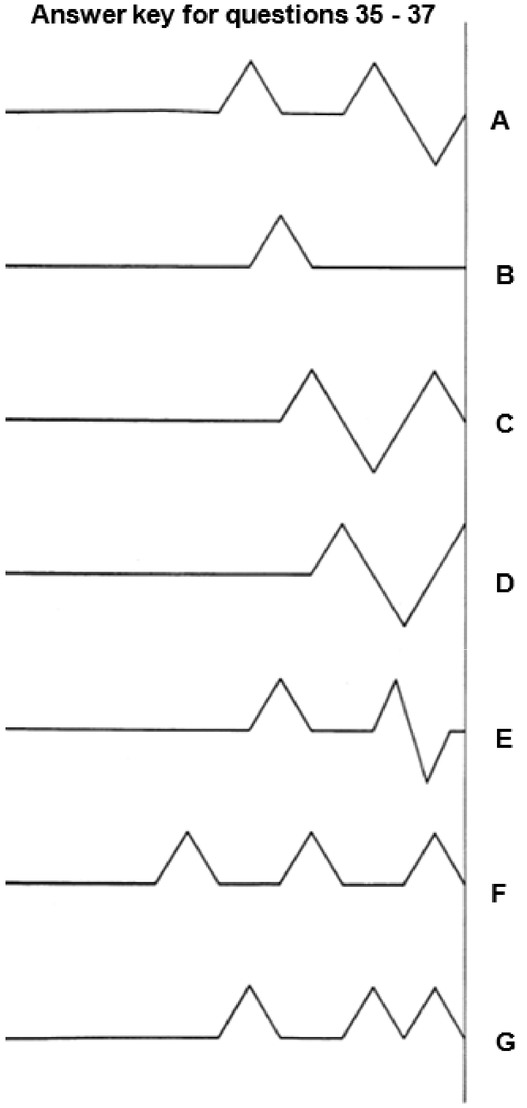
Example 20 1977 Question 36, 1 mark

$t = \frac{3\lambda}{2v}$

Example 21 1977 Question 37, 1 mark

$t = \frac{7\lambda}{4v}$

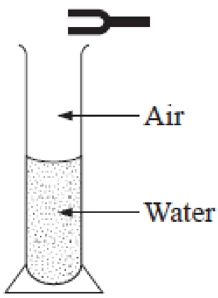
Answer key for questions 35 - 37



Resonance

Example 22 NSW 1998 Question 14, 1 mark

A student holds a vibrating 256 Hz tuning fork above a measuring cylinder full of water. She then gradually lowers the water height, creating an air column as shown. She observes that the sound produced becomes quite loud for the first time when the length of the air column is 32 cm. The student selects a tuning fork of a different frequency and vibrates it above the 32 cm long air column. It also produces quite a loud sound.



What is a possible frequency for the second tuning fork?

A. 768 Hz

B. 512 Hz

C. 128 Hz

D. 85 Hz

Example 23 NSW 1999 Question 14, 1 mark

A wine glass is shown below.

When a vibrating tuning fork is held a short distance from the open end of the wine glass a loud sound is heard coming from the wine glass.
This effect is due to

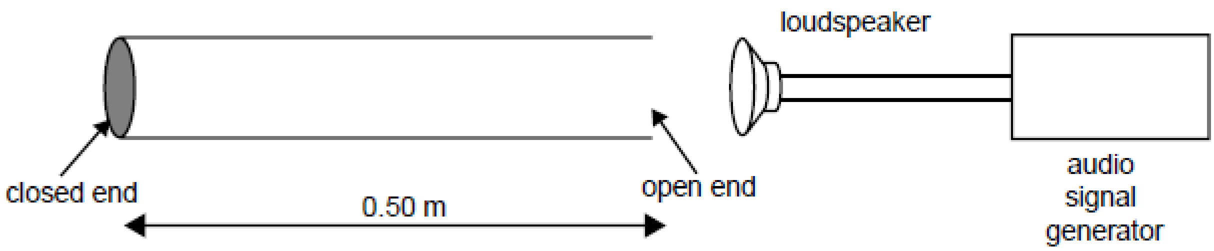
A. diffraction.

B. dispersion.

C. refraction.

D. resonance.

In order to study resonance in air columns, students use a narrow tube of length 0.50 m that is closed at one end and open at the other. They use a signal generator and loudspeaker as shown below. Take speed of sound in air as 340 m s^{-1}.



The students begin the experiment by using a sound of frequency 100 Hz.
The students increase the frequency until the first resonance (first harmonic) is reached.

Example 24 2007 Question 5, 2 marks

As they increase the frequency above the first resonance, at what frequency **(A - D)** will they hear the next resonance?

A. 85 Hz

B. 170 Hz

C. 340 Hz

D. 510 Hz

Sarah is planning to buy some plastic pipe from a hardware store. To measure the length of the pipe, she intends to blow across one end of the pipe and measure the frequency of the resonance produced.
The shop owner questions this method, but in the end agrees to let her perform the measurements. Sarah takes a section of pipe **open at both ends**, and performs the measurements. A clear resonance of 200 Hz can be heard.

Example 25 2006 Question 8, 2 marks

At which **one or more** of the following frequencies could the pipe also resonate?

A. 300 Hz

B. 400 Hz

C. 500 Hz

D. 600 Hz

Example 26 NSW 1997 Question 14, 1 mark

A 1.0 m long pipe, open at both ends, resonates with a tuning fork of frequency 680 Hz. Given that the speed of sound in air is 340 m s^{-1}, which harmonic does this resonance represent?

A. 1st

B. 2nd

C. 3rd

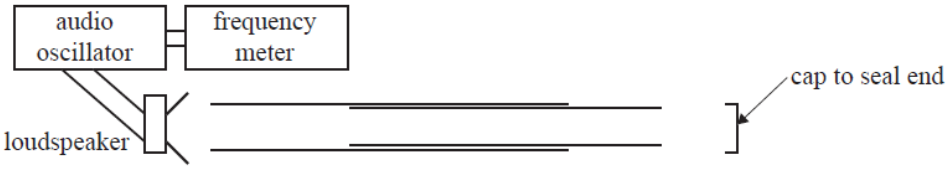
D. 4th

Use the following information to answer Questions 9 and 10.

Freda and Fred are studying sound resonance. They have a tube with a sliding inner tube so that the combined length of the tubes can be adjusted. A cap can be placed across one end to form a closed end.

They have an audio oscillator, a loudspeaker and a frequency meter.

The figure below shows the situation. The speed of sound in air should be taken to be 340 m s^{-1}. The oscillator is set to a frequency of 170 Hz.



With the cap **on**, Freda and Fred move the sliding section of the tube until they reach the fundamental (lowest frequency) resonance.

Example 27 2012 Question 9, 2 marks

Which of the following is closest to the combined length of the tubes when the fundamental frequency resonance is reached?

A. 0.25 m

B. 0.50 m

C. 1.0 m

D. 2.0 m

Example 28 2012 Question 10, 2 marks

Freda and Fred now increase the combined length of the tubes by sliding out the inner tube until they can hear the next resonance.

Which of the following is closest to the combined length of the tubes when this next resonance is reached?

A. 0.75 m

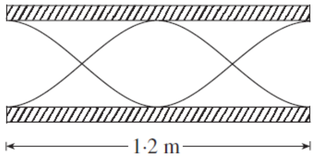
B. 1.0 m

C. 1.5 m

D. 3.0 m

Example 29 NSW 2000 Question 14, 1 mark

An organ is constructed so that it has open pipes. A note produced by one of these pipes has a frequency of 280 Hz. The length of this pipe is 1·2 m. A representation of a standing wave corresponding to this note is shown.



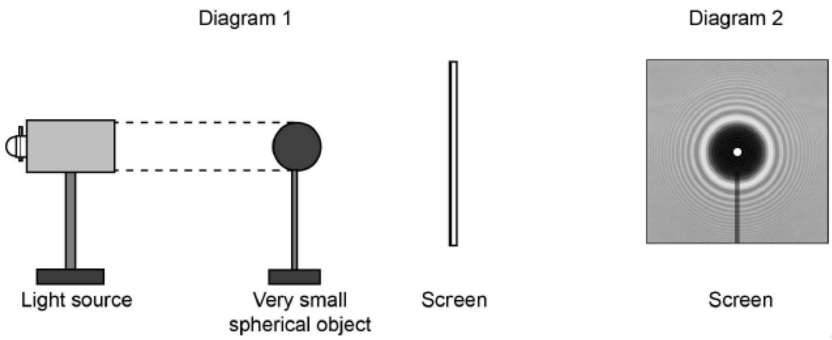
What are the frequency and wavelength of the fundamental resonance for this pipe?

	Frequency (Hz)	Wavelength (m)
A.	140	1.2
B.	140	2.4
C.	560	1.2
D.	560	2.4

Extended answer questions

Diffraction

An experiment was conducted to investigate the nature of light. A parallel beam of monochromatic light was directed at a very small spherical object and a white screen was positioned behind the object (Diagram 1). The pattern observed on the white screen is shown in Diagram 2. (Note: diagrams not to scale.)



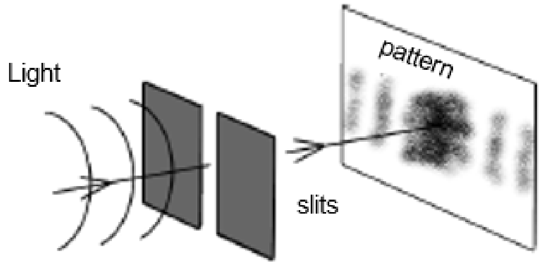
Example 30 WA 2018 Question 6a, 5 marks

Discuss how the pattern in Diagram 2 was produced.

Example 31 WA 2018 Question 6b, 1 mark

From this experiment, what conclusion can be made regarding the nature of light?

A single slit is illuminated with *coherent*, *monochromatic* light. A pattern is observed on a sheet of paper placed 1 m away as shown in the diagram.



Example 32 TAS 2019 Question 17a, 2 marks

What is meant by the term "monochromatic"?

Example 33 TAS 2019 Question 17b, 2 marks

What is meant by the term "coherent" in this context?

Example 34 TAS 2019 Question 17c, 2 marks

Using the diagram of a single slit, explain how a pattern can be created on the sheet of paper.

Peta and Danny are playing music in a soundproof recording room. Peta leaves the room while Danny is still playing. She notices that when she is standing at point **X**, as shown below, with the door open, she can still hear the music. The music is not only softer, but some of the frequencies seem to be much softer. The door to the recording room is 1 m wide.

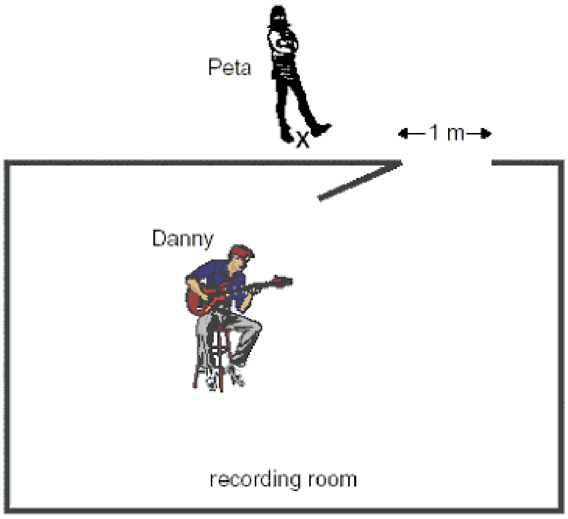
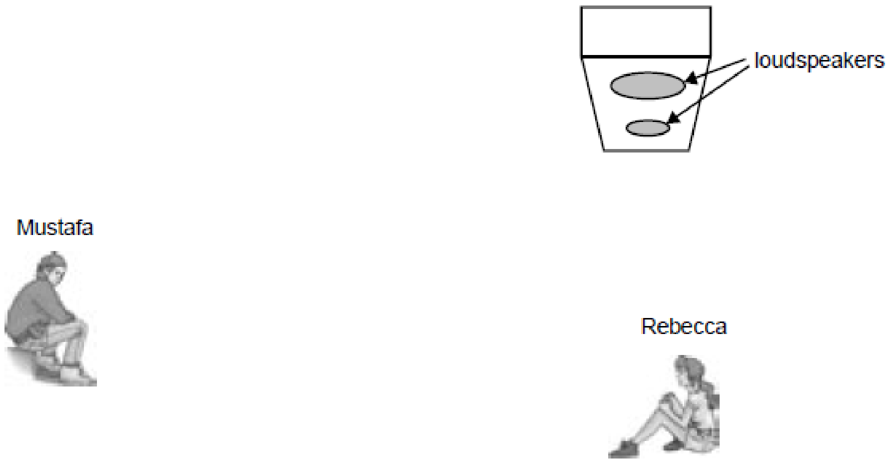


Figure 3

Example 35 2002 Question 6, 4 marks

Explain in what way the music sounds different, and why this is so. Give an estimate of the range of frequencies that are much reduced in intensity. The speed of sound in air is 340 m s^{-1}.

Mustafa has bought a new speaker system. The system has two loudspeakers: one 30 cm in diameter (for the frequency components below 500 Hz) and one 12 cm in diameter (for the higher frequency components). He invites his friend Rebecca to listen to some music. They are located as shown below.



Rebecca says that the sound is great, but Mustafa is disappointed, as the frequencies above 6000 Hz are very soft. He thinks that the small speaker is broken, however on checking he finds that the speaker is working.

Example 36 2003 Question 7, 1 mark

What is the wavelength of sound with a frequency of 6000 Hz?
Take the speed of sound as 340 m s^{-1}.

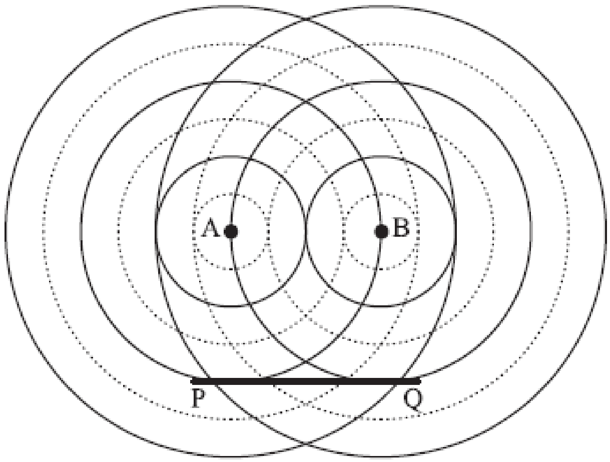
Example 37 2003 Question 8, 3 marks

In the space below explain why each listener hears the sound differently.

Interference

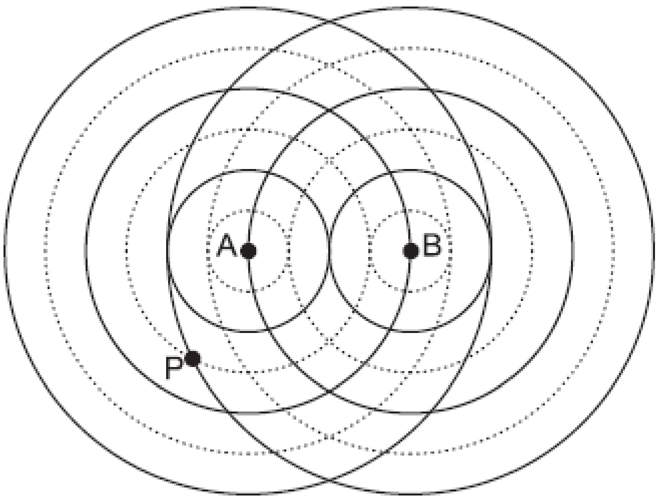
Example 38 QLD 2018 Question 5, 3 marks

Two in-phase point sources, A and B, generate audible sound waves as indicated in the diagram below, in which the full lines indicate compressions and the dotted lines indicate rarefactions. Using the terms ‘loud’ and ‘soft’, describe how the sounds change as a person walks in a straight line from P to Q.

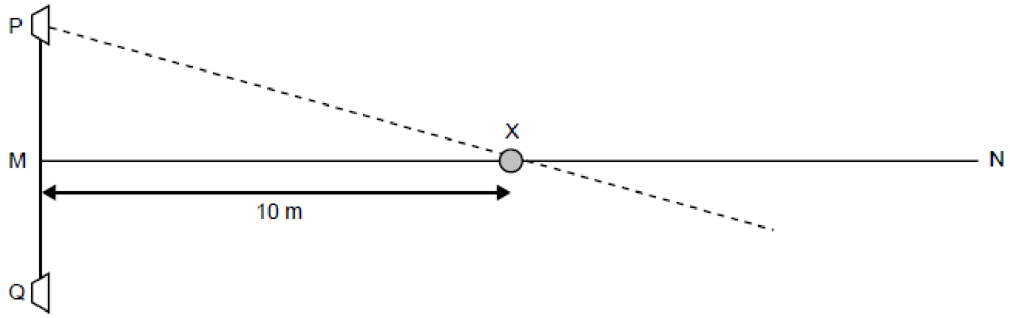


Example 39 QLD 2019 Question 5, 2 marks

Two in-phase point sources, A and B, generate waves as shown in the diagram below. The solid lines indicate crests while the dotted lines indicate troughs. Calculate the path difference between the lines AP and BP, and state the type of interference produced at point P.



In a demonstration of the perception of loudness, a teacher sets up a loudspeaker (P) on a stand at the centre of the school oval. The loudspeaker emits sound equally in all directions. The teacher now adds a second loudspeaker Q, and the loudspeakers P and Q are placed as shown below. They are connected to the same source using cables of the same length, and emit sound in phase. The point M is midway between the two speakers and the line MN is perpendicular to the line PQ.



The wavelength of the sound is 1.0 m.
Val again stands at the point X, and the teacher slowly moves loudspeaker P **directly towards Val** along the dashed line PX, until Val finds that the sound is very soft. When the teacher moves the loudspeaker even closer towards point X the sound becomes louder again.

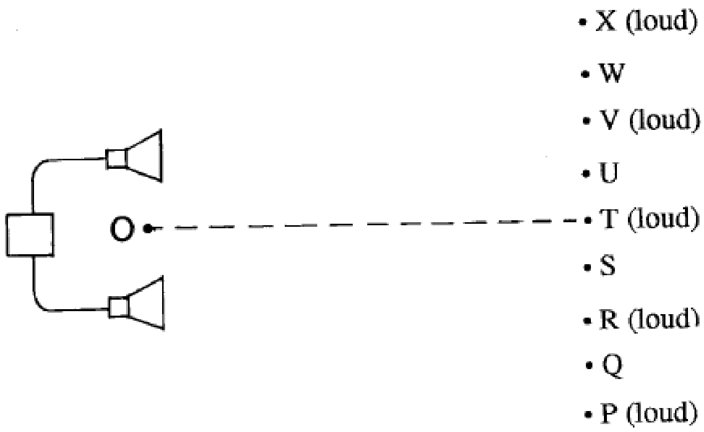
Example 40 2003 Question 5, 3 marks

In the space below, explain Val's observations.

Example 41 2003 Question 6, 3 marks

When Val heard the sound at its softest, how far had the teacher moved the loudspeaker along the line PX?

Two loudspeakers, shown below, driven by a signal generator, emit sound of wavelength 0.60 metre.
A student walks from point P to point X, and observes that the sound intensity alternates between loud (at points P, R, T, V and X) and very soft (at points Q, S, U and W).
Point T is on the perpendicular bisector of the line joining the speakers and is a considerable distance from the loudspeakers. (O is the midpoint of the line joining the speakers.)



Example 42 1989 Question 38, 1 mark

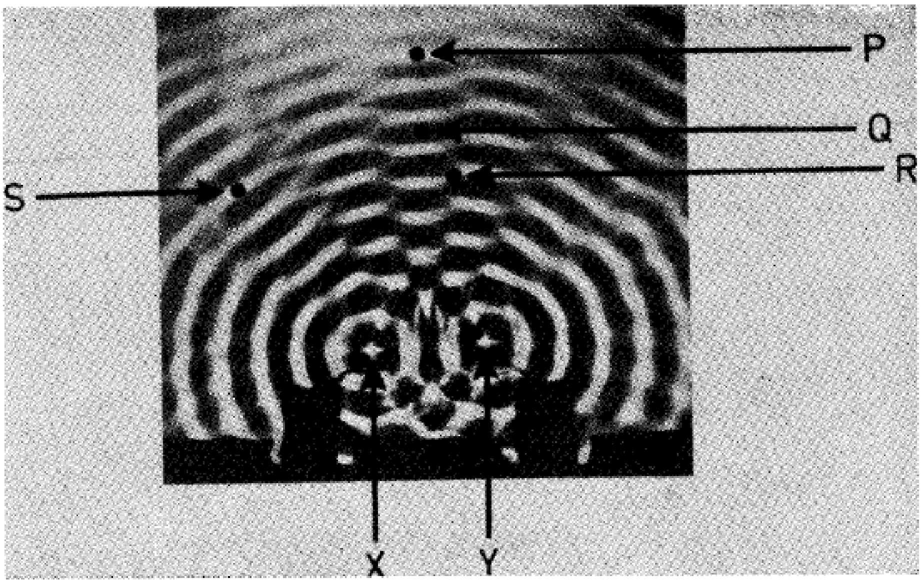
What is the path difference in metres, from the two speakers to the point U?

Example 43 1989 Question 39, 1 mark

What is the path difference in metres, from the two speakers to the point P?

Example 44 1989 Question 40, 1 mark

If the speed of sound in air is 330 m s^{-1}, what is the frequency of the signal given out by the speakers?



Answer questions 38 and 39 in numbers of wavelengths of the original waves.

Example 45 1978 Question 38, 1 mark

What is the length of PQ?

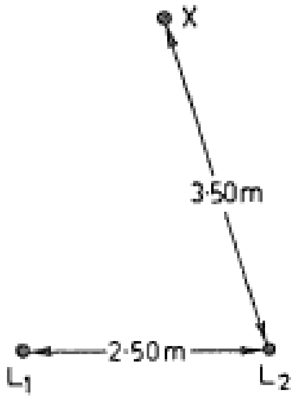
Example 46 1978 Question 39, 1 mark

What is the length (SY - SX)?

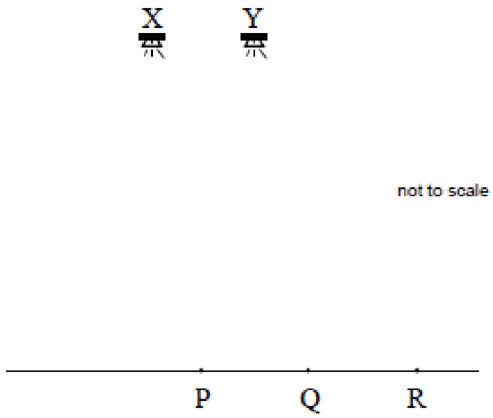
Two small identical loudspeakers, L_1 and L_2, are placed 2.50 m apart.
They both emit sound uniformly in all directions.
The wavelength of the sound is 1.00 m.
They are in phase.
Point X, a nodal point, is 3.50 m from L_2 and *at least* 3.50 m from L_1.

Example 47 1972 Question 57, 1 mark

What is the smallest distance that X can be from L_1?



A teacher sets up a loudspeaker system on the school oval, with two speakers placed at points X and Y as shown below.



The speakers emit sound in phase with a wavelength of 0.20 m.
A student walks from point P to point R and notices that the sound intensity is a maximum at P, then decreases to a minimum at Q, and increases to another maximum at R.
The distances XP and YP are equal.

Example 48   1999 Question 12, 4 marks

If the distance from Y to Q is 9.0 m, what is the distance from X to Q? Make sure you show your working clearly.

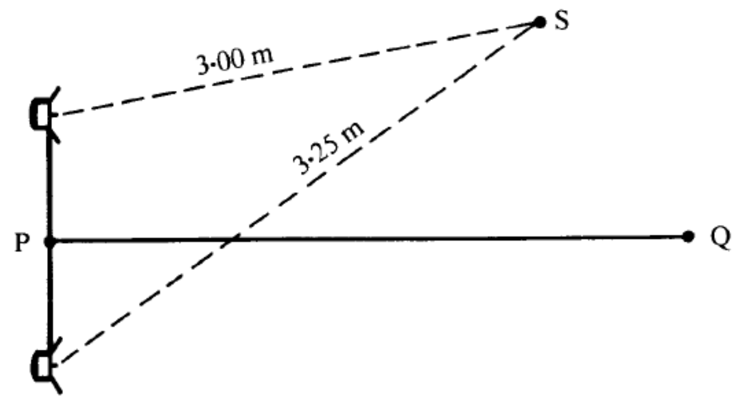
Two identical loudspeakers are emitting sound waves in phase.
A person stands at the point S, 3.00 m from one speaker and 3.25 m from the other.
The speed of sound in air is taken as 330 m s^{-1}

Example 49 1984 Question 45, 1 mark

What is the longest wavelength of sound for which destructive interference will occur at this point?

Example 50 1984 Question 46, 1 mark

What is the lowest frequency of sound for which destructive interference will occur at this point?



The person moves to a point on the line PQ, where P is midway between the speakers and PQ is perpendicular to the line joining the speakers.

Example 51 1984 Question 47, 1 mark

Which one or more of the statements below correctly describes the interference observed?

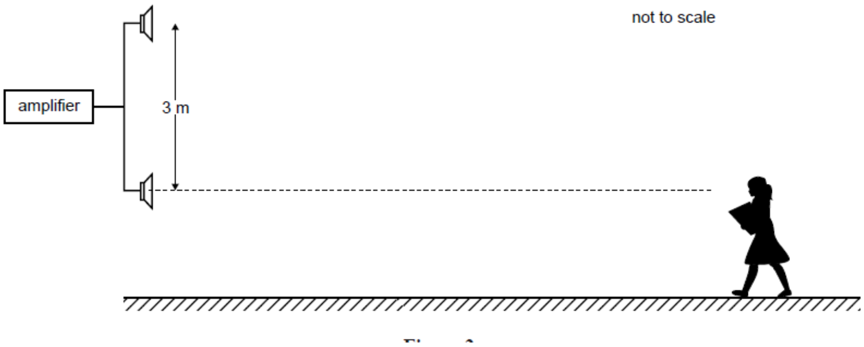
A. There will be destructive interference at this point.

B. There will be constructive interference at this point.

C. Whether the interference is constructive or destructive depends on the separation of the speakers.

D. Whether the interference is constructive or destructive depends on the position of the person along the line PQ.

Two speakers are mounted on a wall in the school gymnasium. One speaker is at head-height and the other is 3 m directly above it. The speakers are connected to the same amplifier, and emit sound waves in phase with a wavelength of 2 m. The speed of sound in air is 340 m s^{-1}.



A student walks from the far end of the gym towards the lower speaker. Although the sound is quite audible, at a certain distance from the speaker it becomes soft, then increases again.

Example 52 2002 Question 5, 4 marks

How far is the student from the lower speaker when the sound level first becomes a minimum?

Young's Double slit

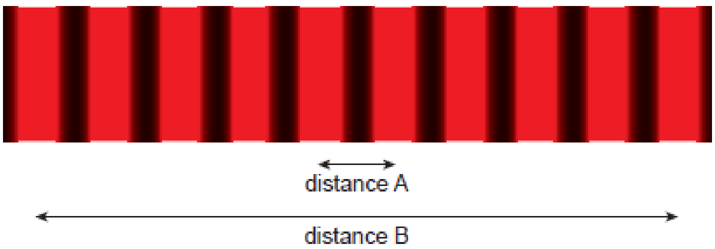
Example 53 QLD 2018 Question 6, 3 marks

In a Young's double-slit experiment, light was passed through two slits 0.235 mm apart and a pattern of bright and dark fringes appeared on a screen 4.00 m away. The distance between pairs of adjacent bright fringes was found to be a constant 1.00 cm. From this data determine the wavelength of the light used in the experiment.

Example 54   QLD 2019 Question 6, 3 marks

An experiment, similar to Young's double-slit experiment, was conducted using monochromatic light with a wavelength of 530.0 nm. The light sources were separated by a distance of 2.00×10^{-3} and the screen was 6.00 m away. Calculate the distance between adjacent dark fringes produced on the screen.

Two students conducted a two-slit experiment to determine the wavelength of the red light produced by a laser. The distance between the slits was 1.2×10^{-4} m. The diagram below shows
the pattern that was produced on a screen that was positioned 1.9 m from the slits.



When determining the distance between adjacent maxima, one student measured distance A and found that it was 11 mm. The other student measured distance B and found that it was 91 mm.

Example 55   SA 2019 Question 4a, 2 marks

Explain why measuring distance B demonstrates better experimental skills than measuring distance A.

Example 56   SA 2019 Question 4b, 1 +3 = 4 marks

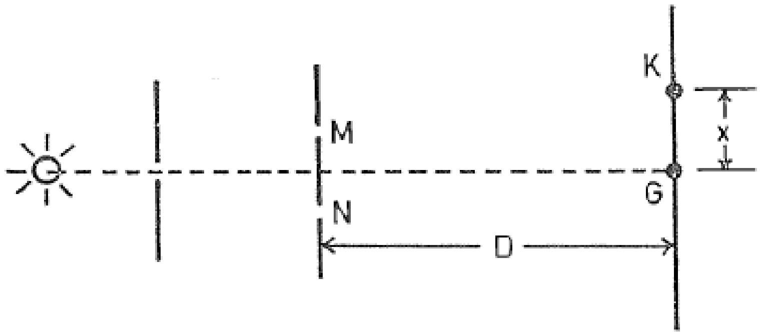
(i) Distance B was used in a calculation of the distance between adjacent maxima. Show that the result was $\Delta y = 1.0 \times 10^{-2}$ m.

(ii) Determine the wavelength of the light used in the experiment.

Example 57 SA 2019 Question 4c, 2 marks

Explain how the bright fringes in the pattern were produced.

Young's experiment is performed with light of wavelength, λ, using the apparatus shown in the diagram. *G is* equidistant from slits *M* and *N.*



K is a point such that *NK - MK* = λ/2.

Example 58 1967 Question 63, 1 mark

If the distance between slits *M* and *N* is 1.0×10^{-3} m, *D* = 2.0 m, and $\lambda = 6.0 \times 10^{-7}$ m, find the value in metre of *x,* the distance of *K* from *G.*

Two students are studying interference of light.
They use a laser of wavelength 580 nm.
The students set up the laser, two slits, S_1 and S_2, and a screen on which an interference pattern is observed, as shown in Figure 1a.
The pattern they observe on the screen is also shown in Figure 1b.
C indicates the centre of the pattern.

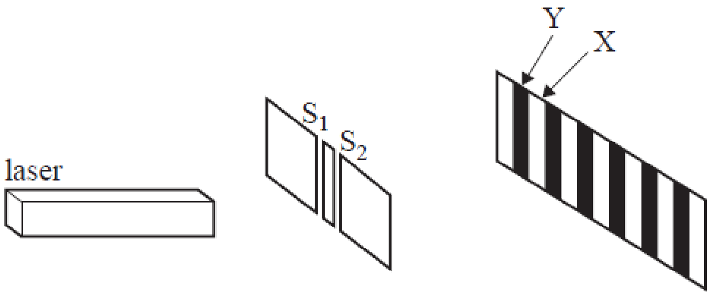


Figure 1a

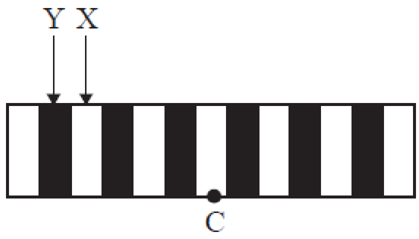


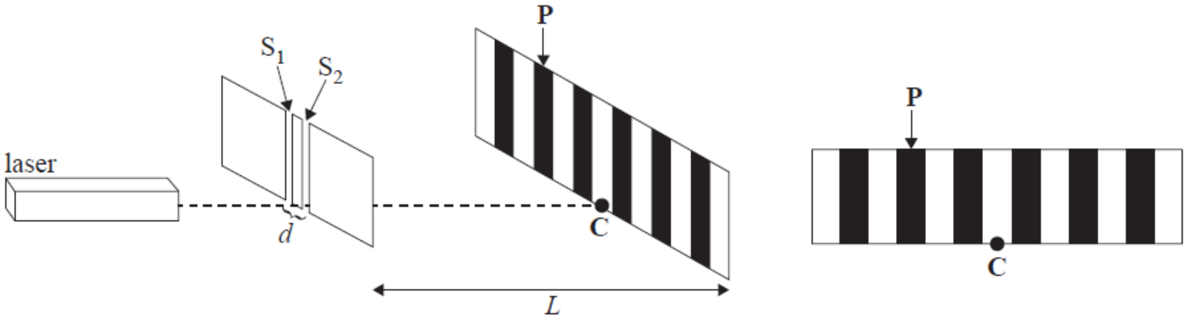
Figure 1b

X is at the centre of a bright band. Y is at the centre of the dark band next to X and further away from the centre of the pattern.
The path difference $S_2X–S_1X$ is 1160 nm.

Example 59 2010 Question 4, 2 marks

What is the path difference $S_2Y–S_1Y$? Show your working.

Use the following information to answer Questions 1–3.



Students set up the apparatus shown below to repeat Young's double-slit experiment.
They user a laser of λ = 560 nm as the light source.
In the first experiment, the separation, d, of the two narrow slits, S_1 and S_2, is 0.32 mm.
P is a point on the interference pattern at the centre of the second dark band from the centre of the pattern, C.

Example 60 2011 Question 1, 2 marks

Calculate the path difference $S_2P – S_1P$. Show your working.

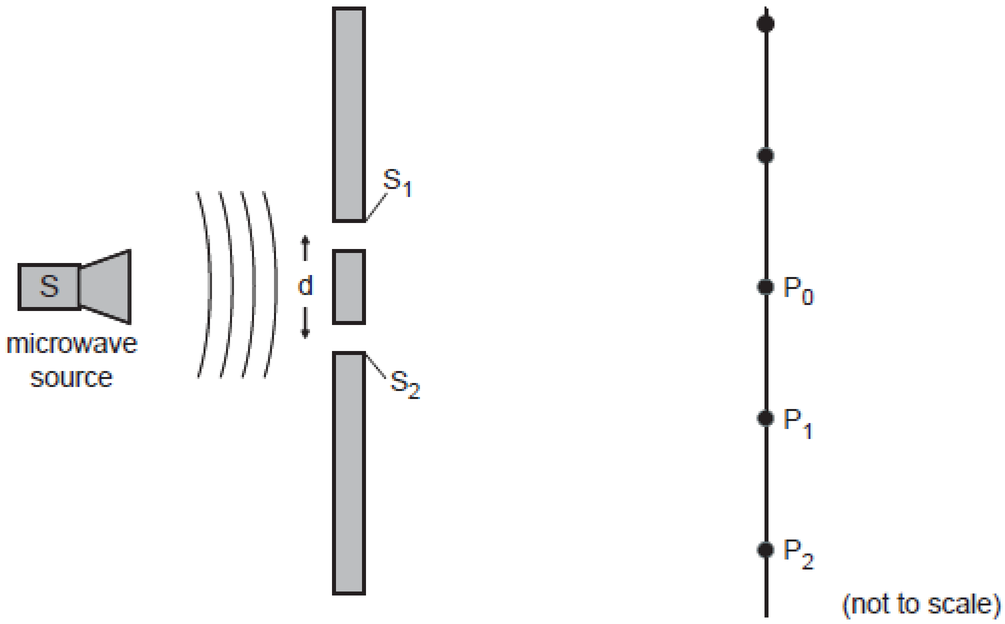
Example 61 2011 Question 2, 1 mark

The distance, L, is now increased. Describe the effect of this change on the spacing of the observed interference pattern.

Example 62 2011 Question 3, 1 mark

L is reset to its original value.
The separation of the slits, d, is then decreased.
Describe the effect of this change on the spacing of the observed interference pattern.

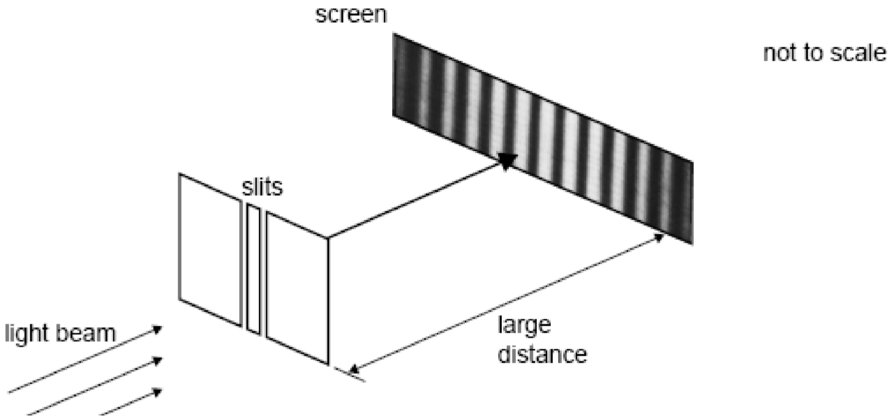
Students have set up an experiment similar to that of English physicist Thomas Young. The students. Experiment uses microwaves of wavelength λ = 2.8 cm instead of light. The beam of microwaves passes through two narrow slits shown as S_1 and S_2 below. The students measure the intensity of the resulting beam at points along the line shown and determine the positions of maximum intensity. These are shown as filled circles and marked P_0, P_1 . . .



Example 63   2006 Question 7, 2 marks

What is the difference in length (S_2P_2 - S_1P_2) where P_2 is the second maximum away from the central axis?

Young's double slit experiment is set up by students in a laboratory as shown below. Monochromatic light is shone onto the slits which are placed at a large distance from the screen. The intensity pattern produced on the screen is a pattern of light and dark bands.

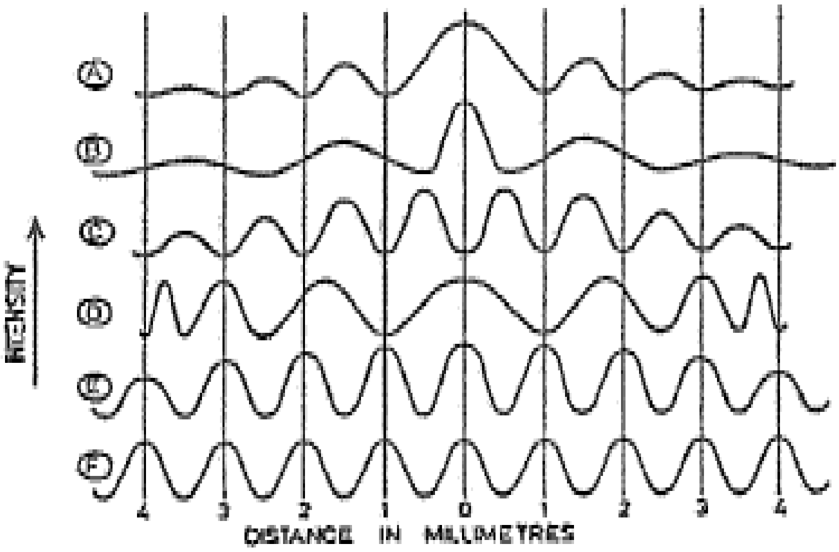


The students then wonder what will happen if the light used is white light rather than monochromatic light. All the students agree that there will be bands of colour on the screen, but have different opinions about the centre band. Pat expects a white band in the centre while Robyn believes a coloured band will be produced.

Example 64 2002 Question 5, 3 marks

Select which of the students is correct and justify your answer.

Question 84 refers to the following diagrams, each of which purports to represent a possible variations of intensity with distance In a direction at right angles to the light and dark bands of an interference or diffraction pattern. In each case, the diagram refers to the central part of the fringe pattern.

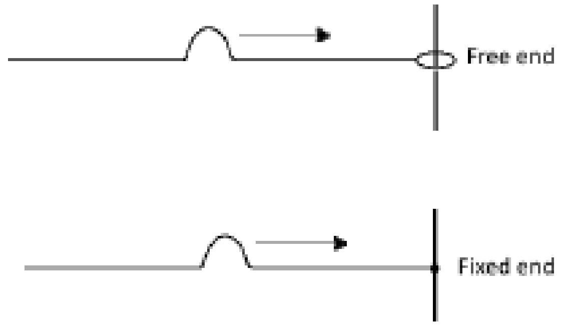


The pattern E represents the interference formed from two parallel slits, with the dimensions shown on a screen 1.5 metre from the slits, using light of wavelength 6.0×10^{-7} m.

Example 65 1968 Question 84, 1 mark

What is the separation of the slits?

In the diagram below, a pulse is directed down two strings, one free at one end, the other fixed at one end.



Example 66 TAS 2019 Question 13a, 2 marks

On the diagram above sketch the subsequent reflection from each end.

Example 67 TAS 2019 Question 13b, 2 + 2 = 4 marks

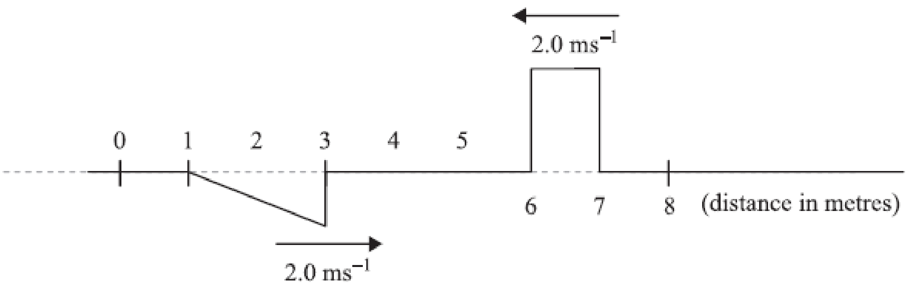
Explain your answer to part (a) in terms of forces on the string at the end limit and the subsequent motion of the string;

(i) for the free-end string.

(ii) for the fixed-end string.

Example 68 QLD 2018 Question 3, 4 marks

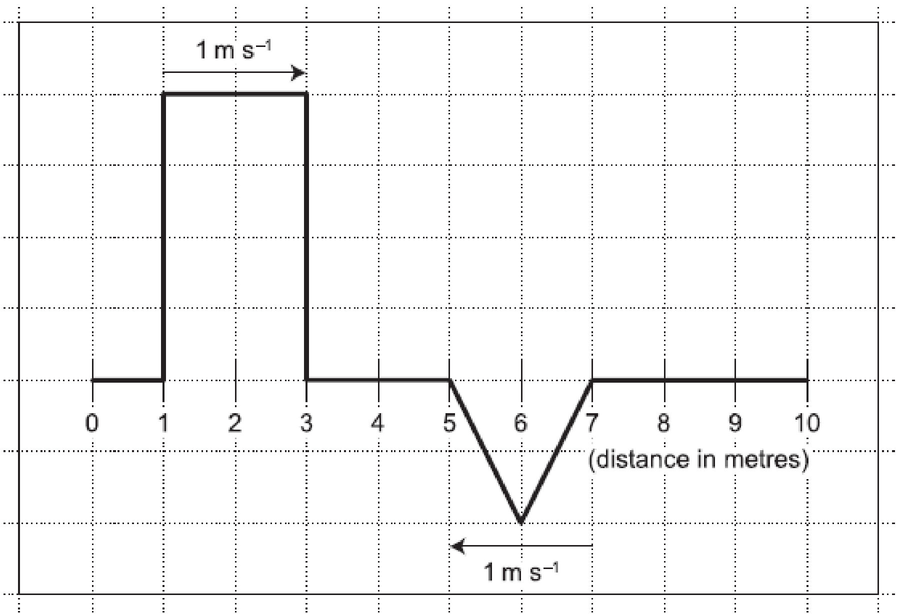
The diagram below shows two wave forms travelling in opposite directions with speeds as indicated. The wave coming from the right has twice the amplitude of the wave coming from the left.



Sketch the wave shapes 1.0 second after the starting position shown in the diagram.

Example 69 QLD 2019 Question 3, 4 marks

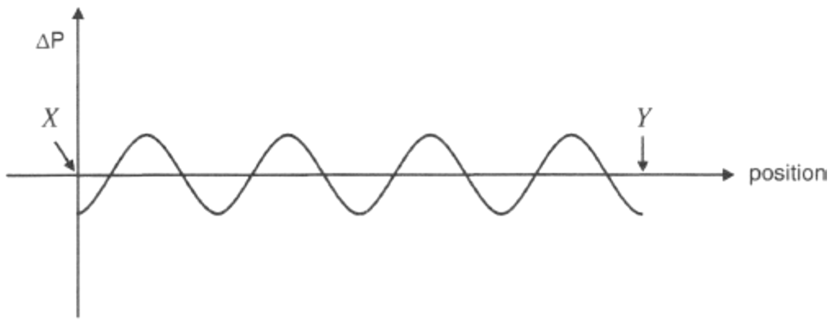
The diagram below shows two wave forms travelling in opposite directions with speeds as indicated.



Use the principle of superposition to sketch the wave shape 1.5 seconds after the time indicated on the graph.

Two loudspeakers are set up facing each other about 40 m apart. They are driven from the same signal generator and emit sound of wavelength 2.0 m. The situation is sketched below, with two points X and Y shown.

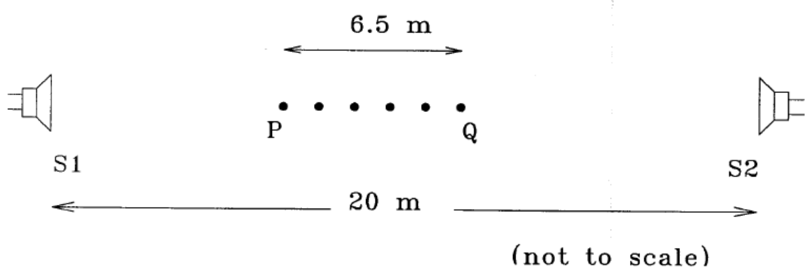
The figure below shows the pressure variation as a function of distance between the points X and Y, at a time when the pressure range is a maximum.



Example 70 1995 Question 5, 2 marks

A person walks along the line joining points X and Y. Describe what is heard, and explain why this is so.

Two loud speakers, S_1, and S_2, are placed 20 m apart in a flat open space, well away from reflecting surfaces. The speakers are connected to the same amplifier, and emit sound at the same loudness. A student walks along the line joining the speakers, and marks six successive locations from P to Q where she hears the loudness to be at a minimum. These are shown on the diagram below. The distance PQ is 6.5 m.



Example 71 1990 Question 32, 1 mark,

What is the wavelength of the sound?

A domestic microwave oven operates at a frequency of 2.45 GHz.

Example 72 TAS 2019 Question 16a, 1 mark

Calculate the wavelength of the microwave emission.

Example 73 TAS 2019 Question 16b, 2 marks

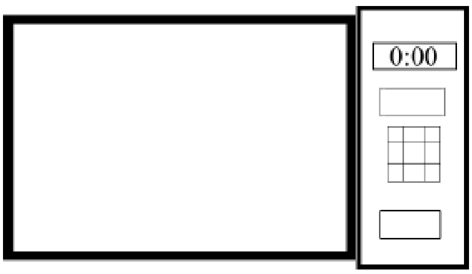
The interior dimensions of a common brand of microwave oven are:

36.7 cm × 36.7 cm × 24.5 cm.

How many complete waves do these values represent?

Example 74 TAS 2019 Question 16c, 2 marks

If the walls, being metal, are nodal, on the diagram below, sketch the pattern of standing waves **ACROSS** the width of the microwave oven.



Example 75 TAS 2019 Question 16d, 1 mark

Explain why many microwave ovens have rotating glass plates on which items that are intended to be heated are placed.

Example 76   TAS 2019 Question 16e, 1 mark

A microwave oven turned on without a food or liquid inside to be heated can cause the wave generator (a magnetron) to fail due to overloading. Give a reason why this may happen.

Example 77   1981 Question 46, 1 mark

Two microwave generators X and Y are facing each other at a distance of 1.0 m apart.

They emit waves, in phase, of frequency 6.0×10^8 Hz and speed of 3.0×10^8 m s^{-1}.
When a detector is moved from X towards Y, the first maximum in intensity is found at P.
How far is P from X?

Standing Waves

Two equal and opposite pulses approach each other on a coil spring.
Each travels with a speed of 2 m s^{-1}. Figure 1 shows the spring at time t = 0.

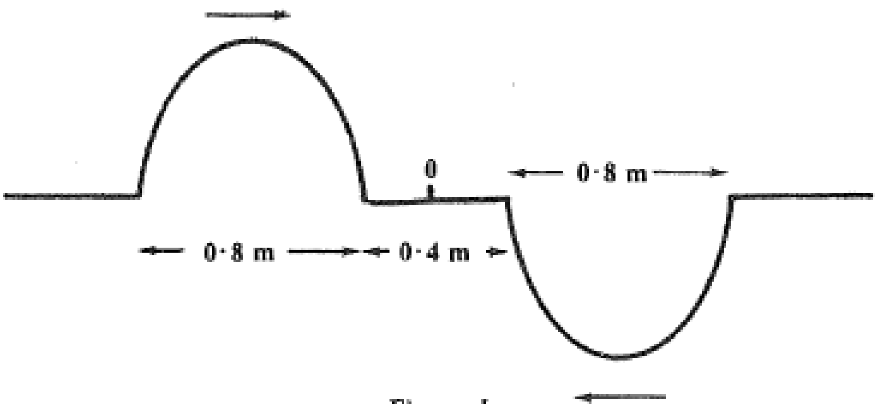
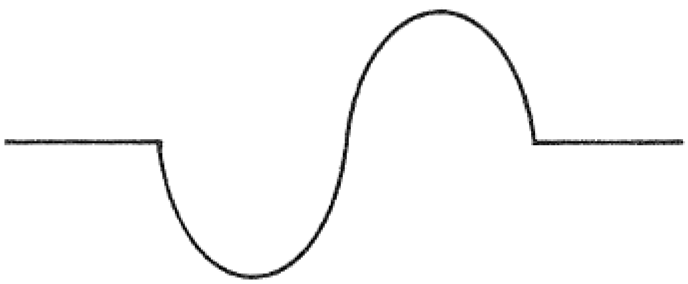


Figure 1

Example 78   1982 Question 41, 1 mark

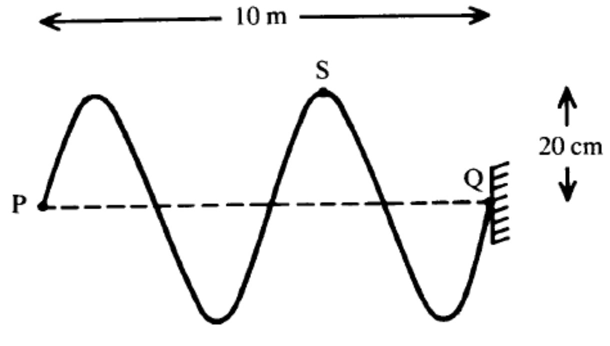
At what time will the spring look like
diagram (i) below?
diagram (ii) below?

(i)



(ii)

A student stretches a slinky, which has one end fixed firmly at the point Q t0 a length of 10 m. She observes that a transverse pulse generated at one end takes 2.0 seconds to travel the 20 m down and back along the slinky.
She now shakes the slinky at right angles to the direction PQ, in such a way as to generate a standing wave of wavelength 5.0 m and amplitude 20 cm. At time t_0 the standing wave pattern is as shown below.



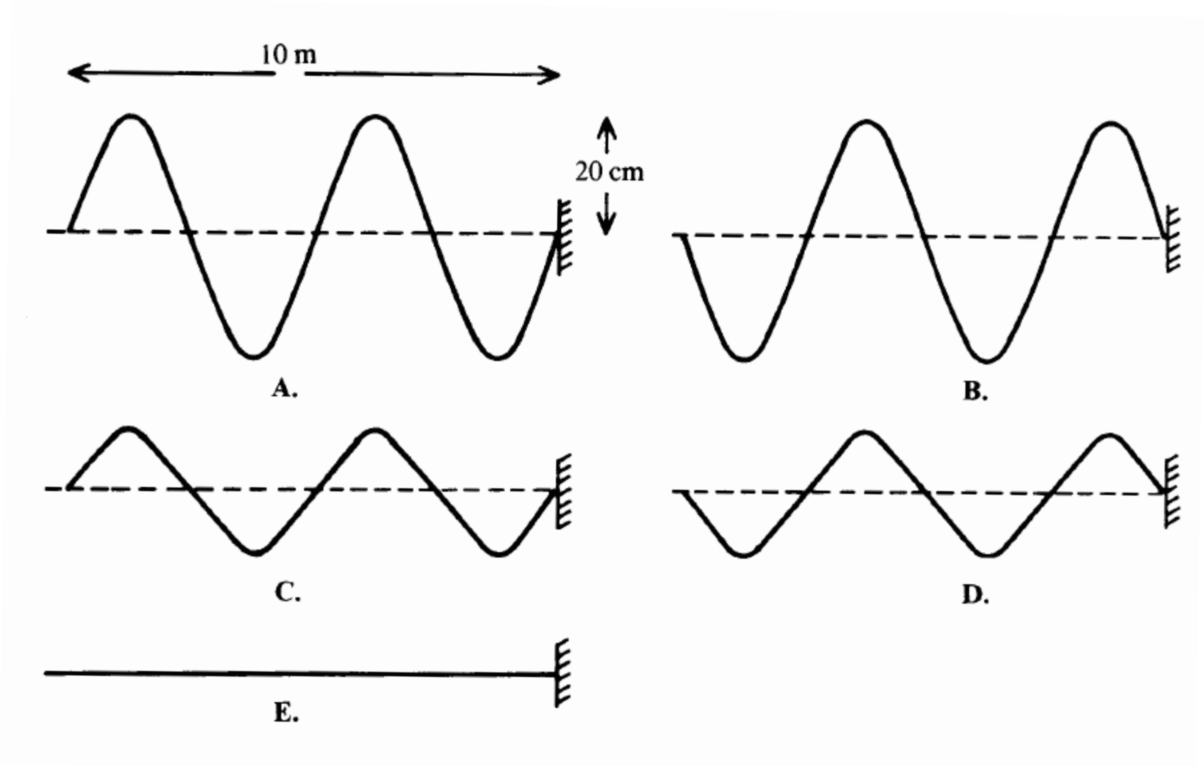
at time t_o

Example 79   1984 Question 41, 1 mark

With what frequency does she shake the end of the slinky in order to obtain the standing wave pattern (of wavelength 5 m) shown above?

Example 80   1984 Question 42, 1 mark

Which of the alternatives (**A - E**) below best shows the shape of the slinky at a time t_0 + 0.125 seconds?



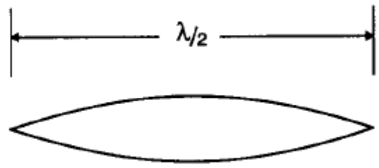
Example 81 1984 Question 43, 1 mark

What is the velocity in the direction PQ of the point S on the slinky, at time t_0 as shown the first figure?

Example 82 1984 Question 44, 1 mark

What is the velocity in the direction perpendicular to PQ of the point S on the slinky, at time t_0 as shown the first figure?

Very often in textbooks on sound, you will observe a standing wave illustrated by a figure similar to that shown below.



Example 83 1994 Question 5, 1 mark

Make three sketches of the standing wave represented above. Each sketch should show the wave at a different time within a single cycle.

If a standing wave is set up in a tube of length L, open at both ends, only certain frequencies will 'resonate' within the tube. The wavelengths of these resonant waves for a tube open at both ends are given by a simple expression involving an integer ‘n’ which has values 1,, 2, 3 and so on.

Example 84 1994 Question 6, 1 mark

Which of the expressions below (**A - D**) gives the set of wavelengths that can exist in a tube open at both ends?

A. nL

B. $\frac{L}{n}$

C. $\frac{4L}{2n-1}$

D. $\frac{2L}{n}$

Resonance

One type of organ pipe is open at both ends (a flue pipe) and is shown below.

Example 85 TAS 2019 Question 14a, 2 marks

Sketch the fundamental standing wave generated in this pipe.

Example 86 TAS 2019 Question 14b, 2 marks

Suppose a pipe is being designed to produce a frequency of 32 Hz and the speed of sound in the concert hall is 339 m s^{-1} what length of pipe needs to be produced?

Example 87 TAS 2019 Question 14c, 3 marks

A concert hall, with the large pipe in the organ, has heating installed and the ambient temperature is raised from 12°C to 20°C.
The speed of sound is given by the formula:

$$v = 331.3 + 0.606\ T \text{ m s}^{-1} \text{ where T is in °C.}$$

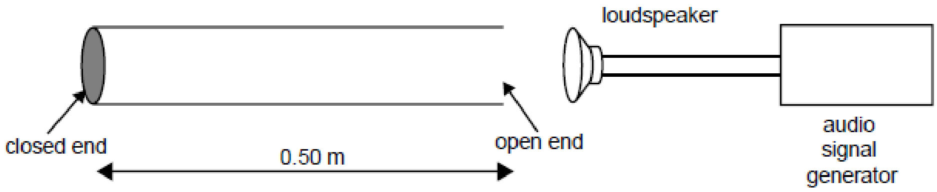
Calculate the new frequency of the pipe.

Example 88 TAS 2019 Question 14d, 1 mark

What effect might raising the temperature of a concert hall have on the sound of the organ?

Use the following information to answer Questions 2 - 4.

In order to study resonance in air columns, students use a narrow tube of length 0.50 m that is closed at one end and open at the other. They use a signal generator and loudspeaker as shown below. Take speed of sound in air as 340 m s^{-1}.



The students begin the experiment by using a sound of frequency 100 Hz.

Example 89 2007 Question 2, 2 marks

What is the wavelength of the sound?

The students increase the frequency until the first resonance (first harmonic) is reached.

Example 90 2007 Question 3, 2 marks

At what frequency will this occur?

Example 91 2007 Question 4, 2 marks

What will the students hear that will enable them to identify this resonance frequency? Explain why this occurs.

Sarah is planning to buy some plastic pipe from a hardware store. To measure the length of the pipe, she intends to blow across one end of the pipe and measure the frequency of the resonance produced.
The shop owner questions this method, but in the end agrees to let her perform the measurements. Sarah takes a section of pipe **open at both ends**, and performs the measurements. A clear resonance of 200 Hz can be heard.

Example 92 2006 Question 7 (Sound), 3 marks

Use this information to determine the length of the pipe. Show your working/reasoning.
(speed of sound 340 m s^{-1}.)

Example 93 2006 Question 9 (Sound), 3 marks

Briefly explain resonance in terms of the behaviour of the sound waves in a tube open at both ends.

A manufacturer is testing a new method of measuring the height to which a cylindrical container is filled with liquid. As the liquid fills the container, air is blown over the open end so that a resonant sound is emitted. The container is 27 cm long and, when empty, the fundamental resonance frequency is 300 Hz. When filled to the correct level the resonance frequency is 2700 Hz.

Example 94   1995 Question 6, 1 mark

What is the wavelength of the resonant sound emitted when the container is empty?

Example 95   1995 Question 7, 1 mark

Assuming that end effects can be ignored, how far from the top of the container is the liquid when correctly filled?

A physics student tests a container that is filled to the correct level by holding a 2700 Hz tuning fork at the open end. As expected, a strong resonance is heard. The student then holds the 2700 Hz tuning fork over an empty container, expecting that no resonance sound would be heard at
2700 Hz, since the fundamental resonance frequency is 300 Hz. In fact, a relatively weak, but noticeable, resonance is heard at 2700 Hz.

Example 96   1995 Question 8, 2 marks

Explain what caused this weak response. Your answer should mention the possible standing waves that can exist in the container, and indicate why the observed resonance at 2700 Hz is relatively weak.