Multiple choice solutions

Example 1 1973 Question 50, 47%

The extent of diffraction is given by $\frac{\lambda}{w}$. Therefore the largest value for $\frac{\lambda}{w}$ is $\frac{2.5}{2.0}$

$\therefore$ **C (ANS)**

Example 2 1973 Question 51, 55%

The extent of diffraction is given by $\frac{\lambda}{w}$

Since $\frac{\lambda}{w}$ > 1, there will not be any nodal lines.

$\therefore$ **C (ANS)**

Example 3 1988 Question 40

The extent of diffraction is given by $\frac{\lambda}{w}$.

Doubling the gap halves the spreading due to diffraction.

$\therefore$ **D (ANS)**

Example 4 2012 Question 8, 68%

The sound will diffract as it passes through the gap. The extent of diffraction is given by $\frac{\lambda}{w}$. The 500 Hz sound (with its longer wavelength) will diffract more and so will be heard relatively strongly, the 5000 Hz will not diffract as much and sound softer.

$\therefore$ **A (ANS)**

Example 5 1977 Question 49, 77%

The path difference is 1.0 cm. This is $\frac{1}{2}\lambda$, therefore there will be destructive interference resulting in a local minimum

$\therefore$ **A (ANS)**

Example 6 1989 Question 41

As they walk from T to O, the student would expect to hear the sound intensity increase, as they are walking along the central maxima.

$\therefore$ **B (ANS)**

Example 7 1978 Question 36, 70%

The wave sources are X and Y. There is a set of waves that move away from them. P is equidistant from both sources, where constructive interference will always occur.

$\therefore$ **A (ANS)**

Example 8 1978 Question 37, 70%

The wave sources are X and Y. The point R is on a nodal line.

$\therefore$ **D (ANS)**

Example 9 QLD 2009 Question 8

If the distance $PS_2 – PS_1$ is known and the point P is a local maxima, then the information required is how many maxima are between P and O. Then use PD ($PS_2 – PS_1$) = $n\lambda$

$\therefore$ **D (ANS)**

Example 10 1967 Question 61, 92%

G is the same distance from M and N, therefore constructive interference as the path difference is zero.

$\therefore$ **C (ANS)**

Example 11 1967 Question 62, 85%

If the path difference is $\lambda/2$, then destructive interference will occur.

$\therefore$ **B (ANS)**

Example 12 1974 Question 59, 73%

As the distance to the first maxima is given by

$x = \frac{\lambda L}{d}$, to get the nodal lines closer together, x needs to get smaller. Therefore decrease λ, or increase d.

$\therefore$ **A (ANS)**

Example 13 2005 Question 5, 50%

Use $\Delta x = \frac{\lambda L}{d}$

The only option that increases Δx is decreasing the slit separation.

Option A will not have any effect on the distance Δx, and options C and D will decrease Δx.

$\therefore$ **B (ANS)**

Example 14 2004 Sample Question 1

Constructive interference occurs when the two waves reinforce each other (i.e. in phase).

$\therefore$ **A & D (ANS)**

Example 15   1991 Question 40

Waves in a string are transverse, so the point P can move only in the vertical. This is a travelling wave, so the point is moving downwards.

$\therefore$ **E (ANS)**

Example 16   1991 Question 41

Waves in a string are transverse, so the point P can move only in the vertical if at all. As it is a standing wave, the nodes will remain stationary. P is a node.

$\therefore$ **A (ANS)**

Example 17   QLD 2015 Question 7

Standing waves can only occur when the two component waves have both the same amplitude and wavelength. Standing waves can be observed with sound and light.

$\therefore$ **A (ANS)**

Example 18   1973 Question 49, 87%

The pulse is reflected upside down, and continues with the same profile.

$\therefore$ **D (ANS)**

Example 19   1977 Question 35, 76%

Use d = v × t to find how far the leading edge of the wave has travelled in the specified time.

$\therefore$ d = v × $\frac{\lambda}{v}$

$\therefore$ d = λ

$\therefore$ **F (ANS)**

Example 20   1977 Question 36, 59%

Use d = v × t to find how far the leading edge of the wave has travelled in the specified time.

$\therefore$ d = v × $\frac{3\lambda}{2v}$

$\therefore$ d = $\frac{3\lambda}{2}$

In this time the first pulse will have reflected upside down, and the leading edge of the second pulse is $\frac{\lambda}{2}$ from the reflecting wall.

$\therefore$ **A (ANS)**

Example 21 1977 Question 37, 27%

Use d = v × t to find how far the leading edge of the wave has travelled in the specified time.

$$\therefore d = v \times \frac{7\lambda}{4v}$$

$$\therefore d = \frac{7\lambda}{4}$$

In this time the leading edge of the second wave will be $\frac{\lambda}{4}$ from the reflecting wall. The trailing edge of the first wave will also be $\frac{\lambda}{4}$ from the reflecting wall, so they will cancel each other.

$\therefore$ **B (ANS)**

Example 22 NSW 1998 Question 14, 42%

This is a pipe open at one end only, so only the odd harmonics will exist. The longest wavelength that will resonate at 32 cm is with the 256 Hz tuning fork. Therefore, the next resonance will be with an odd fraction $\left(\frac{1}{3}\right)$ of the original wavelength. Therefore 3 times the initial frequency.

$\therefore$ **A (ANS)**

Example 23 NSW 1999 Question 14, 90%

This is an example of resonance

$\therefore$ **D (ANS)**

Example 24 2007 Question 5, 65%

For a tube opened at one end the resonant frequencies are odd multiples of the fundamental.
For a pipe closed at one end the fundamental is given by

$$\lambda_1 = 4L$$

$$\therefore f_1 = \frac{v}{4L}$$

$$\therefore f_1 = \frac{340}{4 \times 0.5}$$

$$\therefore f_1 = 170 \text{ Hz}$$

So the next resonance is

$3f_1 = 3 \times 170$

$= 510$ Hz

$\therefore$ **D (ANS)**

Example 25 2006 Question 8, 80%

For a tube opened at both ends the resonant frequencies are whole number multiples of the fundamental.
So the possibilities are 200, 400, 600, 800 etc.

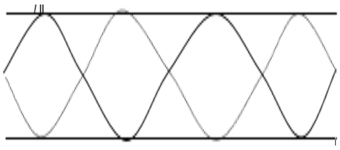
$\therefore$ **B, D (ANS)**

Example 26 NSW 1997 Question 14, 45%

Use v = fλ

$\therefore$ 340 = 680 × λ

$\therefore$ λ = 0.5 m



This represents the fourth overtone.

$\therefore$ **D (ANS)**

Example 27 2012 Question 9, 74%

With the cap **ON** the fundamental frequency will occur when the pipe is ¼ of a wavelength long.

$\therefore$v = fλ

$\therefore$340 = 170 × λ

$\therefore$ λ = 2 m

$\therefore$ pipe length is ¼ × 2 = 0.5 m

$\therefore$ **B (ANS)**

Example 28 2012 Question 10, 65%

The next resonance will occur when the tube has $\frac{3}{4}$ of a wavelength in it, as it needs to have a node at the open end and an antinode at the closed end. With a wavelength of 2 m, the length of the pipe must now be 1.5 m.

$\therefore$ **C (ANS)**

Example 29 NSW 2000 Question 14, 55%

The fundamental is the lowest resonant frequency. It will occur when $\frac{1}{2}\lambda = 1.2$ m.

Therefore the frequency is 140 Hz and the wavelength is 2.4 m

$\therefore$ **B (ANS)**

Extended response solutions

Example 30 WA 2018 Question 6a

As the light passes the edges of the small sphere, it diffracts. This means that its path is bent from the original straight line.
The light ‘waves’ interfere and create an interference pattern, where constructive interference occurs and is seen as light circles on the screen. Destructive interference occurs and is seen as dark circles on the screen. The bright dot in the middle is where all waves are in phase as the path difference to this point from the circumference of the sphere is zero.

Example 31 WA 2018 Question 6b

This demonstrates the wavelike nature of light.

Example 32 TAS 2019 Question 17a

Monochromatic means light of a single frequency (hence wavelength).

Example 33 TAS 2019 Question 17b

Coherent light has the same frequency and all the waves are in phase, i.e. the crests (and troughs) all overlap.
(it is interesting that the description included monochromatic and in phase. If the waves are in phase, they must be monochromatic.)

Example 34 TAS 2019 Question 17c

As the light passes through the slit, it diffracts, this means that its path is bent from the original straight line.
The light 'waves' interfere and create an interference pattern, where constructive interference occurs and is seen as light bands and destructive interference is seen as dark bands.
The central band is where the path difference for all 'pairs' of waves reaching here is zero, so constructive interference occurs.

Example 35 2002 Question 6, 36%

This is a diffraction question. Your response should be based on the fact that the amount of diffraction depends upon the wavelength of the sound compared with the width of the door.

This is expressed as the ratio $\frac{\lambda}{d}$ where d is the width of the door and diffraction is the most when this ratio is > 1, ie when $\lambda > 1$. Since $v = f\lambda$ and $v = 340$ m s^{-1}, the corresponding frequency is 340 Hz.

An estimate of what frequencies will have a reduced intensity is when the $\frac{\lambda}{d}$ ratio is, say, 0.1. This will result in a frequency of 3 400 Hz. So frequencies above 3400 Hz are not likely to diffract, and so won't be heard very loudly by Peta.

Example 36 2003 Question 7, 92%

Use $v = f \times \lambda$

$\therefore 340 = 6000 \times \lambda$

$\therefore \lambda = 0.057$

$\therefore \boldsymbol{\lambda = 5.7 \times 10^{-2}}$ **m (ANS)**

Example 37 2003 Question 8, 56%

This is a diffraction question. Your response should be based on the fact that the amount of diffraction depends upon the wavelength of the sound compared with the width of the speaker.

This is expressed as the ratio $\frac{\lambda}{d}$ where d is the width of the speaker and diffraction is the most when this ratio is > 1. At 6000 Hz the wavelength is 5.7 cm. This means that not much diffraction will occur, and so this sound will be very directional, and only project where the actual speaker is pointing. This means that Mustafa won't hear this frequency very well.
Rebecca will hear all the frequencies being produced, but only the lower frequencies will diffract sufficiently for Mustafa to hear.

Example 38 QLD 2018 Question 5

As the person walks from P to Q, they are going to experience a series of loud and soft sounds. Initially at Point P the sound will be loud, due to the combination of the two compressions. It will then go soft and loud again at the perpendicular bisector (midway point). Then soft and finally loud again at Q.

Example 39 QLD 2019 Question 5

Path length AP is 1.5 λ, path length BP is 3λ,

∴ Path difference = 3 λ – 1.5 λ

= 1.5 λ.

This will result in destructive interference creating a local minimum.

Example 40 2003 Question 5, 59%

Initially Val is the same distance from both speakers, so the sound from both will interfere constructively, giving a local maximum of intensity, hence loudness. As the speaker P comes towards Val, the path length from the speaker to Val will decrease. This means that the waves from both sources will no longer interfere constructively. The first soft point occurs when the path difference is ½λ. As the path difference increases the sound that Val hears will vary from loud, (path difference a multiple of λ) to soft (path difference a multiple of ½λ).

Examiners comment

Those who appeared to copy directly from their A4 sheet, gave answers that were very general and did not refer to the specific situation in the question (and scored poorly).

Example 41 2003 Question 6, 60%

The sound is first soft when the path difference is ½λ. Since λ = 1, the distance the teacher moves the speaker is

0.5 m (ANS)

Example 42 1989 Question 38

The path difference to the point U is $\frac{1}{2}\lambda$.

Since λ = 0.60 m

∴ **P.D. = 0.30 m (ANS)**

Example 43 1989 Question 39

The path difference to the point P is 2λ.

Since λ = 0.60 m

∴ **P.D. = 1.2 m (ANS)**

Example 44 1989 Question 40

Use v = f λ

∴ 330 = f × 0.600

∴ **f = 550 Hz (ANS)**

Example 45 1978 Question 38, 81%

Q is a dark band. Counting cycles from Q to P gives $2\frac{1}{2}\lambda$

∴ **$2\frac{1}{2}\lambda$ (ANS)**

Example 46 1978 Question 39, 41%

The point S is between the 2nd and 3rd nodal lines is a dark band. The path difference to the first nodal line = $\frac{1}{2}\lambda$

Path difference to 2nd nodal line = $1\frac{1}{2}\lambda$.

Path difference to 3rd nodal line = $2\frac{1}{2}\lambda$.

∴ **2 λ (ANS)**

Example 47   1972 Question 57, 57%

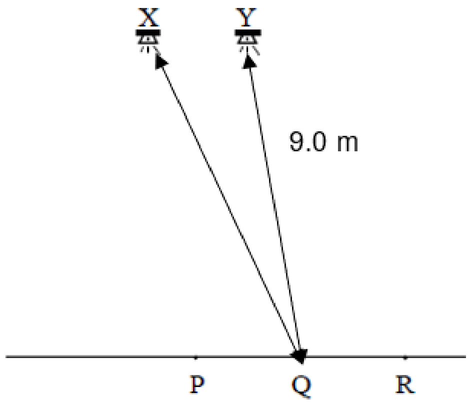
For Point X to be the first nodal line, the path difference between L_1X and L_2X needs to be $\frac{1}{2}\lambda$.

$\frac{1}{2}\lambda = 0.5$ m

$\therefore L_1X = 3.50 + 0.5$

$\therefore$ **4.0 m (ANS)**

Example 48   1999 Question 12, 57%



The point Q is the first nodal point from the central maximum at P. So the path difference between XQ and YQ must 0.5 λ.

$\therefore 0.5\lambda = 0.1$ m

$\therefore$ if YQ = 9.0 m then XQ = 9.1 m

$\therefore$ **XQ = 9.1 m (ANS)**

Example 49   1984 Question 45, 48%

For destructive interference with the longest wavelength, the path difference needs to be 0.5λ.

$\therefore 3.25 - 3.00 = 0.5\lambda$

$\therefore$ **λ = 0.5 m (ANS)**

Example 50   1984 Question 46, 70%

Use $v = f\lambda$

$\therefore 330 = f \times \lambda$

$\therefore 330 = f \times 0.5$

$\therefore$ **f = 660 Hz (ANS)**

Example 51   1984 Question 47, 52%

The line PQ is equidistant from both speakers. Therefore, it will always have constructive interference. So it will be a local maximum.

$\therefore$ **B (ANS)**

Example 52 2002 Question 5, 30%

The path difference for the sound coming from both speakers must be $\frac{1}{2}\lambda$ = 1 m.
You can make this algebraic, and say that the distance from the lower speaker to the student is ‘x’ metres, then the distance from the upper speaker is ‘x + 1’ metres.

$(x + 1)^2 = x^2 + 3^2$

$\therefore x^2 + 2x + 1 = x^2 + 9$

$\therefore 2x – 8 = 0$

$\therefore$ **x = 4 (ANS)**

The other way of looking at it is to see that it must be a 3:4:5 triad.

Example 53 QLD 2018 Question 6

Use $\Delta x = \dfrac{\lambda L}{d}$

where $\Delta x = 1.00 \times 10^{-2}$ m, L = 4.00 m and
$d = 2.35 \times 10^{-4}$ m.

$\therefore \lambda = \dfrac{\Delta x \times d}{L}$

$\therefore \lambda = \dfrac{1.00 \times 10^{-2} \times 2.35 \times 10^{-4}}{4.00}$

$\therefore \lambda = 5.875 \times 10^{-7}$

$\therefore$ **λ = 588 nm (ANS)**

Example 54 QLD 2019 Question 6

Use $\Delta x = \dfrac{\lambda L}{d}$

where $\lambda = 5.300 \times 10^{-7}$ m, L = 6.00 m and
$d = 2.00 \times 10^{-3}$ m.

$\therefore \Delta x = \dfrac{5.300 \times 10^{-7} \times 6.00}{2.00 \times 10^{-3}}$

$\therefore \Delta x = 0.00159$

$\therefore$ **$\Delta x = 1.59 \times 10^{-3}$ m (ANS)**

Example 55 SA 2019 Question 4a

Every measurement has an associated uncertainty due to the limitations of the measuring device.
To measure across 9 fringes, and then to divide by 9 reduces the size of the uncertainty.

Example 56 SA 2019 Question 4b

(i) The distance B is the distance for 9 bands.

$\therefore \Delta y = \frac{91}{9}$

$\therefore \Delta y = 1.01$ cm

$\therefore \Delta y = 1.0 \times 10^{-2}$ m

(ii) Use $\Delta y = \frac{\lambda L}{d}$,

where L = 1.9, and d = 1.2 × 10^{-4} m.

$\therefore \lambda = \frac{\Delta y \times d}{L}$

$\therefore \lambda = \frac{1.01 \times 10^{-2} \times 1.2 \times 10^{-4}}{1.9}$

$\therefore \lambda = 6.37 \times 10^{-7}$ m

$\therefore$ **λ = 6.4 × 10^{-7} m (ANS)**

Example 57 SA 2019 Question 4c

As the light passes through the slits it diffracts. The light from both slits interferes to create the interference pattern. The bright bands are due to constructive interference because the path difference from both slits is a whole number multiple of λ.

Example 58 1967 Question 63, 49%

The distance to the first maxima is given by $x \approx \frac{n\lambda D}{d}$ where n = 1, λ = 6.0 × 10^{-7} m,

d =1.0 × 10^{-3} and D = 2.0.

We need to find the distance to the first local minima, therefore use $x \approx \frac{n\lambda D}{2d}$

$\therefore x = \frac{1 \times 6.0 \times 10^{-7} \times 2.0}{2 \times 1.0 \times 10^{-3}}$

$\therefore$ **x = 6.0 × 10^{-4} m (ANS)**

Example 59 2010 Question 4, 51%

The point ‘C’ is the bright central maximum is in the middle of the diagram.
This means that the path difference to ‘X’ is 2λ and the path difference to ‘Y’ is $\frac{5}{2}\lambda$.

$\therefore S_2X - S_1X = 1160$ nm

$= 2\lambda$

$\therefore \lambda = 580$ nm

$\therefore S_2Y - S_1Y = \frac{5}{2}\lambda$

$\therefore$ **$S_2Y - S_1Y = 1450$ nm (ANS)**

Example 60 2011 Question 1, 65%

P is second dark band from the central band C,

$\therefore$ path diff = 1.5 × wavelengths

= 1.5 × 560

= 840 nm (ANS)

Remember that the question stated, “Show your working.”

Example 61 2011 Question 2, 80%

As the separation between the slits and the screens increases so will the size of the pattern shown on the screen.

Therefore the spacing of the bright and dark bands will increase.

Example 62 2011 Question 3, 70%

Use $\Delta x = \frac{\lambda L}{d}$

Decreasing the separation of the slits (i.e. d is decreased) increases the separation of the bands in the pattern. This is to accommodate the path difference to P (for instance) to remain the same.

Example 63 2006 Question 7, 57%

The second maximum is when the path difference is 2λ. (the central max has PD = 0λ, first max PD = 1λ)

$\therefore$ Length = 2×2.8 cm

= 5.6 cm (ANS)

Example 64 2002 Question 5, 74%

The central spot will be white with slight coloured fringes. The central maximum is a central maximum for all wavelengths/colours, since this is where the path difference is zero. It will be white as all colours together make white. Towards the edge of the central spot, the minimum for different wavelengths/colours will be at slightly different positions producing coloured fringes.

$\therefore$ Pat is the ‘most correct’.

Example 65 1968 Question 84, 46%

The distance to the first maxima is given by $x = \frac{\lambda L}{d}$ where $\lambda = 6.0 \times 10^{-7}$ and L = 1.5 m.

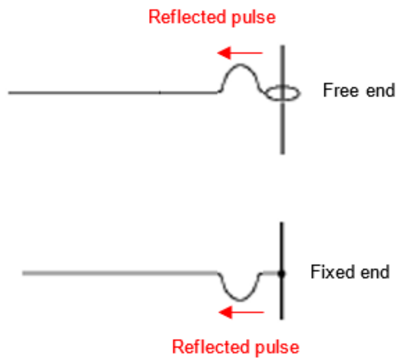
From the diagram E, the distance x is 1.0 mm.

$$\therefore d = \frac{\lambda L}{x}$$

$$\therefore d = \frac{6.0 \times 10^{-7} \times 1.5}{1.0 \times 10^{-3}}$$

$\therefore$ **d = 9.0×10^{-4} m (ANS)**

Example 66 TAS 2019 Question 13a

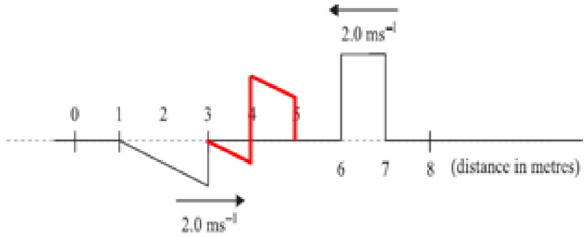


Example 67   TAS 2019 Question 13b, 25%

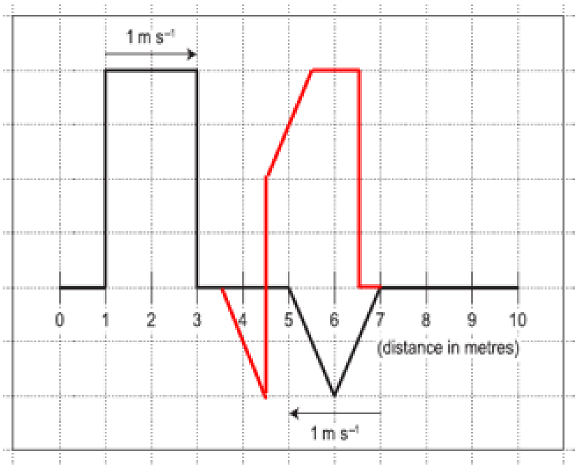
(i)   When the pulse arrives at the free end, it wants to continue moving forward. The free end will slide up and down. The pulse continues in the opposite direction without inverting. The free end is not able to exert a force on the pulse, so it will not invert.

(ii)   When the pulse comes into the fixed end, it exerts an upwards force on the fixed end. The fixed end exerts an equal and opposite downward force on the string. The fixed end does not move, so the downward force it exerts on the string produces an inverted pulse.

Example 68   QLD 2018 Question 3



Example 69 QLD 2019 Question 3



Example 70 1995 Question 5

A standing wave is set up between the loudspeakers.
To create a standing wave requires two waves of equal amplitude, frequency and wavelength travelling in opposite directions.
This is a pressure variation envelope. At both X and Y, there is maximum pressure variation and therefore a louder sound. These are antinodes. At other points, there is zero pressure variation. These are pressure nodes where, in theory, no sound is heard. Hence, the person walking along the line will hear loud, soft, loud, soft…..
Nodal points are caused by destructive interference when crest meets trough.
Antinodal points like X and Y are caused by constructive interference, when crest meets crest and trough meets trough.

Example 71 1990 Question 32

The standing wave between the two speakers has a soft spot every half wavelength. Therefore 2.5 λ = 6.5 m

$$\therefore \lambda = \frac{6.5}{2.5}$$

$\therefore$ **$\boldsymbol{\lambda}$ = 2.6 m (ANS)**

Example 72 TAS 2019 Question 16a

Use $v = f\lambda$

$\therefore 3.0 \times 10^{8} = 2.45 \times 10^{9}\,\text{m} \times \lambda$

$\therefore \lambda = 0.1224$ m

$\therefore$ **$\boldsymbol{\lambda}$ = 12.2 cm (ANS)**

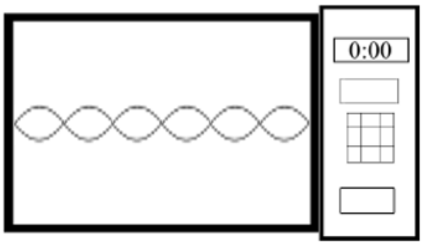
Example 73 TAS 2019 Question 16b

With dimensions of 36.7 cm × 36.7 cm × 24.5 cm.

When divided by 12.24 cm gives

3 wavelengths × 3 wavelengths × 2 wavelengths

Example 74 TAS 2019 Question 16c



Example 75 TAS 2019 Question 16d

The nodal areas inside the microwave represent regions where there is minimal energy. Any food located at this spot will not heat up. Rotating the glass plate minimises the variation in the heating within the microwave cavity.

Example 76 TAS 2019 Question 16e

The contents of the microwave absorb the energy produced by the magnetron. If there isn't anything in the microwave to absorb this energy, it will be absorbed by the magnetron. This will damage the magnetron.

Example 77 1981 Question 46, 30%

The wavelength of the microwaves is given by

$c = f\lambda$

$\therefore\ 3.0 \times 10^8 = 6.0 \times 10^8 \times \lambda$

$\therefore\ \lambda = 0.5$ m.

The first maximum of intensity will be $\frac{1}{2}\lambda$ from X.

The standing wave pattern will look like

$\therefore$ **P is 0.25 m from X (ANS)**

Example 78 1982 Question 41, 30%

(i) For diagram (i) to occur the back end of the top crest has to have moved to the point O, a distance of 1.0 m. At a speed of 2 m s^{-1} this will take 0.5 s.

  ∴ **0.5 (ANS)**

(ii) For diagram (ii) to occur both pulses need to overlap completely. This means that the peak of each pulse needs to be at the position O. Therefore each need to move 0.6 m. This will take 0.3.

  ∴ **0.3 sec (ANS)**

Example 79 1984 Question 41, 69%

Use v = fλ, where v = 10 m s^{-1} and λ = 5 m.

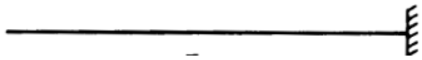
  ∴ 10 = f × 5

  ∴ **f = 2.0 Hz (ANS)**

Example 80 1984 Question 42, 15%

If the frequency is 2 Hz, the period is 0.5 s.

∴ 0.125 s is $\frac{1}{4}$ of a cycle later. The wave will be midway between its extreme positions.



  ∴ **E (ANS)**

Example 81 1984 Question 43, 58%

This is a transverse wave, so the point S does not move in the direction PQ

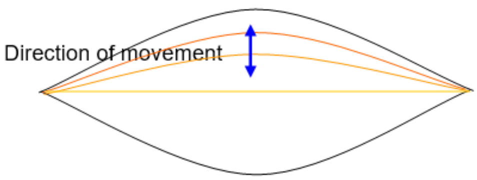
  ∴ **0 m s^{-1} (ANS)**

Example 82 1984 Question 44, 53%

The point S is at the extremity of its motion, therefore, it is not moving in the direction perpendicular to PQ at this instant. It is about to move down.

  ∴ **0 m s^{-1} (ANS)**

Example 83 1994 Question 5



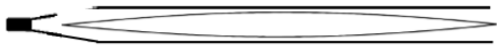
It is a standing wave, so the particles move up and down, so the coloured lines represent the wave at different times within the cycle.

Example 84 1994 Question 4

From you cheat sheet you should have that the wavelength of stationary waves in a tube open at both ends is given by $\frac{2l}{n}$ where l is the length of the tube and n = 1, 2, 3, etc.

$\therefore$ **D (ANS)**

Example 85 TAS 2019 Question 14a



Example 86 TAS 2019 Question 14b

The fundamental has a wavelength twice the length of the pipe.
Use $v = f \times \lambda$

$\therefore 339 = 32 \times \lambda$

$\therefore \lambda = 10.59$ m

The pipe needs to be half this length,

$\therefore$ **L = 5.30 m (ANS)**

Example 87 TAS 2019 Question 14c

Substitute T = 20 into

$v = 331.3 + 0.606\ T$

$\therefore v = 343.42.$

The wavelength of the fundamental will remain constant (on the assumption that the pipe length doesn't change due to the increase in temperature).

$\therefore 343.42 = f \times 10.59$

$\therefore$ **f = 32.4 Hz (ANS)**

Example 88 TAS 2019 Question 14d

The frequency (pitch) of the notes will increase.

Example 89 2007 Question 2, 65%

The wavelength of 100 Hz is determined using
$v = f\lambda$.

Hence $\lambda = \frac{340}{100}$

$\therefore$ **λ = 3.4 m (ANS)**

Example 90 2007 Question 3, 65%

For a pipe closed at one end the fundamental is given by

$$\lambda_1 = 4L$$

$$\therefore f_1 = \frac{v}{4L}$$

$$\therefore f_1 = \frac{340}{4 \times 0.5}$$

$$\therefore \mathbf{f_1 = 170\ Hz\ (ANS)}$$

Example 91 2007 Question 4, 65%

Constructive interference (from the waves reflected from both ends of the pipe) will produce a standing wave. This standing wave will be louder. As the driving frequency gets closer to the natural frequency of the pipe, the sound produced by the pipe will increase in intensity.

Example 92 2006 Question 7, 60%

Use $v = f \times \lambda$

$$\therefore \lambda = \frac{v}{f}$$

$$\therefore \lambda = \frac{340}{200}$$

$$\therefore \lambda = 1.7\ m$$

For a pipe open at both ends, the first resonance is when there is a node at both ends, hence $L = \frac{\lambda}{2}$

$$\therefore \mathbf{L = 0.85\ m\ (ANS)}$$

Example 93 2006 Question 9, 40%

When the frequency is 200 Hz, the sound is reflected at both (open) ends of the pipe. This produces two identical waves travelling in opposite directions inside the tube.

The two waves interfere (the principal of superposition) with each other and produce a standing wave (resonance) inside the tube. This standing wave persists for some time.

Resonance will also occur for other frequencies when multiples of the wavelength of the standing wave matches the length of the tube.

Example 94   1995 Question 6

For a container open at one end, the wavelength of the resonant sound is equal to four times the length of the container.

$\therefore \lambda = 4 \times L$

$= 4 \times 0.27$

$\mathbf{= 1.08\ m\ (ANS)}$

Example 95   1995 Question 7

When the liquid is filled to the correct level the pipe is much shorter.
If the new resonance frequency is 2700 Hz, then at this frequency the length of the air column above the liquid is still $\frac{1}{4}\lambda$

The speed of sound will not have changed so we need to use this to link these two situations together.
Use $v = f\lambda$

$\therefore$ $v = 300 \times 1.08$ (from initial information)

$\therefore v = 324\ m\ s^{-1}$

$\therefore 324 = 2700 \times \lambda$

but $\lambda = 4L$ (because $\frac{1}{4}\lambda = L$)

$\therefore 324 = 2700 \times 4 \times L$

$\therefore L = 324/(2700 \times 4)$

$\therefore$ **L = 0.03 m (ANS)**

Example 96   1995 Question 8

For pipes closed at one end the fundamental frequency is given by $f_1 = 4L$, we only get odd harmonics and the ratio of the frequencies is given by 1 : 3 : 5 : 7 : 9 etc.

Here we are given that the new resonant frequency is 2700 Hz, this is 9 times the fundamental, $\therefore$ it is the 9 harmonic or the

$\therefore$ **5th overtone (ANS)**

This overtone would be relatively weak compared with the fundamental.