Waves

Question1

When both source of sound and observer approach each other with a speed equal to 10% of the speed of sound, then the percentage change in frequency heard by the observer is nearly

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Options:

A.

33.3%

B.

12.2%

C.

22.2%

D.

11.1%

Answer: C

Solution:

Given:

Both **source** and **observer** are moving **towards each other**.

Each moves at **10% of the speed of sound**.

$v_s = 0.1v, \quad v_o = 0.1v$

where v = speed of sound.

Formula (for Doppler effect):

When both are moving **towards each other**, the apparent frequency f' heard by the observer is

$f' = f \frac{v+v_o}{v-v_s}$

Substituting given values:

$f' = f \frac{v+0.1v}{v-0.1v} = f \frac{1.1v}{0.9v} = f \times \frac{1.1}{0.9}$

$\frac{1.1}{0.9} = 1.222...$

So,

$f' = 1.222f$

Percentage change in frequency:

$\%$ increase $= (1.222 - 1) \times 100 = 22.2\%$

✅ **Final Answer:**

$\boxed{22.2\%}$ (Option C)

Question2

The equation of a transverse wave propagating along a stretched string of length 80 cm is $y = 1.5 \sin \left\{ \left(5 \times 10^{-3} x\right) + 20t \right\}$, here ' x ' and ' y ' are in cm and the time ' t ' is in second. If the mass of the string is 3 g , then the tension in the string is 80 cm

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Options:

A.

12 N

B.

4 N

C.

6 N

D.

8 N

Answer: C

Solution:

From the given wave equation

$$\begin{aligned} k &= 5 \times 10^{-3} \text{ cm}^{-1} = 5 \times 10^{-1} \text{ m}^{-1} \\ &= 0.5 \text{ m}^{-1} \\ w &= 20 \text{rad/s} \\ \therefore \quad v &= \frac{\omega}{k} = \frac{20}{5 \times 10^{-1}} = 40 \text{ m/s} \\ \therefore \quad \mu &= \frac{m}{l} = \frac{3 \times 10^{-3}}{0.8} \\ &= 3.75 \times 10^{-3} \text{ kg/m} \end{aligned}$$

$$\therefore \text{ Since, } v = \sqrt{\frac{T}{\mu}}$$

$$\begin{aligned} \Rightarrow \quad v^2 &= \frac{T}{\mu} \\ \Rightarrow \quad T &= \mu v^2 = 3.75 \times 10^{-3} \times 40^2 \\ &= 3.75 \times 10^{-3} \text{ N} = 6 \text{ N} \end{aligned}$$

Question3

If a travelling wave is given by $y(x, t) = 0.5 \sin(70.1x - 10\pi t)$, where x and y are in metre the time t is in second, then the frequency of the wave is

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Options:

A.

6 Hz

B.

7 Hz

C.

4 Hz

D.

5 Hz

Answer: D

Solution:

Standard equation of a travelling wave is,

$y = A\sin(kx - \omega t)$

Given, $y = 0.5\sin(70.1x - 10\pi t)$

$\therefore \omega =$ angular frequency $= 10\pi$

But $\omega = 2\pi f, f =$ frequency

$\Rightarrow f = \frac{\omega}{2\pi} = \frac{10\pi}{2\pi} = 5$ Hz

----

Question4

The path difference between two waves given by the equations

$y_1 = a_1 \sin\left(\omega t - \frac{2\pi x}{\lambda}\right)$ **and** $y_2 = a_2 \sin\left(\omega t - \frac{2\pi x}{\lambda} + \phi\right)$ **is**

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Options:

A.

$\left(\frac{\lambda}{\pi}\phi\right)$

B.

$\frac{\lambda}{\pi}\left(\phi - \frac{\pi}{2}\right)$

C.

$\frac{\lambda}{2\pi}\phi$

D.

$\frac{\lambda}{2\pi}\left(\phi-\frac{\pi}{2}\right)$

Answer: C

Solution:

Phase difference between waves is

$$\begin{aligned}\phi_1-\phi_2 &= \left(\omega t-\frac{2\pi x}{\lambda}+\phi\right)-\left(\omega t-\frac{2\pi x}{\lambda}\right)\\ &= \phi\end{aligned}$$

As, relation of phase and path difference is,

$\frac{\Delta\phi}{2\pi}=\frac{\Delta L}{\lambda}$

$\Rightarrow$ Path difference, $\Delta L=\frac{\lambda\phi}{2\pi}$.

Question5

If two progressive sound waves represented by $y_1=3\sin 250\pi t$ and $y_2=2\sin 260\pi t$ (where displacement is in metre and time is in second) superimpose, then the time interval between two successive maximum intensities is

AP EAPCET 2025 - 23rd May Evening Shift

Options:

A.

0.1 s

B.

0.4 s

C.

0.5 s

D.

0.2 s

Answer: D

Solution:

$$
\begin{aligned}
& y_1 = 3\sin 250\pi t \\
\therefore \quad & \omega_1 = 250\pi \mathrm{rad/s} \\
& y_2 = 2\sin 260\pi t \\
\therefore \quad & \omega_2 = 260\pi \mathrm{rad/s} \\
\therefore \quad & f_1 = \frac{\omega_1}{2\pi} = \frac{250\pi}{2\pi} = 125 \text{ Hz} \\
& f_2 = \frac{\omega_2}{2\pi} = \frac{260\pi}{2\pi} = 130 \text{ Hz} \\
& T = \frac{1}{f_2 - f_1} \\
& = \frac{1}{130-125} = \frac{1}{5} = 0.2 \text{ s}
\end{aligned}
$$

Question6

In a closed organ pipe, the number of nodes formed in fifth and ninth harmonics are respectively

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Options:

A.

5,9

B.

5,7

C.

3,5

D.

2,4

Answer: C

Solution:

In a closed organ pipe, the number of nodes formed in the nth harmonic is equal to $\left(\frac{n+1}{2}\right)$ if n is odd.

Thus, for the fifth $(n=5)$ harmonic, the number of nodes $=\frac{5+1}{2}=3$

and for the ninth harmonic ($n=9$), the number of nodes $=\frac{9+1}{2}=5$

Question7

When a stretched wire of fundamental frequency f is divided into three segments, the fundamental frequencies of these three segments are f_1, f_2 and f_3 respectively. Then the relation among f_1, f_2, f_3 and f is (Assume tension is constant)

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Options:

A.

$\sqrt{f}=\sqrt{f_1}+\sqrt{f_2}+\sqrt{f_3}$

B.

$f=f_1+f_2+f_3$

C.

$\frac{1}{f}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}$

D.

$\frac{1}{\sqrt{f}}=\frac{1}{\sqrt{f_1}}+\frac{1}{\sqrt{f_2}}+\frac{1}{\sqrt{f_3}}$

Answer: C

Solution:

Given:

A stretched wire has a **fundamental frequency** f.

When it is divided into **3 segments**, their fundamental frequencies are f_1, f_2, and f_3.

Tension T is **constant**.

We need to find the relation among f, f_1, f_2, f_3.

Step 1: Formula for fundamental frequency of a stretched string

For a string under tension T, length L, and linear density μ:

$$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$$

Step 2: Frequencies of the three parts

Suppose the original length is divided into three parts of lengths L_1, L_2, L_3, so that

$$L = L_1 + L_2 + L_3$$

Then their fundamental frequencies are

$$f_1 = \frac{1}{2L_1}\sqrt{\frac{T}{\mu}}, \quad f_2 = \frac{1}{2L_2}\sqrt{\frac{T}{\mu}}, \quad f_3 = \frac{1}{2L_3}\sqrt{\frac{T}{\mu}}$$

Step 3: Express L_i in terms of f_i

From the above,

$$L_i = \frac{1}{2f_i}\sqrt{\frac{T}{\mu}}$$

and

$$L = \frac{1}{2f}\sqrt{\frac{T}{\mu}}$$

Step 4: Use $L = L_1 + L_2 + L_3$

$$\frac{1}{2f}\sqrt{\frac{T}{\mu}} = \frac{1}{2}\sqrt{\frac{T}{\mu}}\left(\frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}\right)$$

Cancel the common factor $\frac{1}{2}\sqrt{\frac{T}{\mu}}$:

$$\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}}$$

✅ **Correct Option: (C)**

$$\boxed{\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}}$$

Question8

A steel wire of length 81 cm has a mass of 5×10^{-3} kg.

If the wire is under a tension of 50 N , then the speed of transverse waves on the wire is

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Options:

A.

$100 \mathrm{~ms}^{-1}$

B.

$105 \mathrm{~ms}^{-1}$

C.

$90 \mathrm{~ms}^{-1}$

D.

$60 \mathrm{~ms}^{-1}$

Answer: C

Solution:

Mass per unit length,

$\mu=\frac{M}{l}=\frac{5 \times 10^{-3}}{0.81}$

$\therefore$ Speed of transverse wave

$$v=\sqrt{\frac{T}{\mu}}=\sqrt{\frac{50}{\frac{5 \times 10^{-3}}{0.81}}}$$
$$=\sqrt{\frac{50 \times 0.81}{5 \times 10^{-3}}}=90 \mathrm{~m} / \mathrm{s}$$

Question9

The speed of a stationary wave represented by the equation

$y=0.7\sin\left(\frac{7\pi}{4}x\right)\cos(350\pi t)$ is

(In the given equation x and y are in metre and t is in second)

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Options:

A.

$100\ \mathrm{ms}^{-1}$

B.

$150\ \mathrm{ms}^{-1}$

C.

$160\ \mathrm{ms}^{-1}$

D.

$200\ \mathrm{ms}^{-1}$

Answer: D

Solution:

$y=0.7\sin\left(\frac{7\pi}{4}x\right)\cos(350\pi t)$

Comparing with equation of stationary wave,

$y=2A\sin(kx)\cos\omega t$

We get, $k=\frac{7\pi}{4}, \omega=350\pi$

$\therefore$ Speed of stationary wave,

$v=\frac{\omega}{k}=\frac{350\pi}{\frac{7\pi}{4}}=200\ \mathrm{m/s}$

Question10

Two sound waves of wavelengths 99 cm and 100 cm produce 10 beats in a time of t seconds. If the speed of sound in air is $330 \mathrm{~ms}^{-1}$, then the value of t in seconds is

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Options:

A.

12

B.

9

C.

6

D.

3

Answer: D

Solution:

$$
\begin{aligned}
f_1 & =\frac{v}{\lambda_1}=\frac{330}{0.99}=333.33 \mathrm{~Hz} \\
f_2 & =\frac{v}{\lambda_2}=\frac{330}{1}=330 \mathrm{~Hz} \\
\therefore f_{\text {beat }} & =f_1-f_2=333.33-330=3.33 \mathrm{~Hz} \\
\therefore \quad t & =\frac{\text { Total number of beat }}{f_{\text {beat }}}=\frac{10}{3.33}=3 \mathrm{~s}
\end{aligned}
$$

Question11

The frequency of fifth harmonic of a closed organ pipe is equal to the frequency of third harmonic of an open organ pipe. If the length of the open pipe is 72 cm , then length of the closed organ pipe is

AP EAPCET 2024 - 23th May Morning Shift

Options:

A. 60 cm

B. 45 cm

C. 30 cm

D. 75 cm

Answer: A

Solution:

Here's how to find the closed-pipe length L_c:

For a closed pipe (one end closed), only odd harmonics appear:

$f_m = \frac{m\,v}{4\,L_c} \quad (m = 1, 3, 5, \ldots)$

For an open pipe (both ends open), all harmonics appear:

$f_n = \frac{n\,v}{2\,L_o} \quad (n = 1, 2, 3, \ldots)$

Equate the 5th harmonic of the closed pipe to the 3rd harmonic of the open pipe:

$\frac{5\,v}{4\,L_c} = \frac{3\,v}{2\,L_o}$

Solve for L_c:

$\frac{5}{4\,L_c} = \frac{3}{2\,L_o} \implies L_c = \frac{5}{6}\,L_o = \frac{5}{6} \times 72 \text{ cm} = 60 \text{ cm}$

Answer: **60 cm** (Option A).

Question12

The fundamental frequency of an open pipe is 100 hz If the bottom end of the pipe is closed and $1/3$ rd of the pipe is filled with water, then the fundamental frequency of the pipe is

Options:

A. 200 Hz

B. 100 Hz

C. 75 Hz

D. $150H_2$

Answer: C

Solution:

To determine the new fundamental frequency when changing the configuration of the pipe, follow these steps:

Initial Conditions

Length of the pipe (L): The total length of the open pipe.

Speed of sound (v): A constant parameter in this context.

Open Pipe Fundamental Frequency

For an open pipe, the fundamental frequency (f_0) is given by:

$f_0 = \frac{v}{2L}$

Given that $f_0 = 100\,\text{Hz}$, we have:

$100 = \frac{v}{2L} \quad \Rightarrow \quad v = 200L$

Closed Pipe Adjustment

When the pipe's bottom end is closed and $\frac{1}{3}$ of the pipe is filled with water, the air column effectively resonating is:

$L' = L - \frac{L}{3} = \frac{2L}{3}$

Closed Pipe Fundamental Frequency

For a closed pipe, the fundamental frequency (f_C) is calculated using:

$f_C = \frac{v}{4L'}$

Substitute L' into the formula:

$f_C = \frac{v}{4 \times \frac{2L}{3}} = \frac{3v}{8L}$

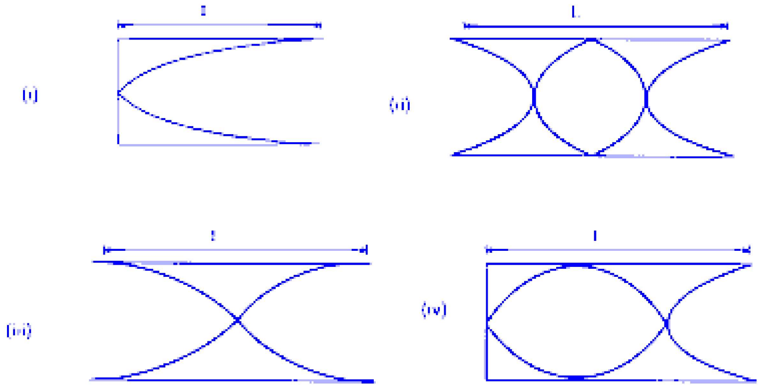
Plug in the value of v from the earlier expression:

$f_C = \frac{3 \times 200L}{8 \times L} = \frac{600}{8} = 75\,\text{Hz}$

Thus, the new fundamental frequency when the pipe is closed and partly filled with water is **75 Hz**.

Question13

The vibrations of four air columns are shown below. The ratio of frequencies is



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Options:

A. 1 : 2 : 3 : 4

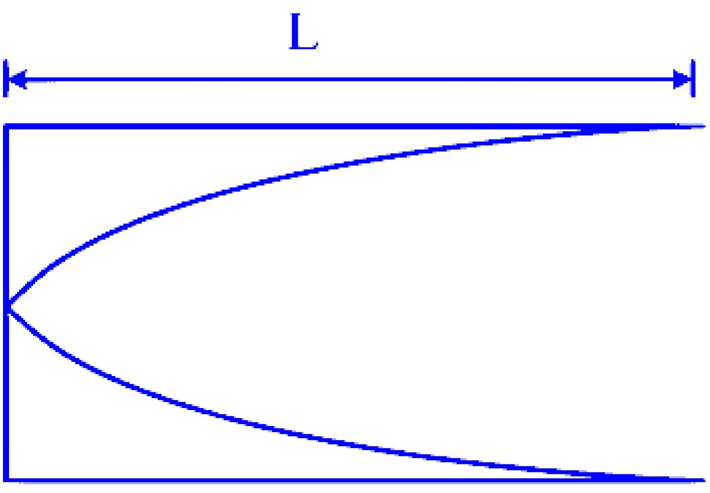
B. 1 : 3 : 2 : 4

C. 1 : 4 : 3 : 2

D. 1 : 4 : 2 : 3

Answer: D

Solution:

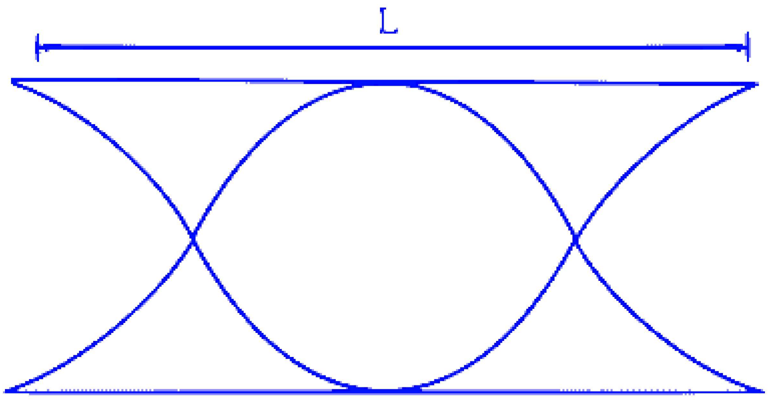


(a)

The pipe is closed $f = \frac{\nu}{\lambda}$

Here, $L = \frac{\lambda}{4}$

$\therefore \quad f_a = \frac{v}{4L}$



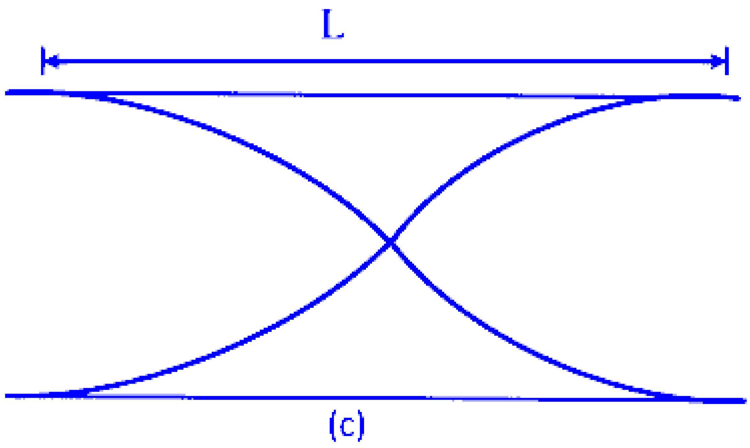
(b)

The pipe is open

So, $f = \frac{v}{\lambda}$

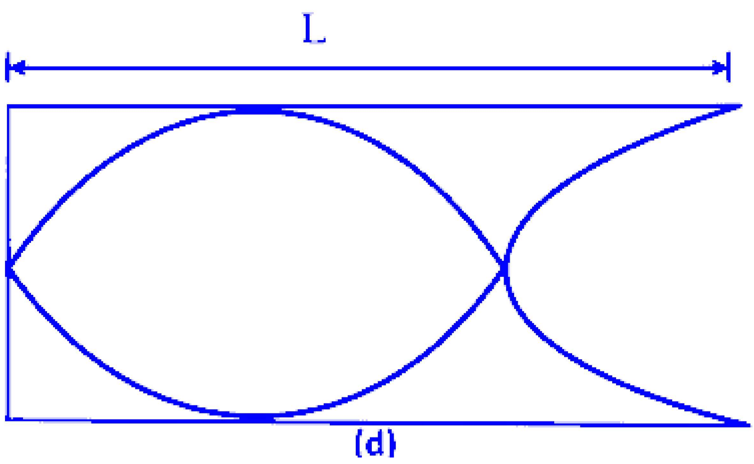
Here, $L = \lambda$

$f_b = \frac{v}{L}$



The pipe is open, $f = \frac{v}{\lambda}$

Here, $L = \frac{\lambda}{2}, f_c = \frac{v}{2L}$



The pipe is closed

So, $f = \frac{v}{\lambda}$

Here, $L = \frac{3\lambda}{4} \Rightarrow f_d = \frac{3v}{4L}$

Now, $f_a : f_b : f_c : f_d$

$\frac{v}{4L} : \frac{v}{L} : \frac{v}{2L} : \frac{3v}{4L} = 1 : 4 : 2 : 3$

Question14

When a wave enters into a rarer medium from a denser medium, the property of the wave which remains constant is

AP EAPCET 2024 - 21th May Evening Shift

Options:

A. wavelength

B. frequency

C. velocity

D. amplitude

Answer: B

Solution:

When a wave transitions from a denser medium to a rarer medium, the property that remains constant is the **frequency**.

Frequency is determined by the source of the wave and remains unchanged when the wave passes from one medium to another.

Question15

A car sounding a horn of frequency 1000 Hz passes a stationary observer. The ratio of frequen'ies of the horn noted by the observer before and after passing of the car is $11:9$. The speed of car is (speed of sound $v = 340 \text{ ms}^{-1}$)

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Options:

A. 34 ms^{-1}

B. 17 ms^{-1}

C. 170 ms^{-1}

D. 340 ms^{-1}

Answer: A

Solution:

Let's define:

$f = 1000\,\text{Hz}$: the original frequency of the horn.

$v = 340$ m/s: the speed of sound.

v_c: the speed of the car.

Apparent Frequency Formulas

Approaching Observer:

$$f_1 = f\left(\frac{v}{v - v_c}\right)$$

Receding from Observer:

$$f_2 = f\left(\frac{v}{v + v_c}\right)$$

Frequency Ratio Equation

Given $\frac{f_1}{f_2} = \frac{11}{9}$, we equate and solve:

$$\frac{f\left(\frac{v}{v - v_c}\right)}{f\left(\frac{v}{v + v_c}\right)} = \frac{v + v_c}{v - v_c} = \frac{11}{9}$$

Solving for v_c

Starting from:

$$\frac{11}{9} = \frac{340 + v_c}{340 - v_c}$$

Cross-multiplying gives:

$$11(340 - v_c) = 9(340 + v_c)$$

Simplifying:

$$3740 - 11v_c = 3060 + 9v_c$$

$$680 = 20v_c$$

$$v_c = \frac{680}{20} = 34 \text{ m/s}$$

Thus, the speed of the car is 34 m/s.

Question16

A pipe with 30 cm length is open at both ends. Which harmonic mode of the pipe resonates with the 1.65 kHz source? (Velocity of sound in air $= 330 \text{ ms}^{-1}$)

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Options:

A. 2

B. 3

C. 3.5

D. 2.5

Answer: B

Solution:

Given:

Frequency, $v_n = 1.65\,\text{kHz} = 1650\,\text{Hz}$

Velocity of sound, $v = 330\,\text{m/s}$

Length of pipe, $L = 30\,\text{cm} = 0.3\,\text{m}$

The frequency of the nth harmonic in an open pipe is calculated using the formula:

$v_n = \frac{nv}{2L}$

Substitute the given values:

$1650 = \frac{n\times330}{2\times0.3}$

Solving for n:

$1650 = \frac{n\times330}{0.6}$

$1650 \times 0.6 = n \times 330$

$990 = n \times 330$

$n = \frac{990}{330} = 3$

Thus, the pipe resonates at the 3rd harmonic.

Question17

If the frequency of a wave is increased by 25%, then the change in its wavelength is (medium not changed)

AP EAPCET 2024 - 20th May Morning Shift

Options:

A. 20% increase

B. 20% decrease

C. 25% increase

D. 25% decrease

Answer: B

Solution:

When the frequency of a wave is increased by 25%, the wavelength changes as follows (assuming the medium remains unchanged).

The speed of the wave remains the same because the medium does not change:

$v =$ constant

Therefore, according to the wave equation:

$f_1 \lambda_1 = f_2 \lambda_2$

If the initial frequency f_1 is increased by 25%, the new frequency f_2 becomes:

$f_2 = 1.25 \times f_1$

Substituting this into the wave equation:

$f_1 \lambda_1 = (1.25 \times f_1) \lambda_2$

Solving for the new wavelength λ_2:

$\lambda_2 = \frac{\lambda_1}{1.25} = 0.8 \lambda_1$

The change in wavelength $\Delta \lambda$ is calculated as:

$\Delta \lambda = \frac{\lambda_2 - \lambda_1}{\lambda_1} \times 100 = \frac{0.8 \lambda_1 - \lambda_1}{\lambda_1} \times 100$

Simplifying this gives:

$\Delta \lambda = \frac{-0.2 \lambda_1}{\lambda_1} \times 100 = -20\%$

Thus, the wavelength decreases by 20%.

Question18

The speed of a wave on a string is $150 \mathrm{~ms}^{-1}$ when the tension is 120 N . The percentage increase in the tension in order to raise the wave speed by 20% is

Options:

A. 44

B. 40

C. 22

D. 20

Answer: A

Solution:

To determine the percentage increase in tension required to raise the wave speed by 20%, we start by examining the given relationship between wave speed and tension.

Step-by-Step Solution

Calculate the New Wave Speed:

Given that the original wave speed is v_1 and we need to increase it by 20%, the new speed v_2 is:

$v_2 = v_1 + 20\%\text{ of } v_1 = v_1 + \frac{v_1}{5} = \frac{6v_1}{5}$

Relate Wave Speed to Tension:

The speed of a wave on a string is given by:

$v = \sqrt{\frac{T}{m}}$

This implies:

$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$

Squaring both sides gives:

$\frac{T_2}{T_1} = \left(\frac{v_2}{v_1}\right)^2$

Substitute v_2 and v_1:

$\frac{T_2}{T_1} = \left(\frac{\frac{6v_1}{5}}{v_1}\right)^2 = \left(\frac{6}{5}\right)^2 = \frac{36}{25}$

Find the Required Increase in Tension:

$\frac{T_2 - T_1}{T_1} = \frac{T_2}{T_1} - 1 = \frac{36}{25} - 1 = \frac{11}{25}$

Convert to Percentage:

$\frac{T_2 - T_1}{T_1} \times 100\% = \frac{11}{25} \times 100\% = 44\%$

Thus, the tension needs to be increased by **44%** to achieve a 20% increase in wave speed.

Question19

Two stretched strings A and B when vibrated together produce 4 beats per second. If the tension applied to the string A increased. The number of beats produced per second is increased to 7. If the frequency of string B is 480 Hz initially, the frequency of string A is

AP EAPCET 2024 - 18th May Morning Shift

Options:

A. 473 Hz

B. 476 Hz

C. 484 Hz

D. 487 Hz

Answer: C

Solution:

To determine the frequency of string A, we start with the following information:

Initial beat frequency is 4 beats per second.

Frequency of string B, $f_B = 480\,\text{Hz}$.

The relation for beat frequency: $|f_A - f_B| = 4$.

Given that the tension on string A is increased, the frequency of A will increase, leading to an increase in the beat frequency. The new beat frequency becomes 7 beats per second.

The vibration frequency of a string is determined by the formula:

$f = \frac{n}{2L} \cdot \sqrt{\frac{T}{\mu}}$

Where:

n is the mode of vibration.

L is the length of the string.

T is the tension in the string.

μ is the linear mass density.

Since the tension in string A is increased, we know the frequency of A increases. Consequently, the following must be true for the beat frequency to increase:

$f_A - f_B = 4 \quad \text{or} \quad f_B - f_A = 4$

However, since the frequency of A increases and the beat frequency becomes 7, it implies that:

$f_A - f_B = 7$

Given:

Initially, $f_A - 480 = 4$, thus $f_A = 484\,\text{Hz}$.

Therefore, as f_A increases past 480 Hz and still satisfies the condition where the beat frequency becomes 7, this confirms that initially:

$f_A = 484\,\text{Hz}$

Question20

Two cars are moving towards each other at the speed of $50\ \text{ms}^{-1}$. If one of the cars blows a horn at a frequency of 250 Hz , the wave length of the sound perceived by the driver of the other car is

(Speed of sound in air $= 350\ \text{ms}^{-1}$)

AP EAPCET 2022 - 5th July Morning Shift

Options:

A. 18.7 cm

B. 105 cm

C. 75 cm

D. 10.5 cm

Answer: B

Solution:

Here, both cars are moving towards each other, hence one car is like an observer and another car is like a source.

$\therefore \quad v_s = 50 \text{ m/s} \Rightarrow v_0 = -50 \text{ m/s}$

Frequency of horn blown by the source car,

$v = 250 \text{ Hz}$

According to Doppler's effect, frequency heared by another car v' is given as

$v' = \frac{v-v_0}{v-v_s} \times v = \frac{350-(-50)}{350-50} \times 250$

$\therefore (v = \text{speed of sound} = 350 \text{ m/s})$

$= \frac{400 \times 250}{300} \Rightarrow v' = \frac{100}{3} \text{ Hz}$

Wavelength of heard sound,

$$\lambda' = \frac{v}{v'}$$
$$= \frac{350}{1000/3} = \frac{1050}{1000} = 1.05 \text{ m} = 105 \text{ cm}$$

Question21

Speed of sound in air near room temperature is approximately

AP EAPCET 2022 - 4th July Evening Shift

Options:

A. $3.4 \times 10^2 \text{ ms}^{-1}$

B. 34 ms^{-1}

C. 34 kms^{-1}

D. 3.4 km s^{-1}

Answer: A

Solution:

The speed of sound in air at room temperature is approximately $340 \mathrm{~m/s}$ or $3.4 \times 10^2 \mathrm{~m/s}$.

Question22

A body is suspended from a string of length 1 m and mass 2 g. The mass of the body to produce a fundamental mode of 100 Hz frequency in the string is (Acceleration due to gravity $= 10 \mathrm{~ms}^{-2}$)

AP EAPCET 2022 - 4th July Morning Shift

Options:

A. 80 g

B. 4 kg

C. 400 g

D. 8 kg

Answer: D

Solution:

Given, mass of string, $m = 2 \mathrm{~g}$

$= 2 \times 10^{-3} \mathrm{~kg}$

length of the string, $l = 1 \mathrm{~m}$

$\therefore$ Mass per unit length

$\mu = \frac{m}{l} = 2 \times 10^{-3} \mathrm{~kg/m}$

Tension in the string,

$T = \text{ mass of body } \times g$
$T = m'g$

Frequency of transverse wave is given as

$$f=\frac{1}{21}\sqrt{\frac{T}{\mu}}$$

$$\Rightarrow \quad 100=\frac{1}{2\times 1}\sqrt{\frac{m'g}{2\times 10^{-3}}} \quad (\because \text{ Given, } f=100 \text{ Hz})$$

$$\Rightarrow (200)^2=\frac{m'g}{2\times 10^{-3}}$$

$$\Rightarrow \quad m'=\frac{4\times 10^4\times 2\times 10^{-3}}{g}=\frac{80}{10}=8 \text{ kg}$$

Question23

Two waves are represented by $x_1=A\sin\left(\omega t+\frac{\pi}{6}\right)$ and $x_2=A\cos\omega t$. Then, the phase difference between them is

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Options:

A. $\frac{\pi}{6}$

B. $\frac{\pi}{2}$

C. $\frac{\pi}{3}$

D. π

Answer: C

Solution:

We are given two waves:

$x_1=A\sin(\omega t+\frac{\pi}{6})andx_2=A\cos\omega t$

Step 1: Find the phase of each wave

For the first wave, x_1, the phase is the angle inside the sine function:Phase of $x_1(\phi_1)=\frac{\pi}{6}$

For the second wave, $x_2=A\cos\omega t$, we can write cosine as sine:$\cos\omega t=\sin\left(\omega t+\frac{\pi}{2}\right)$So, $x_2=A\sin\left(\omega t+\frac{\pi}{2}\right)$The phase of x_2 is:Phase of $x_2(\phi_2)=\frac{\pi}{2}$

Step 2: Find the phase difference

The phase difference between the waves is:$\Delta\phi = \phi_2 - \phi_1$

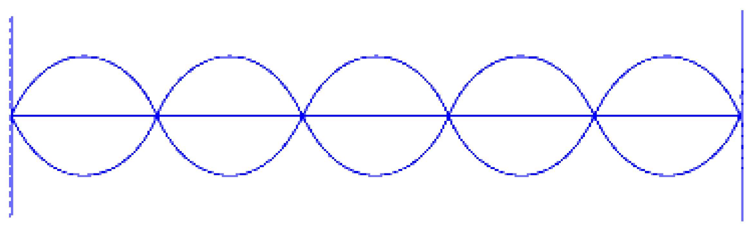
Substitute the values:$\Delta\phi = \frac{\pi}{2} - \frac{\pi}{6}$

Find a common denominator and subtract:$= \frac{3\pi}{6} - \frac{\pi}{6} = \frac{2\pi}{6} = \frac{\pi}{3}$

So, the phase difference between the waves is $\frac{\pi}{3}$.

Question24

A string fixed at both ends vibrate in 5 loopsas shown in the figure. The total number ofnodes and anti-nodes respectively are



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Options:

A. 6 and 5

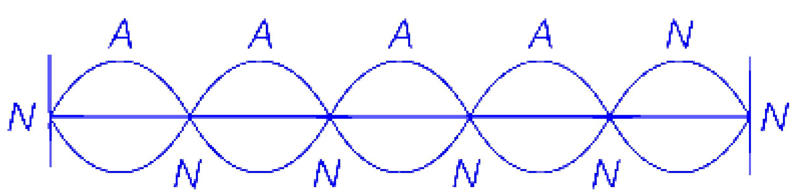
B. 6 and 10

C. 2 and 5

D. 10 and 6

Answer: A

Solution:



From above wave diagram,

Number of node, N = 6

and number of anti-node, A = 5

Question25

Match the following.

	Column I		Column II
(A)	Transverse wave through a steel rod	1.	$\sqrt{B + \left(\frac{4}{3}\right)\frac{\eta}{\rho}}$
(B)	Longitudinal waves in Earth's crust	2.	$\sqrt{\frac{\eta}{\rho}}$
(C)	Longitudinal waves through a steel rod	3.	$\sqrt{\frac{2\pi T}{\rho\lambda}}$
(D)	Ripples	4.	$\sqrt{\frac{\lambda}{\rho}}$

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Options:

A. A - 2, B - 1, C - 4, D - 3

B. A - 1, B - 3, C - 4, D - 2

C. A - 3, B - 4, C - 1, D - 2

D. A - 2, B - 4, C - 1, D - 3

Answer: A

Solution:

Speed of transverse wave, $v = \sqrt{\eta/\rho}$

where, $\eta =$ modulus of elasticity $\rho =$ density

$\therefore$ (A) $\rightarrow$ (2)

Speed of longitudinal wave in earth crust

$$v=\sqrt{B+\frac{4}{3}\left(\frac{\eta}{\rho}\right)}$$

$\therefore$ (B) $\rightarrow$ (1)

Speed of longitudinal wave, $v=\sqrt{\lambda/\rho}$ where, $\lambda=$ wavelength of wave.

$\therefore$ (C) $\rightarrow$ (4)

Ripples speed, $v=\sqrt{\frac{2\pi T}{\lambda\rho}}$

where, $T=$ surface tension coefficient.

$\therefore$ (D) $\rightarrow$ (3)

Question26

The sources of sound A and B produce awave of 350 Hz in same phase. A particle P isvibrating under an influence of these twowaves. If the amplitudes at P produced by thetwo waves is 0.3 mm and 0.4 mm, theresultant amplitude of the point P will be,when AP $-$ BP = 25 cm and the velocity ofsound is 350 ms^{-1}

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Options:

A. 0.7 mm

B. 0.1 mm

C. 0.2 mm

D. 0.5 mm

Answer: D

Solution:

Given, frequency of wave, $f=350$ Hz

Amplitudes of wave a_1, a_2 is 0.3 mm and 0.4 mm, respectively.

Path difference $(AP - BP = \Delta x) = 25$ cm

Speed of sound, $v = 350 \text{ ms}^{-1}$

As, we know that,

$$\Delta\phi = \frac{2\pi}{\lambda}\Delta x$$

and (wavelength) $\lambda = \dfrac{\text{(speed) } v}{\text{(frequency) } f}$

$$= \frac{350}{350} = 1 \text{ m} = 100 \text{ cm}$$

$$\Delta\phi = \frac{2\pi}{100} \times 25 = \pi/2$$

As, resultant amplitude,

$$\begin{aligned} a_R &= \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi} \\ \Rightarrow \quad a_R &= \sqrt{0.3^2 + 0.4^2 + 2 \times 0.3 \times 0.4 \cos\pi/2} \\ &= \sqrt{9/100 + 16/100} \\ &= \sqrt{25/100} \\ &= 5/10 = 0.5 \text{ mm} \end{aligned}$$
