Waves

Question1

The angle between the particle velocity and wave velocity in a transverse wave is [except when the particle passes through the mean position]

KCET 2025

Options:

A. $\frac{\pi}{4}$ radian

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

C. π radian

D. Zero radian

Answer: B

Solution:

In a transverse wave, particles oscillate in a direction perpendicular to the wave's direction of propagation. Therefore, the angle between the particle velocity and wave velocity is $\frac{\pi}{2}$ radians, except when the particle crosses the mean position.

Question2

A motor-cyclist moving towards a huge cliff with a speed of $18 \mathrm{kmh}^{-1}$, blows a horn of source frequency 325 Hz . If the speed of the sound in air is $330 \mathrm{~ms}^{-1}$, the number of beats heard by him is

KCET 2024

Options:

A. 5

B. 4

C. 10

D. 7

Answer: A

Solution:

To find the number of beats heard by the motor-cyclist:

Convert the speed of the motor-cyclist:

The speed given is 18 km/h.

Convert km/h to m/s:

$v_s = 18 \times \frac{5}{18}$ m/s $= 5$ m/s

Determine the properties given:

Frequency of the source, $f = 325$ Hz.

Speed of sound in air, $v = 330$ m/s.

Calculate the number of beats heard:

The formula for the frequency change due to the Doppler effect, when the observer and the source are moving towards each other, is:

$\Delta f = f\left(\frac{v_s}{v - v_s}\right)$

Substitute the known values:

$\Delta f = 325\left(\frac{5}{330-5}\right) = 5$

Conclusion:

The number of beats heard by the motor-cyclist is 5.

Question3

A galaxy is moving away from the Earth so that a spectral line at 600 nm is observed at 601 nm . Then, the speed of the galaxy with respect to the Earth is

KCET 2024

Options:

A. 500 km s^{-1}

B. 200 km s^{-1}

C. 50 km s^{-1}

D. 20 km s^{-1}

Answer: A

Solution:

The Doppler effect describes the change in frequency or wavelength of a wave in relation to an observer moving relative to the source of the waves. For light, this effect is observed in the form of redshift or blueshift, depending on whether the object is moving away from or towards the observer, respectively.

The formula to calculate the redshift z can be written as:

$$z = \frac{\lambda_{\text{observed}} - \lambda_{\text{original}}}{\lambda_{\text{original}}}$$

where:

$\lambda_{\text{observed}} = 601$ nm (the wavelength observed),

$\lambda_{\text{original}} = 600$ nm (the original wavelength).

Substitute the given values:

$$z = \frac{601 \text{ nm} - 600 \text{ nm}}{600 \text{ nm}} = \frac{1}{600}$$

The redshift is also related to the velocity v of the galaxy and the speed of light c by the formula:

$$z = \frac{v}{c}$$

Using this relationship, we can solve for v, the speed of the galaxy:

$$v = z \cdot c = \left(\frac{1}{600}\right) \cdot (3 \times 10^5 \text{ km/s})$$

Calculating this gives:

$v = \frac{3 \times 10^5 \text{ km/s}}{600} = 500 \text{ km/s}$

Thus, the speed of the galaxy with respect to the Earth is 500 km/s.

Correct Option: A 500 km s^{-1}

Question4

To propagate both longitudinal and transverse waves, a material must have

KCET 2021

Options:

A.

bulk and shear moduli

B.

bulk modulus

C.

shear modulus

D.

Young's and bulk modulus

Answer: A

Solution:

In transverse waves, the particle motion is normal to the direction of the wave. Therefore, as the wave propagates each element of the medium undergoes shearing strain. in longitudinal waves, the constituents of the medium oscillate about their mean position along the direction of wave propagation like propagation of sound wave. This involves compressive stress (pressure). Thus, transverse waves be propagated in medium which can sustain shearing stress. Similarly, longitudinal waves can be propagated in medium which can sustain bulk modulus.

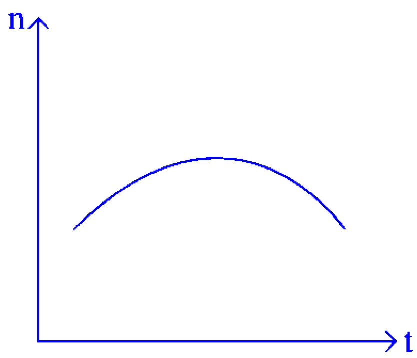
Question5

A train whistling at constant frequency n is moving towards a station at a constant speed v. The train goes past a stationary observer on the station. The frequency n of the sound as heard by the observer is plotted as a function of time t. Identify the correct curve.

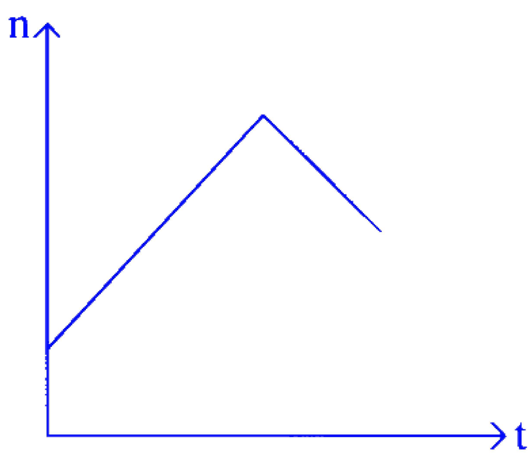
KCET 2020

Options:

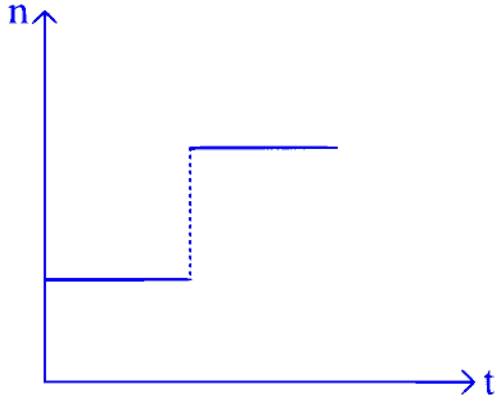
A.



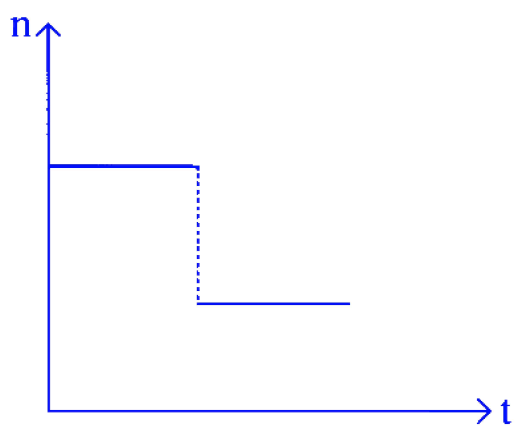
B.



C.



D.



Answer: D

Solution:

Since, the observer is stationary, so when train is approaching towards the observer or moving towards the observer, apparent frequency is given as,

$n' = n\left(\frac{v}{v - v_s}\right)$

where, v_s is the speed of sound.

It is clear from the above expression that $n' > n$.

However, when the train is going away from the observer, then apparent frequency,

$$n' = n\left(\frac{v}{v + v_s}\right)$$
$$\therefore \quad n' < n$$

Hence, graph represented in option (d) is correct.

Question6

The equation of a stationary wave is $y = 2\sin\left(\frac{\pi x}{15}\right)\cos(48\pi t)$. The distance between a node and its next antinode is

KCET 2019

Options:

A. 7.5 units

B. 1.5 units

C. 22.5 units

D. 30 units

Answer: A

Solution:

The Equation of stationary wave is $y = A \sin kx \cos \omega t$ comparing, $k = \frac{2\pi}{\lambda} = \frac{\pi}{15} \Rightarrow \lambda = 30 \text{ m}$

Distance between a node and antinode

$= \frac{\lambda}{4} = \frac{30}{4} = 7.5$ units

Question7

First overtone frequency of a closed pipe of length l_1 is equal to the second harmonic frequency of an open pipe of length l_2. The ratio $\frac{l_1}{l_2}$ is equal to

KCET 2018

Options:

A. $\frac{3}{4}$

B. $\frac{4}{3}$

C. $\frac{3}{2}$

D. $\frac{2}{3}$

Answer: A

Solution:

To solve for the ratio $\frac{l_1}{l_2}$ between the lengths of the closed pipe and the open pipe, we can compare their respective frequencies:

The first overtone frequency of a closed pipe (which corresponds to the third harmonic since a closed pipe supports only odd harmonics) is given by:

First overtone frequency $= \frac{3v}{4l_1}$

The second harmonic frequency of an open pipe is given by:

Second harmonic frequency $= \frac{2v}{2l_2} = \frac{v}{l_2}$

According to the problem, these two frequencies are equal. Hence, we set them equal to each other:

$\frac{3v}{4l_1} = \frac{v}{l_2}$

By simplifying this equation, we eliminate v and solve for the ratio $\frac{l_1}{l_2}$:

$\frac{3}{4l_1} = \frac{1}{l_2}$

Cross-multiplying gives:

$3l_2 = 4l_1$

So the ratio $\frac{l_1}{l_2}$ is:

$\frac{l_1}{l_2} = \frac{3}{4}$

Question8

The waves set up in a closed pipe are

KCET 2017

Options:

A. longitudinal and progressive

B. transverse and progressive

C. transverse and stationary

D. longitudinal and stationary

Answer: D

Solution:

In a closed pipe, the wave pattern that forms is a standing wave (also called a stationary wave). Here's why:

Type of Wave:

Sound in air is a longitudinal wave. This means that the particles in the medium (air molecules) oscillate in the same direction as the wave propagation.

Nature of the Wave in a Closed Pipe:

In a closed pipe—where one end is closed and the other end is open—the wave is reflected at the closed end, interfering with the incoming wave to produce a standing (stationary) wave pattern. In this standing wave, certain points (nodes) remain fixed, while other points (antinodes) reach maximum displacement.

Why Not the Other Options:

"Longitudinal and progressive" (Option A) describes sound waves in an open medium where the wave travels continuously. In a closed pipe, reflections lead to a standing wave.

"Transverse and progressive" (Option B) and "transverse and stationary" (Option C) are incorrect because sound waves in air are not transverse—they involve compressions and rarefactions along the direction of propagation.

Thus, the correct answer is:

Option D: Longitudinal and stationary.

This means that the wave pattern in a closed pipe is made up of longitudinal sound waves that are standing rather than continuously traveling along the pipe.
