Two small identical speakers are connected (in phase) to

A pipe with both ends open has a fundamental frequency of$

The number of audible beats resulting from two sound waves of frequency

The number of antinodes in a standing wave of wavelength$

A moving police car sounding its 1000 Hz siren. You are in a car which moves toward the police car at a speed of 72 km/h (i.e. 20 m s\(^{-1}\)). The frequency you hear is 973 Hz. The detector is moving toward the source (+ sign in numerator). The source is moving away from the detector (+ sign in denominator).

The number of antinodes in a standing wave of wavelength \( \lambda \) established in a stretched string of length \( L = 2 \lambda \) is 4 (C)

Two sounds differ in sound level by 10 dB. The ratio of their intensities is:

Two small identical speakers are connected (in phase) to the same source. The speakers are 3 m apart and at ear level. A listener stands at \( A \), 4 m in front of one speaker as shown. The sound she hears will be most intense if the wavelength verifies:

The number of audible beats resulting from two sound waves of frequency 1000 Hz and 1003 Hz = 1003 − 1000 = 3 (C)

A pipe with both ends open has a fundamental frequency of 680 Hz. How long is the pipe if the speed of sound in air is 340 m/s?

Radio receivers are usually tuned by adjusting the capacitor of an \( LC \) circuit. If \( C = C_1 \) for a frequency of 1200 kHz, then for a frequency of 600 kHz one must adjust \( C \) to:

\[
\frac{f_2}{f_1} = \frac{\omega_2}{\omega_1} = \sqrt{\frac{LC_1}{LC_2}} \Rightarrow \frac{C_1}{C_2} = \left(\frac{f_2}{f_1}\right)^2 = C_1 \left(\frac{1200}{600}\right)^2 = 4C_1 \tag{B}
\]
11. The figure shows an LC circuit. Take \( C = 1 \text{nF} \) and \( \omega = \pi \times 10^3 \text{ rad s}^{-1} \). The capacitor is initially (at \( t = 0 \)) charged with 1 \( \mu \text{C} \). The energy stored in the capacitor at \( t = 1 \text{ ms} \) is:

\[
U(t) = \frac{1}{2} \frac{q^2(t)}{C} = \frac{1}{2} \frac{q_0^2}{C} \cos^2(\omega t) \Rightarrow U(1\text{ms}) = \frac{1}{2} \frac{q_0^2}{C} \cos^2\left(\pi \times 10^3 \times 10^{-3}\right) = \frac{1}{2} \frac{q_0^2}{2} = \frac{1}{2} \times 10^{-12} = 0.5 \text{mJ}
\]  

(C)

12. One of the following statements is not true for an electromagnetic wave:

A) The energy associated with the electric field \( E \) is greater than the energy associated with the magnetic field \( B \): False

B) The wave travels in the direction of \( \vec{E} \times \vec{B} \): True

C) \( c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \): True

D) \( c = \frac{E_m}{B_m} \): True

13. A plane electromagnetic wave, with frequency \( 3 \times 10^8 \text{ Hz} \), travels in vacuum in the positive \( y \) direction with its electric field (\( \vec{E} \)), of amplitude 7.5 \( nT \), directed along the positive \( x \) axis. The wavenumber for this wave (in \( m^{-1} \)) is:

\[
k = \frac{2\pi}{\lambda} = \frac{2\pi}{c/v} = \frac{2\pi \times 3 \times 10^8}{3 \times 10^8} = 2\pi \text{\( m^{-1} \)}
\]

14. In the previous question the amplitude of the associated electric field \( \vec{E} \) is:

\[E_m = B_m \times c = 7.5 \times 10^{-9} \times 3 \times 10^8 = 2.25 \text{ V/m} \text{ along the} \ z \text{ axis (C)}
\]

15. The magnitude of the Poynting vector for the previous wave is:

\[S = \frac{1}{\mu_0} E_m B_m = \frac{10^7}{4\pi} \times 2.25 \times 7.5 \times 10^{-9} \approx 13 \times 10^{-3} \text{ W/m}^2 \text{ (B)}
\]

16. If a light beam is incident on one of the two perpendicular reflecting surfaces, the relation between the angle of incidence \( \theta_0 \) and the angle of reflection \( \theta \) is:

\[\theta_0 + \theta = 90^\circ \text{ (C)}
\]

17. A black, totally absorbing piece of plastic of area \( A = 2 \text{ cm}^2 \) intercepts light with an intensity of 15 \( \text{ W/m}^2 \). The radiation pressure produced on this object by the light (in \( Pa, \ 1 \text{ Pa} = 1 \text{ N/m}^2 \)) is:

\[U = \frac{I}{c} = \frac{15}{3 \times 10^8} = 0.5 \times 10^{-7} \text{ Pa} \text{ (A)}
\]

18. A beam of light (\( \lambda = 600 \text{ nm} = 6000 \text{ Å} \)) passes through a piece of glass (\( n = 4/3 \)). The critical angle is:

\[
\sin \theta_c = \frac{1}{4/3} = 0.75 \Rightarrow \theta_c = 49^\circ \text{ (B)}
\]

19. When a beam of light is incident from air on a transparent plate, the maximum angle of refraction occurs at 42°. The index of refraction of the plate material is:

\[n_1 = n_2 \sin \theta_c \Rightarrow n_2 = 1/\sin 42^\circ = 1.5 \text{ (D)}
\]

20. In a double-slit arrangement, a stable interference pattern is obtained if the incident light is coherent. (C)