PHYSICS

TARGET : JEE- Advanced 2023

CAPS-19

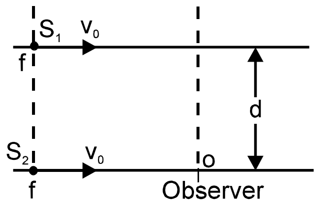
SOUND WAVES

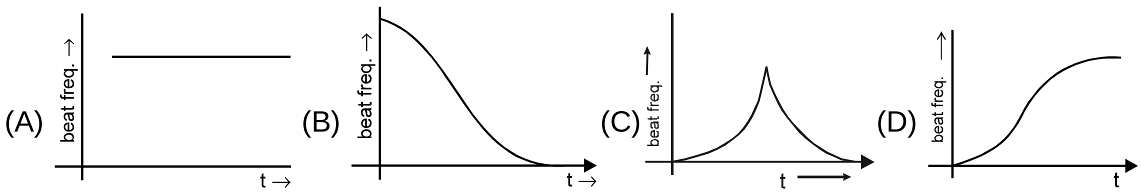
SCQ (Single Correct Type) :

1. The fundamental frequency of a sonometer wire of length ℓ is f_o. A bridge is now introduced at a distance of $\Delta\ell$ from the centre of the wire ($\Delta\ell << \ell$). The number of beats heard if both sides of the bridges are set into vibration in their fundamental modes are

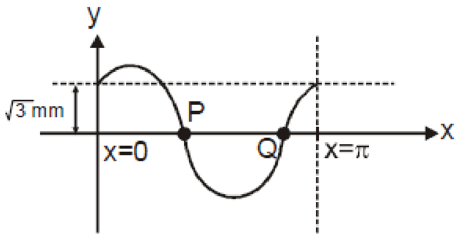
(A) $\frac{8f_0\Delta\ell}{\ell}$ (B) $\frac{f_0\Delta\ell}{\ell}$ (C) $\frac{2f_0\Delta\ell}{\ell}$ (D) $\frac{4f_0\Delta\ell}{\ell}$

2. Two identical sources moving parallel to each other at separation 'd' are producing sounds of frequency 'f' and are moving with constant velocity v_0. A stationary observer 'O' is on the line of motion of one of the sources. Then the variation of beat frequency heard by O with time is best represented by: (as they come from large distance and go to a large distance)





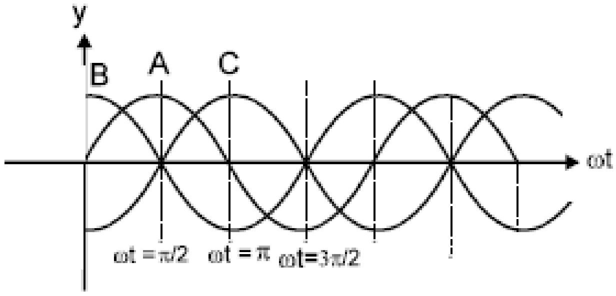
3. A transverse sinusoidal wave of amplitude 2mm is travelling in a long uniform string. Snapshot of string from x = 0 to x = π meter is taken at t = 0 and shown in figure. Velocity of point P is in positive ydirection and magnitude of relative velocity of P with respect to Q is 4 cm/s then the wave equation is :



(A) $y = (2 \times 10^{-3}) \sin (10t - 2x + \frac{2\pi}{3})$ meter (B) $y = (2 \times 10^{-3})\sin(10t + 2x + \frac{4\pi}{3})$ meter

(C) $y = (2 \times 10^{-3})\sin(10t - 2x + \frac{\pi}{3})$ meter (D) $y = (2 \times 10^{-3})\sin(10t + 2x + \frac{\pi}{3})$ meter

4. The figure shows three progressive waves A, B & C. It can be concluded from the figure that with respect to wave A:



(A) the wave C is ahead by a phase angle of $\pi/2$ & the wave B lags behind by a phase angle $\pi/2$

(B) the wave C lags behind by a phase angle of $\pi/2$ & the wave B is ahead by a phase angle of $\pi/2$

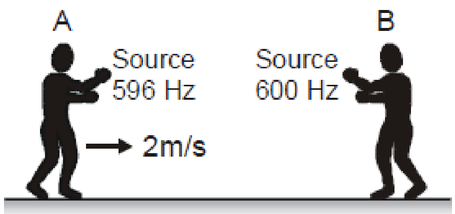
(C) the wave C is ahead by a phase angle of π & the wave B lags behind by the phase angle of π

(D) the wave C lags behind by a phase angle of π & the wave B is ahead by a phase angle of π

5. A tube of length ℓ open at only one end is cut into two equal halves. The sixth overtone frequency of piece closed at one end equals to sixth overtone frequency of piece open at both ends. The radius of cross–section of tube is :

(A) $\frac{5\ell}{72}$ (B) $\frac{\ell}{24}$ (C) $\frac{5\ell}{24}$ (D) $\frac{5\ell}{12}$

6. Two persons A and B each carrying a source of frequency 596 Hz and 600 Hz respectively are standing at rest a few metres apart. A starts moving towards B with a velocity of 2 m/s. If the speed of sound is 300 m/s. Which of the following statement is true.



(A) Beats heard per second by A is zero and B is 8.

(B) Beats heard per second by A is 8 and B is zero.

(C) Frequency of B heard by A is 600 Hz.

(D) Frequency of A as heard by B is 604 Hz.

MCQ (One or more than one correct) :

7. Two particles of a medium disturbed by the wave propagation are at $x_1 = 0$ and $x_2 = 1$ cm. The wave is propagating in positive x-direction. The displacement of the particles is given by the equation: $y_1 = (2\sin 3\pi t)$cm and $y_2 = 2\sin(3\pi t - \pi/8)$cm (t is in seconds)

(A) The frequency of wave is 1.5 Hz

(B) Wavelength of the wave can be 16 cm.

(C) Velocity of the wave can be 24 cm/s

(D) Wave equation can be $y = (2)\sin\left[\frac{2\pi}{16}(24t - x)\right]$ cm.

8. A narrow organ pipe of length 28cm closed at one end is found to be at resonance when a tuning fork of frequency 850 Hz is sounded near the open end. If velocity of sound in air is 340 m/s, then the

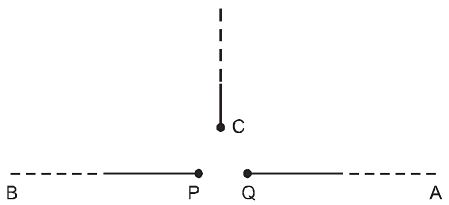
(A) Air in the pipe is vibrating in fundamental mode

(B) Air in the pipe is vibrating in first overtone

(C) End correction of the pipe is 1 cm

(D) End correction of the pipe is 2cm

9. Two monochromatic sources of electromagnetic wave, P and Q emit waves of wavelength $\lambda = 20$ m and separated by 5m as shown. A,B and C are three points where interference of these waves is observed. If phase of a wave generated by P is ahead of wave generated by Q by $\pi/2$ then (given intensity of both waves is I) :



C is symmetrical with respect to P and Q

(A) phase difference of these waves at B is 180^0

(B) intensities at A,B and C are in the ratio 2 : 0 : 1 respectively.

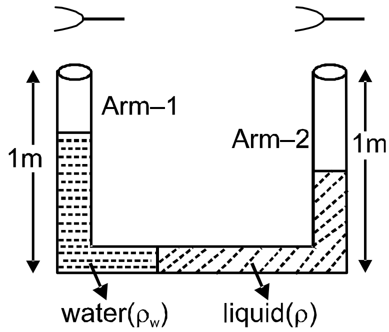
(C) intensities at A,B and C are in the ratio 1 : 2 : 0 respectively.

(D) phase difference at A is 0^0.

Comprehension Type Question:

COMPREHENSION # 1

A U–tube, open from both the ends, contains two arms, arm–1 and arm–2 each of having equal cross–section and height of each arm is 1m. Water of density ρ_w and an unknown liquid of density ρ is filled as shown.



A tuning fork of frequency 300Hz is vibrated on arm–1, then a loud sound of fundamental tone is produced. If the same tuning fork is vibrated on arm–2, again a loud sound of 1st overtone is produced. (V_{sound} = 300 m/sec., g = 10 m/sec^2, density of water $\rho_w = 10^3$ kg/m^3, atmospheric pressure = 10^5 Pa). Neglect the effect of surface tension and end correction.

10. Density of the unknown liquid (ρ) is :

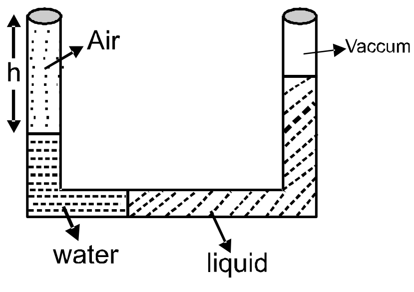
(A) $2\rho_w$ (B) $2.5\ \rho_w$ (C) $3\rho_w$ (D) $3.5\ \rho_w$

11. Now we use a tuning fork of frequency 302Hz, instead of 300 Hz, with how much velocity should we move the tuning fork, so that resonance is created with the air column in any arm ?

(A) 2 m/sec. towards the tube (B) 2 m/sec. away from the tube

(C) 4 m/sec. towards the tube (D) 4 m/sec. away from the tube

12. Tuning forks are removed. Now we seal the ends of both the arms. Air in arm–2 is completely evacuated, then the height (h) of air column in arm–1 at equilibrium will be : (assume the tube is conducting so the temperature of air in arm–1 remains constant)



(A) $\frac{1+\sqrt{41}}{8}$m (B) $\frac{1+\sqrt{19}}{8}$m (C) $\frac{1+\sqrt{31}}{8}$m (D) $\frac{1+\sqrt{11}}{8}$m

COMPREHENSION # 2

In a kundt's tube, a gas is filled and it is found that the heaps of lycopodium powder were formed at a distance of 10 cm from each other. When the gas was replaced with helium gas, the heaps were formed at a distance of $\frac{50}{\sqrt{42}}$ cm. The first gas was diatomic. Assume that the temperature of system remains the same.The velocity of the sound wave in the rod used in kundt's tube is 10 times that in the first gas. The rod is clamped at the centre.

13. Find the molar mass of the first gas?

(A) 2 gm (B) 32 gm (C) 28 gm (D) none of these

14. What is the length of the rod if it is oscillating in the fundamental mode?

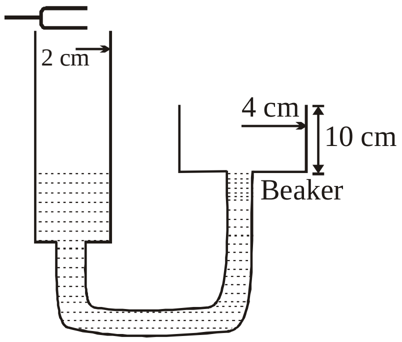
(A) 2 m (B) 1 m (C) 0.5 m (D) none of these

15. Specific heat capacity of first gas at constant volume is (take R = $\frac{25}{3}$ J/moleK)

(A) 14672.6 J/kgK (B) 20833.3 J/kgK (C) 5208.3 J/kgK (D) 10416.6 J/kgK

Numerical based Questions :

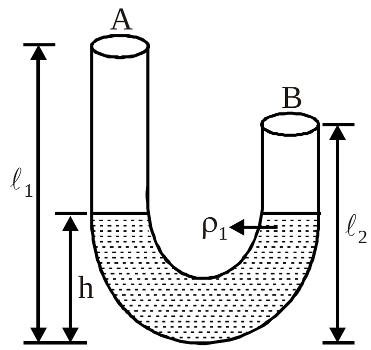
16. In a resonance column apparatus, first resonance is obtained when the water filling beaker (of cylindrical shape) is just empty as shown. The water filling beaker is lowered down and it is seen that second resonance is obtained when beaker is filled upto brim. If the tuning fork has a frequency 420 Hz. What is the velocity (in m/s) of sound in air?



17. The equation of a longitudinal stationary wave in a metal rod is given by, y = 0.002 sin $\frac{\pi x}{3}$ sin 1000 πt, where x & y are in cm and t is in seconds . If maximum change in pressure (the maximum tensile stress) at the point x = 2 cm is $\frac{1}{n}\times 10^{-3}$ dyne/cm^2, Find n. Given young's modulus of the material is $\frac{3}{8\pi}$ dynes/cm^2.

18. If we run towards a resonance column apparatus vibrating in the fundamental mode with a speed of 5 m/s, we hear a frequency of 165 Hz. When we run away from the apparatus with a speed of 5m/s, we hear a frequency of 160 Hz. What is the length of the resonance column (in cm) that we see? Neglect end correction.

19. A U-tube having uniform cross-section but unequal arm length l_1 = 100 cm and l_2 = 50 cm has same liquid of density ρ_1 filled in it upto a height h = 30 cm as shown in figure. Another liquid of density $\rho_2 = \rho_1/2$ is poured in arm A. Both liquids are immiscible. What length of the second liquid (in cm) should be poured in A so that second overtone of A is in unison with fundamental tone of B. (Neglect end correction)



20. A source of sound with natural frequency f_0 moves unifromly along a straight line. A stationary sound detector is located at a distance of 300 m from the straight line. When the source is closest to the detector, it records a frequency of $3f_0$ as received from the source. Find the distance of the source from the detector at the instant when it records natural frequency f_0 of the source.

21. A source emitting sound of frequency f_0 is moving in a circle of radius R, having centre at the origin, with a uniform speed = c/3, where c = speed of sound. Find the maximum and minium frequencies heard by a stationary listener at the point (R/2, 0).

Matrix Match Type :

22. Match the statements in column-I with the statements in column-II.

Column-I	**Column-II**
(A) A tight string is fixed at both ends and sustaining standing wave	(p) At the middle, antinode is formed in odd harmonic
(B) A tight string is fixed at one end and free at the other end	(q) At the middle, node is formed in even harmonic
(C) Standing wave is formed in an open organ pipe. End correction is not negligible.	(r) At the middle, neither node nor antinode is formed
(D) Standing wave is formed in a closed organ pipe. End correction is not negligible.	(s) Phase difference between SHMs of any two particles will be either π or zero.

Subjective Type Questions :

23. A road passes at some distance from a standing man. A truck is coming on the road with some acceleration. The truck driver blows a whistle of frequency 500 Hz when the line joining the truck and the man makes an angle θ with the road. The man hears a note having a frequency of 600 Hz when the truck is closest to him. Also the speed of truck has got doubled during this time. Find the value of 'θ'.

24. A point sound source is located on the perpendicular to the plane of a ring drawn through the centre O of the ring. The distance between the point O and the source is ℓ = 1.00 m, the radius of the ring is R = 0.50 m. Find the mean energy flow rate across the area enclosed by the ring if at the point O the intensity of sound is equal to I_0 = 30 μW/m^2. The damping of the waves is negligible.

25. The equation of a longitudinal standing wave due to superposition of the progressive waves produced by two sources of sound is $s = -20 \sin 10\pi x \sin 100\pi t$ where s is the displacement from mean position measured in mm ; x is in metres and t in seconds. The specific gravity of the medium is 10^{-3}. Find

(a) wavelength, frequency and velocity of the progressive waves.

(b) Bulk modulus of the medium and the pressure amplitude of constituent progressive wave.

(c) minimum distance between pressure antinode and the displacement antinode.