JEE Main 2021 | Waves

Question 1

(Integer type question) 2021

Two cars X and Y are approaching each other with velocities $36\ km/h$ and $72\ km/h$ respectively. The frequency of a whistle sound as emitted by a passenger in car X, heard by the passenger in car Y is $1320\ Hz$. If the velocity of sound in air is $340\ m/s$, the actual frequency of the whistle sound produced is ..... Hz.

Question 2

(Integer type question) 2021

A tuning fork is vibrating at $250\ Hz$. The length of the shortest closed organ pipe that will resonate with the tuning fork will be ..... cm. (Take speed of sound in air as $340\ ms^{-1}$)

Question 3

(Integer type question) 2021

A wire having a linear mass density $9.0 \times 10^{-4}\ kg/m$ is stretched between two rigid supports with a tension of $900\ N$. the wire resonates at a frequency of $500\ Hz$. The next higher frequency at which the same wire resonates is $550\ Hz$. The length of the wire is ..... m.

Question 4

(Only one correct answer) 2021

A student is performing the experiment of resonance column. The diameter of the column tube is $6\ cm$. The frequency of the tuning fork is $504\ Hz$. Speed of the sound at the given temperature is $336\ m/s$. The zero of the meter scale coincides with the top end of the resonance column tube. The reading of the water of the water level in the column when the first resonance occurs is :

- (a) $14.8\ cm$
- (b) $13\ cm$
- (c) $16.6\ cm$
- (d) $18.4\ cm$

Question 5

(Integer type question) 2021

The mass per unit length of a uniform wire is $0.135\ g/cm$, a transverse wave of the form $y = -0.21\sin(x + 30t)$ is produced in it. where x is in meter and t is in second. Then, the expected

value of tension in the wire is $x \times 10^{-2}\ N$. Value of x is .....

(Round-off to the nearest integer)

Question 6

(Only one correct answer) 2021

A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency $340\ Hz$. When fork A is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork A ?

- (a) $342\ Hz$
- (b) $335\ Hz$
- (c) $338\ Hz$
- (d) $345\ Hz$

Question 7

(Integer type question) 2021

A close organ pipe of length L and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open pipe is $\frac{x}{3}L\sqrt{\frac{\rho_1}{\rho_2}}$ where x is .....

(Round off to the Nearest Integer)

Question 8

(Only one correct answer) 2021

A sound wave of frequency $245\ Hz$ travels with the speed of $300\ ms^{-1}$ along the positive x axis. Each point of the wave moves to and fro through a total distance of $6\ cm$. What will be the mathematical expression of this travelling wave ?

- (a) $Y(X,t) = 0.06[\sin 0.8X - (0.5 \times 10^3)t]$
- (b) $Y(X,t) = 0.06[\sin 5.1X - (0.5 \times 10^3)t]$
- (c) $Y(X,t) = 0.03[\sin 5.1X - (0.2 \times 10^3)t]$
- (d) $Y(X,t) = 0.03[\sin 5.1X - (1.5 \times 10^3)t]$

Question 9

(Integer type question) 2021

The amplitude of wave disturbance propagating in the positive x-direction is given by $y = \frac{1}{(1+x)^2}$ at time $t = 0$ and $y = \frac{1}{1+(x-2)^2}$ at $t = 1\ s$, where x and y are in meters. The shape of wave does not change during the propagation. The velocity of the wave will be ..... m/s.

Question 10

(Integer type question) 2021

The frequency of a car horn encountered a change from $400\ Hz$ to $500\ Hz$, when the car approaches a vertical wall. If the speed of sound is $330\ m/s$. Then the speed of car is $\ldots\ldots\ km/h$.

Question 11

(Only one correct answer) 2021

With what speed should a galaxy move outward, with respect to earth so that the sodium-D line at wavelength $5890\ \dot{A}$ is observed at $5896\ \dot{A}$?

- (a) $322\ km/sec$
- (b) $296\ km/sec$
- (c) $306\ km/sec$
- (d) $336\ km/sec$

Question 12

(Integer type question) 2021

Two travelling waves produces a standing wave represented by equation.

$y = 1.0\ mm \cos(1.57\ cm^{-1})x \sin(78.5\ s^{-1})t$. The node closest to the origin in the region $x > 0$ will be at $x = \ldots\ldots\ cm$.

Question 13

(Integer type question) 2021

Two waves are simultaneously passing through a string and their equations are :

$y_1 = A_1 \sin k(x - vt)$, $y_2 = A_2 \sin k(x - vt + x_0)$. Given amplitudes $A_1 = 12\ mm$ and $A_2 = 5\ mm$, $x_0 = 3.5\ cm$ and wave number $k = 6.28\ cm^{-1}$. The amplitude of resulting, wave will be ..... mm.

Question 14

(Only one correct answer) 2021

Which of the following represents a travelling wave ?

- (a) $y = Ae^{x}(\cos(\omega t - \theta))$
- (b) $y = A \sin x(\cos \omega t)$
- (c) $y = Ae^{-x^2}(Vt + \theta)$
- (d) $y = A \sin(15x - 2t)$

Question 15

(Integer type question) 2021

The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4%. will be ..... %.

Question 16

(Integer type question) 2021

A galaxy is moving away from the earth at a speed of $286\ kms^{-1}$. The shift in the wavelength of a redline at $630\ nm$ is $x \times 10^{-10}\ m$. The value of x, to the nearest integer is ..... [Take the value of speed of light c, as $3 \times 10^{8}\ ms^{-1}$]

Question 17

(Integer type question) 2021

A source and a detector move away from each other in absence of wind with a speed of $20\ m/s$ with respect to the ground. If the detector detects a frequency of $1800\ Hz$ of the sound coming from the source, then the original frequency of source considering speed of sound in air $340\ m/s$ will be ..... Hz.

Question 18

(Integer type question) 2021

Two cars are approaching each other at an equal speed of $7.2\ km/hr$. When they see each other, both blow horns having frequency of $676\ Hz$. The beat frequency heard by each driver will be ..... Hz. [Velocity of sound in air is $340\ m/s$.]

Answer 1

Solution:

$$f' = f_0\left(\frac{V + V_0}{V - V_s}\right)$$

$$f' = 1320\left(\frac{340 + 20}{340 - 10}\right)$$

$$= 1320 \times \frac{36}{35} = 1210\ Hz$$

Answer 2

Solution:

For closed organ pipe

$$f_0 = (2n + 1)\frac{v}{4l}$$

for minimum length, $n = 0$

$$f_0 = \frac{v}{4l}$$

$$\implies l = \frac{v}{4f_0}$$

$$l = \frac{340}{4 \times 250} = 34\ cm$$

Answer 3

Solution:

$$f_n = \frac{nv}{2l} = 500$$

$$f_{n+1} = \frac{(n+1)v}{2l} = 550$$

$$\frac{n+1}{n} = \frac{11}{10}$$

Thus, $n = 10$

Thus, $l = \frac{nv}{2f_n}\left(v = \sqrt{\frac{T}{\mu}}\right)$

$$= \frac{10}{2 \times 500} \times \sqrt{\frac{900}{9 \times 10^{-4}}} = 10\ m$$

Answer 4

Correct answers is A

Solution:

$$V = f\lambda, \quad \lambda = \frac{V}{f} = \frac{336}{504}$$

$$l + e = \frac{\lambda}{4}$$

$$(l + 0.3 \times 6) \times 10^{-2} = \frac{336}{4 \times 504}$$

$$l = 14.87\ cm$$

Answer 5

Solution:

$$\mu = 0.135\ g/cm = \frac{0.135 \times 10^{-3}}{10^{-2}}\ kg/m$$

$$= 135 \times 10^{-4}\ kg/m$$

$$\nu = \frac{\omega}{k} = \frac{30}{1} = 30 = \sqrt{\frac{T}{\mu}}$$

$$\implies \quad T = \mu\nu^2 = 135 \times 10^{-4} \times 900 = 1215 \times 10^{-2}\ N$$

Answer 6

Correct answers is B

Solution:
Beat frequency $|f_2 - f_1| = 5$.
So $f_2 = 335\ Hz$ or $f_2 = 445\ Hz$
Due to filling of second tuning fork. f_2 increases and according to question beat decreases. So frequency of second tuning fork is $335\ Hz$.

Answer 7

Solution:

First overtone of open pipe $= \dfrac{V_2}{L}$

First overtone of closed pipe at one end $= \dfrac{3V_1}{4L}$

$$\frac{3V_1}{4L} = \frac{V_2}{L}$$

$$\text{Use} \qquad V = \sqrt{\frac{\beta}{\rho}}$$

$$\sqrt{\frac{\beta}{\rho_1}} \cdot \frac{3}{4L} = \sqrt{\frac{\beta}{\rho_2}} \cdot \frac{1}{L}$$

$$\implies \qquad L' = \frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$$

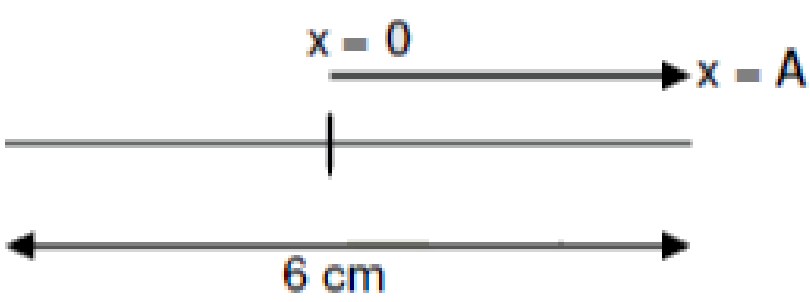
$$\therefore \qquad x = 4$$

Answer 8

Correct answers is D

Solution:

$$2A = 6\ cm, \quad \implies \quad A = 3\ cm$$



$$\omega = 2\pi f = 2\pi \times 245\ rad/s = 490\pi = 1.53 \times 10^3$$

$$K = \frac{\omega}{V} = \frac{1.53 \times 10^3}{300} = 5.1$$

Answer 9

Solution:

$x \to (x - vt)$

$$y = \frac{1}{1 + (x - vt)^2}$$

At $t = 0; y = \dfrac{1}{1 + x^2};$

At $t = 1\ sec; y = \dfrac{1}{1+(x-v)^2}$

By comparing $V = 2\ m/s$

Answer 10

Solution:

Frequency received by wall $f' = \left(\dfrac{V_s}{V_s - V}\right) f_0$

Reflected frequency received by man is $f'' = \left(\dfrac{V_s + V}{V_s}\right) f'$

$$\implies f'' = \left(\frac{V_s + V}{V_s}\right)\left(\frac{V_s}{V_s - V}\right) f_0$$

$$\implies f'' = \left(\frac{V_s + V}{V_s - V}\right) f_0$$

$$\implies 500 = \left(\frac{330 + V}{330 - V}\right) 400$$

$$\implies V = \frac{330}{9} \times \frac{18}{5} = 132\ km/hr$$

Answer 11

Correct answers is C

Solution:

$$\frac{V_{\text{rel}}}{C} = \frac{\Delta\lambda}{\lambda}$$

$$V_{\text{rel}} = \frac{6}{5890} \times 3 \times 10^8$$

$$\approx 306\ km/s$$

Answer 12

Solution:

At Node $y = 0$

$1\cos(1.57x)\sin(178.5)t = 0$

$\cos(1.57x) = 0$

$1.57x = \dfrac{\pi}{2}$

$x = 1\ cm$

Answer 13

Solution:

$\Delta\phi = kx_0 = \dfrac{2\pi}{\lambda}x_0$

$= 2\pi \times 3.5 = 7\pi$

$\left(\lambda = \dfrac{2\pi}{k} = 1\right)$

$$A_R = \sqrt{12^2 + 5^2 + 2 \times 12 \times 5 \times \cos(7\pi)}$$
$$= \sqrt{(12-5)^2} = 7$$

Answer 14

Correct answers is D

Solution:

For traveling wave the function should be in the form of

$$y = f\left(t - \frac{x}{V}\right).$$

So, (d) is the correct Answer.

Answer 15

Solution:

$$V = \sqrt{\frac{T}{\mu}}$$
$$\frac{dV}{V} = \frac{1}{2}\frac{dT}{T}$$

$$\% \text{ change in speed} = \frac{1}{2}\frac{dT}{T} \times 100$$

$$= \frac{1}{2} \times 4 = 2\%$$

Answer 16

Solution:

$$v' = v\sqrt{\frac{1 + v/c}{1 - v/c}} \qquad v << c \text{ thus}$$

$$\lambda' = \lambda\left(1 + \frac{v}{c}\right)$$

$$\lambda' - \lambda = \frac{\lambda v}{c} = \frac{630 \times 10^{-9} \times 286 \times 10^3}{3 \times 10^8}$$
$$= 210 \times 286 \times 10^{-14} = 6 \times 10^{10}$$
$$x = 6$$

Answer 17

Solution:

$$f' = f\left(\frac{V - V_0}{V + V_S}\right)$$
$$1800 = f\left(\frac{340 - 20}{340 + 20}\right)$$
$$f = \frac{1800 \times 360}{320}$$
$$f = 2050\ Hz$$

Answer 18

Solution:

$$f' = f_0\left(\frac{V - V_0}{V - V_S}\right) = 676\left(\frac{340 + 2}{340 - 2}\right) = 684$$

Beat frequency $= 684 - 676 = 8$