Waves

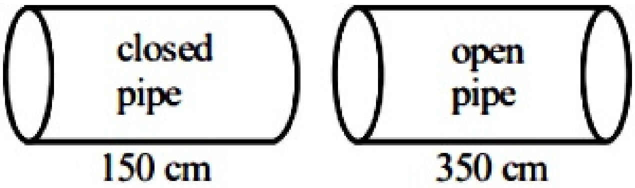
Question1

A closed organ pipe 150cm long gives 7 beats per second with an open organ pipe of length 350cm, both vibrating in fundamental mode. The velocity of sound is ____m/ s.

[27-Jan-2024 Shift 2]

Answer: 294

Solution:



$$f_c = \frac{v}{4\ell_1} \quad f_o = \frac{v}{2\ell_2}$$

$$|f_c - f_0| = 7$$

$$\frac{v}{4 \times 150} - \frac{v}{2 \times 350} = 7$$

$$\frac{v}{600\text{ cm}} - \frac{v}{700\text{ cm}} = 7$$

$$\frac{v}{6\text{m}} - \frac{v}{7\text{m}} = 7$$

$$v\left(\frac{1}{42}\right) = 7$$

$$v = 42 \times 7$$

$$= 294\text{m}/s$$

Question2

In a closed organ pipe, the frequency of fundamental note is 30Hz. A certain amount of water is now poured in the organ pipe so that the fundamental frequency is increased to 110Hz. If the organ pipe has a cross-sectional area of 2cm^2, the amount of water poured in the organ tube is ______g. (Take speed of sound in air is 330m/ s)

[30-Jan-2024 Shift 1]

Answer: 400

Solution:

$\frac{V}{4\ell_1} = 30 \Rightarrow \ell_1 = \frac{11}{4}m$

$\frac{V}{4\ell_2} = 110 \Rightarrow \ell_2 = \frac{3}{4}m$

$\Delta \ell = 2m,$

Change in volume $= A\,\Delta\ell = 400\text{cm}^3$

$M = 400g; (\because \rho = 1\text{g}/\text{cm}^3)$

Question3

A point source is emitting sound waves of intensity $16 \times 10^{-8} Wm^{-2}$ at the origin. The difference in intensity (magnitude only) at two points located at a distances of 2m and 4m from the origin respectively will be______ $\times 10^{-8} Wm^{-2}$.

[30-Jan-2024 Shift 2]

Options:

Answer: 0

Solution:

Question is wrong as data is incomplete.

Question4

The fundamental frequency of a closed organ pipe is equal to the first overtone frequency of an open organ pipe. If length of the open pipe is 60cm, the length of the closed pipe will be :

[31-Jan-2024 Shift 1]

Options:

A.

60 cm

B.

45 cm

C.

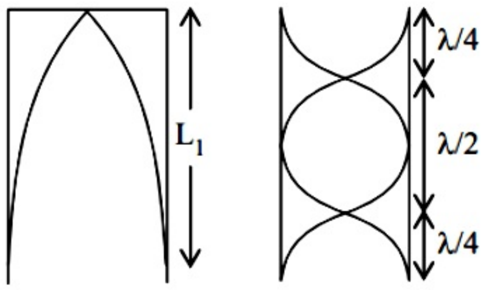
30 cm

D.

15 cm

Answer: D

Solution:



$\frac{\lambda}{4} = L_1 \quad 2\left(\frac{\lambda}{2}\right) = \lambda$

$v = f\lambda \quad f_2 = \frac{2v}{2L_2}$

$v = f_1(4L_1) \quad f_2 = \frac{v}{L_2}$

$f_1 = \frac{v}{4L_1}$

$f_1 = f_2$

$\frac{v}{4L_1} = \frac{v}{L_2}$

$\Rightarrow L_2 = 4L_1$

$60 = 4 \times L_1$

$L_1 = 15 \text{ cm}$

Question5

The speed of sound in oxygen at S.T.P. will be approximately:

(Given, $R = 8.3 JK^{-1}$, $\gamma = 1.4$)

[31-Jan-2024 Shift 2]

Options:

A.

310m/ s

B.

333m/ s

C.

341m/ s

D.

325m/ s

Answer: A

Solution:

$$v = \sqrt{\frac{\gamma RT}{M}} = \sqrt{\frac{1.4 \times 8.3 \times 273}{32 \times 10^{-3}}}$$

$$= 314.8541 \simeq 315 m/s$$

Question6

A tuning fork resonates with a sonometer wire of length 1m stretched with a tension of 6N. When the tension in the wire is changed to 54N, the same tuning fork produces 12 beats per second with it. The frequency of the tuning fork is _____Hz.

[1-Feb-2024 Shift 1]

Options:

Answer: 6

Solution:

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

$$f_1 = \frac{1}{2}\sqrt{\frac{6}{\mu}}$$

$$f_2 = \frac{1}{2}\sqrt{\frac{54}{\mu}}$$

$$\frac{f_1}{f_2} = \frac{1}{3} \qquad f_2 - f_1 = 12$$

$$f_1 = 6\,HZ$$

Question7

A travelling wave is described by the equation

$y(x, t) = [0.05 \sin(8x - 4t]m$
The velocity of the wave is : [all the quantities are in SI unit]
[24-Jan-2023 Shift 1]

Options:

A. $4ms^{-1}$

B. $2ms^{-1}$

C. $0.5ms^{-1}$

D. $8ms^{-1}$

Answer: C

Solution:

From the given equation $k = 8m^{-1}$ and $\omega = 4\,rad / s$

Velocity of wave $= \frac{\omega}{k}$

$v = \frac{4}{8} = 0.5m / s$

Question8

27. The distance between two consecutive points with phase difference of 60° in a wave of frequency $500\,Hz$ is 6.0m. The velocity with which wave is traveling is _______ km / s
[25-Jan-2023 Shift 1]

Answer: 18

Solution:

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

$\frac{\pi}{3} = \frac{2\pi}{\lambda}(6m)$

$\Rightarrow \lambda = 36m$

$V = f\lambda = (500\,Hz)(36m)$

$= 18000m / s = 18\,km / s$

Question9

Match List I with List II

List I	List II
A. Troposphere	I. Approximate 65-75 km over Earth's surface
B. E-Part of Stratosphere	II. Approximate 300 km over Earth's surface
C. F_2 – Part of Thermosphere	III. Approximate 10 km over Earth's surface
D. D-Part of Stratosphere	IV. Approximate 100 km over Earth's surface

Choose the correct answer from the options given below:
[25-Jan-2023 Shift 2]

Options:

A. A-III, B-IV, C-II, D-I

B. A-I, B-II, C-IV, D-III

C. A-I, B-IV, C-III, D-II

D. A-III, B-II, C-I, D-IV

Answer: A

Solution:

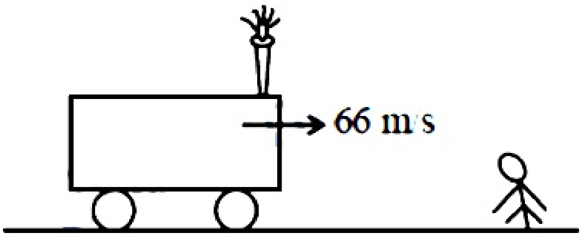
Solution:
NCERT fact based

Question10

A train blowing a whistle of frequency 320 Hz approaches an observer standing on the platform at a speed of 66m / s. The frequency observed by the observer will be (given speed of sound $= 330 ms^{-1}$) ________ Hz.
[25-Jan-2023 Shift 2]

Answer: 400

Solution:



$f_{app} = f\left(\frac{v}{v - v_S}\right)$
$= 320\left(\frac{330}{330 - 66}\right)$
$= 400\,Hz$

Question11

A person observes two moving trains, 'A' reaching the station and ' B ' leaving the station with equal speed of 30m / s. If both trains emit sounds with frequency 300 Hz, (Speed of sound : 330m / s) approximate difference of frequencies heard by the person will be :
[29-Jan-2023 Shift 1]

Options:

A. 33 Hz

B. 55 Hz

C. 80 Hz

D. 10 Hz

Answer: B

Solution:

$f_1 = 300\left(\frac{330 - 0}{330 - (-30)}\right) = 275$
$f_2 = 300\left(\frac{330 - 0}{330 - (30)}\right) = 330$
$\Delta f = 330 - 275 = 55\,Hz.$

Question12

Two simple harmonic waves having equal amplitudes of 8 cm and equal frequency of 10 Hz are moving along the same direction. The resultant amplitude is also 8 cm. The phase difference between the individual waves is degree ________.
[29-Jan-2023 Shift 1]

Answer: 120

Solution:

Solution:

$2A\cos\left(\frac{\Delta\varphi}{2}\right) = A$

$\cos\left(\frac{\Delta\varphi}{2}\right) = \frac{1}{2}$

$\frac{\Delta\varphi}{2} = 60^\circ$

Question13

The displacement equations of two interfering waves are given by
$y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$ cm,
$y_2 = 5[\sin\omega t + \sqrt{3}\cos\omega t]$ cm respectively.
The amplitude of the resultant wave is ____cm.
[31-Jan-2023 Shift 2]

Answer: 20

Solution:

Solution:

Given, $y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$ cm and

$y_2 = 5(\sin\omega t + \sqrt{3}\cos\omega t)$

$= 10\sin\left(\omega t + \frac{\pi}{3}\right)$

Thus the phase difference between the waves is 0 .

so $A = A_1 + A_2 = 20\,\text{cm}$

Question14

A steel wire with mass per unit length 7.0×10^{-3} kg m^{-1} is under tension of 70N. The speed of transverse waves in the wire will be:
[1-Feb-2023 Shift 1]

Options:

A. 200π m / s

B. 100m / s

C. 10m / s

D. 50m / s

Answer: B

Solution:

$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{70}{70 \times 10^{-3}}} = 100m/s$$

Question15

The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is :
[6-Apr-2023 shift 2]

Options:

A. 1 : 4

B. 1 : 2

C. 1 : 1

D. 4 : 1

Answer: D

Solution:

Solution:

Using $v = \sqrt{\frac{\gamma RT}{m}}$

$$\frac{U_{H_2}}{v_{O_2}} = \sqrt{\frac{m_{O_2}}{m_{H_2}}} = \sqrt{\frac{32}{2}} = \sqrt{\frac{16}{1}} = 4 : 1$$

(since both hydrogen and oxygen are di-atomic, γ will be same)

Question16

A person driving car at a constant speed of 15m / s is approaching a vertical wall. The person notices a change of 40 Hz in the frequency of his car's horn upon reflection from the wall. The frequency of horn is Hz.
[6-Apr-2023 shift 1]

$f' = f_0 + 40$

$\Rightarrow f_0\left(\frac{330+15}{330-15}\right) = f_0 + 40$

$\Rightarrow f_0 \times \frac{345}{315} = f_0 + 40$

$\Rightarrow f_0 \times \frac{30}{315} = 40$

$\Rightarrow f_0 = 40 \times \frac{315}{30} = 420\text{ Hz}$

Question17

The engine of a train moving with speed $10ms^{-1}$ towards a platform sounds a whistle at frequency 400 Hz. The frequency heard by a passenger inside the train is : (neglect air speed. Speed of sound in air $= 330ms^{-1}$)
[8-Apr-2023 shift 1]

Options:

A. 400 Hz

B. 388 Hz

C. 200 Hz

D. 412 Hz

Answer: A

Solution:

Solution:
The passenger inside the train is at rest wrt train so frequency heard by passenger inside the train is same as the source frequency i.e., 400 Hz.

Question18

An organ pipe 40 cm long is open at both ends. The speed of sound in air is $360ms^{-1}$. The frequency of the second harmonic is ________ Hz.
[8-Apr-2023 shift 1]

Solution:

Open organ pipe $\ell = 40\text{ cm}$
Speed of sound $v = 360m/s$
Frequency of second harmonics $f_2 = \frac{2v}{2\ell}$

$f_2 = \frac{v}{\ell} \Rightarrow f_2 = \frac{360}{0.4}$

$f_2 = 900\text{ Hz}$

Question19

A guitar string of length 90 cm vibrates with a fundamental frequency of 120 Hz. The length of the string producing a fundamental frequency of 180 Hz will be ________ cm.
[8-Apr-2023 shift 2]

Answer: 60

Solution:

$$f = \frac{V}{2L} \text{ (Fundamental Frequency)}$$

$$120 = \frac{V}{2L} \ldots (1)$$

$$180 = \frac{V}{2L'} \ldots (2)$$

$$\frac{L'}{L'} = \frac{120}{180}$$

$$L' = \frac{2}{3} \times 90$$

$$L' = 60\,\text{cm}$$

Question20

A transverse harmonic wave on a string is given by
y(x, t) = 5sin (6t + 0.003x)
where x and y are in cm and t in sec. The wave velocity is _______ ms^{-1}.
[10-Apr-2023 shift 1]

Answer: 20

Solution:

$$v = \frac{w}{k} = \frac{6}{.003 \times 10^2} = \frac{6}{.3} = \frac{60}{3} = 20m/\ s$$

Question21

The equation of wave is given by $Y = 10^{-2}\sin 2\pi(160t - 0.5x + \pi / 4)$ where x and Y are in m and t in s. The speed of the wave is ________ $km\,h^{-1}$.
[11-Apr-2023 shift 1]

Solution:

$Y = 10^{-2}\sin 2\pi(160t - 0.5x + \pi / 4)$

Speed of wave $= \frac{w}{k} = \frac{160}{0.5} = 320m / sec = 320 \times \frac{18}{5} = 1152\,km / h$ Ans.

Question22

A car P travelling at $20ms^{-1}$ sounds its horn at a frequency of 400 Hz. Another car Q is travelling behind the first car in the same direction with a velocity $40ms^{-1}$. The frequency heard by the passenger of the car Q is approximately [Take, velocity of sound $= 360ms^{-1}$]
[11-Apr-2023 shift 2]

Options:

A. 471 Hz

B. 514 Hz

C. 421 Hz

D. 485 Hz

Answer: C

Solution:

Solution:
$V_c = 20ms^{-1}$
$f = 400\,Hz$

$f_{app} = \left[\frac{V_S - (-V_Q)}{V_S - (-V_p)} \right] f$

$= \left(\frac{360 + 40}{360 + 20} \right) \times 400 = \frac{400}{380} \times 400 = 421\,Hz$

Ans. (3)

Question23

A wire of density $8 \times 10^3\,kg / m^3$ is stretched between two clamps 0.5m apart. The extension developed in the wire is 3.2×10^{-4}m. If $Y = 8 \times 10^{10} N / m^2$, the fundamental frequency of vibration in the wire will be ________ Hz.
[11-Apr-2023 shift 2]

Solution:

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

$f = \frac{1}{\ldots}\sqrt{\frac{YA\,\Delta\ell}{\ldots}}$

$f = \frac{1}{2 \times 0.5}\sqrt{\frac{8 \times 10^{10} \times 3.2 \times 10^{-4}}{8 \times 10^3 \times 0.5}}$

$f = \frac{1}{1}\sqrt{6400}$

$f = 80\,Hz$

Question24

For a certain organ pipe, the first three resonance frequencies are in the ratio of 1 : 3 : 5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is $324ms^{-1}$ the length of the organ pipe is ________ m
[12-Apr-2023 shift 1]

Answer: 1

Solution:

Solution:
Resonance frequency in closed organ pipe

$f = (2n + 1)\frac{V}{4\ell}$

Given is 5^{th} harmonic

So $5\frac{V}{4\ell} = 405$

$\frac{5 \times 324}{4 \times 405} = \ell$

$\ell = 1m$

Question25

In an experiment with sonometer when a mass of 180g is attached to the string, it vibrates with fundamental frequency of 30 Hz. When a mass m is attached, the string vibrates with fundamental frequency of 50 Hz. The value of m is _______ g.
[13-Apr-2023 shift 2]

Solution:

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

$$\frac{f_2}{} = \sqrt{\frac{T_2}{}}$$

1

$$\left(\frac{50}{30}\right)^2 = \frac{mg}{180g}$$

$$m = \frac{25}{9} \times 180 = 500 \text{ gram}$$

Question26

The fundamental frequency of vibration of a string stretched between two rigid support is 50 Hz. The mass of the string is 18g and its linear mass density is 20g / m. The speed of the transverse waves so produced in the string is ______ ms^{-1}
[15-Apr-2023 shift 1]

Answer: 90

Solution:

$$\mu = \frac{m}{\ell} = 20\,\text{gm / m}$$

$$\frac{18\,\text{gm}}{\ell} = 20\,\text{gm / m}$$

$$\ell = \frac{9}{10}\text{m}$$

For fundamental mode,

$$f = \frac{V}{2\ell}$$

$$V = 50 \times \frac{18}{10} = 90\text{m / s}$$

Question27

The equations of two waves are given by:
$y_1 = 5 \sin 2\pi(x - vt)$ cm
$y_2 = 3 \sin 2\pi(x - vt + 1.5)$ cm
These waves are simultaneously passing through a string. The amplitude of the resulting wave is:
[24-Jun-2022-Shift-1]

Options:

A. 2 cm

B. 4 cm

C. 5.8 cm

D. 8 cm

Answer: A

Solution:

$2\pi x - 2\pi vt)$
$y_2 = 3 \sin(2\pi x - 2\pi vt + 3\pi)$
$\Rightarrow$ Phase difference $= 3\pi$
$\Rightarrow A_{net} = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos(3\pi)}$
$\Rightarrow A_{net} = 2$ cm

Question28

Two light beams of intensities in the ratio of 9 : 4 are allowed to interfere. The ratio of the intensity of maxima and minima will be :
[24-Jun-2022-Shift-2]

Options:

A. 2 : 3

B. 16 : 81

C. 25 : 169

D. 25 : 1

Answer: D

Solution:

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{I_1} + \sqrt{I_2}}{\sqrt{I_1} - \sqrt{I_2}} \right)^2 = \left(\frac{5}{1} \right)^2$$
$$= \frac{25}{1}$$

Question29

Two travelling waves of equal amplitudes and equal frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by $y = \left(10 \cos \pi x \sin \frac{2\pi t}{T}\right)$ cm
The amplitude of the particle at $x = \frac{4}{3}$ cm will be _____cm.
[24-Jun-2022-Shift-2]

Solution:

$A = |10 \cos(\pi x)|$
At $x = \frac{4}{3}$
$A = \left| 10 \cos\left(\pi \times \frac{4}{3}\right) \right|$
$= |-5 \text{ cm}|$
$\therefore$ Amp $= 5$ cm

Question30

The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is 20 cm. The length of the open organ pipe is ______cm.
[25-Jun-2022-Shift-1]

Answer: 80

Solution:

Solution:
$2 \times \left(\frac{V}{2L_0} \right) = \left(\frac{V}{4L_c} \right)$
$\Rightarrow L_0 = 4L_c$
$= 4 \times 20$

$= 80\,\text{cm}$

Question31

A set of 20 tuning forks is arranged in a series of increasing frequencies. If each fork gives 4 beats with respect to the preceding fork and the frequency of the last fork is twice the frequency of the first, then the frequency of last fork is _____ Hz
[26-Jun-2022-Shift-2]

Answer: 152

Solution:

Given $v_{20} = 2v_1$
Also $v_{20} = 4 \times 19 + v_1$
So $v_{20} = 152\,\text{Hz}$

Question32

An observer moves towards a stationary source of sound with a velocity equal to one-fifth of the velocity of sound. The percentage change in the frequency will be:
[27-Jun-2022-Shift-1]

Options:

A. 20%

B. 10%

C. 5%

D. 0%

Answer: A

Solution:

$$f' = f_0 \left[\frac{v - v_0}{v - v_s} \right]$$

$$\Rightarrow f' = f_0 \left[\frac{v + \frac{v}{5}}{v} \right]$$

$$\Rightarrow f' = \frac{6f_0}{5}$$

$\Rightarrow \%\ \text{change} = 20$

Question33

If a wave gets refracted into a denser medium, then which of the following is true?
[27-Jun-2022-Shift-2]

Options:

A. wavelength, speed and frequency decreases.

B. wavelength increases, sped decreases and frequency remains constant.

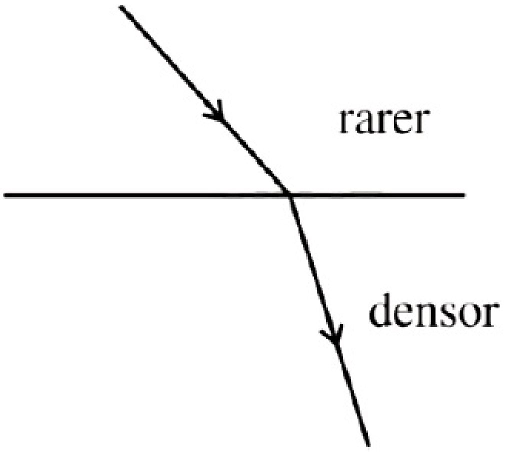
C. wavelength and speed decreases but frequency remains constant.

D. wavelength, speed and frequency increases.

Answer: C

Solution:

Solution:
Frequency is independent of medium. For denser medium, wavelength and speed both would decrease.



No change in frequency but speed and wave-length decreases.

Question34

A radar sends an electromagnetic signal of electric field $(E_0) = 2.25 V/m$ and magnetic field $(B_0) = 1.5 \times 10^{-8} T$ which strikes a target on line of sight at a distance of 3 km in a medium. After that, a part of signal (echo) reflects back towards the radar with same velocity and by same path. If the signal was transmitted at time t = 0 from radar, then after how much time echo will reach to the radar?
[28-Jun-2022-Shift-1]

Options:

A. $2.0 \times 10^{-5} s$

B. 4.0×10^{-5}s

C. 1.0×10^{-5}s

D. 8.0×10^{-5}s

Answer: B

Solution:

$E_0 = 2.25 V/m$
$B_0 = 1.5 \times 10^{-8} T$
$\Rightarrow \frac{E_0}{B_0} = 1.5 \times 10^8 m/s$
$\Rightarrow$ Refractive index $= 2$
Distance to be travelled $= 6$ km
Time taken $= \frac{6 \times 10^3}{1.5 \times 10^8} = 4 \times 10^{-5}$ s

----

Question35

The velocity of sound in a gas, in which two wavelengths 4.08m and 4.16m produce 40 beats in 12s, will be :
[28-Jun-2022-Shift-1]

Options:

A. $282.8 ms^{-1}$

B. $175.5 ms^{-1}$

C. $353.6 ms^{-1}$

D. $707.2 ms^{-1}$

Answer: D

Solution:

Solution:
$\frac{v}{4.08} - \frac{v}{4.16} = \frac{40}{12}$
$v = \frac{40}{12} \times \frac{4.08 \times 4.16}{0.08}$
$= 707.2 m/s$

Question36

A tunning fork of frequency 340 Hz resonates in the fundamental mode with an air column of length 125 cm in a cylindrical tube closed at one end. When water is slowly poured in it, the minimum height of water required for observing resonance once again is _____cm.

(Velocity of sound in air is $340 ms^{-1}$)
[28-Jun-2022-Shift-2]

Solution:

Solution:
Given $340 = \frac{n}{4 \times 125} v$
$\Rightarrow n = 5$
So $\lambda = 100 \text{ cm}$
So minimum height is $\frac{\lambda}{2} = 50 \text{ cm}$

Question37

A longitudinal wave is represented by $x = 10 \sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm. The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to:
[29-Jun-2022-Shift-1]

Options:

A. 2π

B. 5π

C. π

D. $\frac{5\pi}{2}$

Answer: B

Solution:

Solution:
Particle velocity $= \frac{\partial x}{\partial t}$
$\Rightarrow$ Maximum particle velocity $= (2\pi n)(10)$
$\Rightarrow (2\pi n)(10) = (n\lambda)(4)$
$\Rightarrow \lambda = 5\pi$

Question38

In an experiment to determine the velocity of sound in air at room temperature using a resonance tube, the first resonance is observed

when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is $336 ms^{-1}$. The third resonance is observed when the air column has a length of ___cm.
[29-Jun-2022-Shift-2]

4

Solution:

$$400 = \frac{v}{4(L_1 + e)} \text{..... (i)}$$

$$400 = \frac{5v}{4(L_2 + e)} \text{..... (ii)}$$

$$\Rightarrow L_1 + e = \frac{\lambda}{4} = 21 \text{ cm}$$

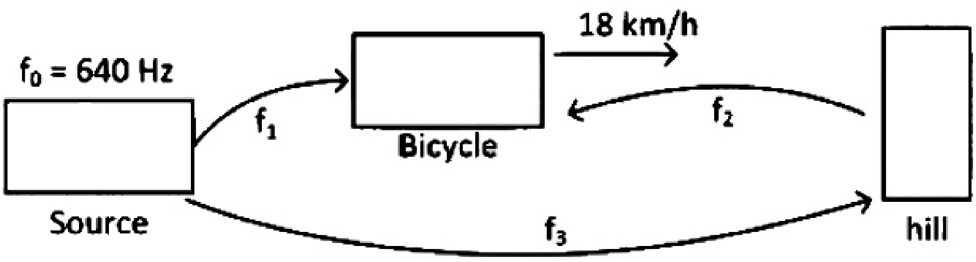
$$L_2 + e = \frac{5\lambda}{4} = 105 \text{ cm}$$

$$\Rightarrow e = 1 \text{cm} \& L_2 = 104 \text{ cm}$$

Question39

An observer is riding on a bicycle and moving towards a hill at $18 kmh^{-1}$. He hears a sound from a source at some distance behind him directly as well as after its reflection from the hill. If the original frequency of the sound as emitted by source is 640H z and velocity of the sound in air is 320m / s, the beat frequency between the two sounds heard by observer will be H z.
[25-Jul-2022-Shift-1]

Answer: 20



$f_1 = f_0\left(\frac{320-5}{320}\right) = 640\left(\frac{315}{320}\right)$
$= 630Hz$
$f_3 = f_0$[No relative motion]
$f_2 = f_0\left[\frac{320+5}{320}\right] = 640\left(\frac{325}{320}\right)$
$= 650$
Beat frequency $= f_2 - f_1$
$= 650 - 630 = 20Hz$

Question40

When a car is approaching the observer, the frequency of horn is 100 Hz. After passing the observer, it is 50 Hz. If the observer moves with the car, the frequency will be $\frac{x}{3}$ Hz where x = __________.
[26-Jul-2022-Shift-1]

Answer: 200

Solution:

$$100 = v_0 \frac{v}{v - v_c}$$

$$50 = v_0 \frac{v}{v + v_c}$$

$$2 = \frac{v + v_c}{v - v_c}$$

$$2v - 2v_c = v + v_c$$

$$v_c = \frac{v}{3}$$

$$100 = v_0 \frac{v \times 3}{2v} \Rightarrow v_0 = \frac{200}{3} = \frac{x}{3}$$

$$\Rightarrow x = 200$$

Question41

A transverse wave is represented by $y = 2\sin(\omega t - kx)$ cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the

maximum particle velocity, will be :
[26-Jul-2022-Shift-2]

Options:

A. 4π

B. 2π

C. π

D. 2

Answer: A

Solution:

$- kx)$
article velocity $= A\omega$

Wave velocity $= \frac{\omega}{k}$

$\frac{\omega}{k} = A\omega$

$k = \frac{1}{A} = \frac{2\pi}{\lambda}$

$\lambda = 2\pi A$

$= 4\pi \text{ cm}$

Question42

A wire of length 30 cm, stretched between rigid supports, has it's n^{th} and $(n+1)^{th}$ harmonics at 400 Hz and 450 Hz, respectively. If tension in the string is 2700N, it's linear mass density is _________ kg / m.
[27-Jul-2022-Shift-2]

Solution:

$\frac{nv}{0.6} = 400 \& \frac{(n+1)v}{0.6} = 450$

$\Rightarrow \left[\frac{0.6 \times 400}{v} + 1\right] \frac{v}{0.6} = 450$

$\Rightarrow = v = 30$

$\Rightarrow \sqrt{\frac{T}{\mu}} = 30$

$\Rightarrow \frac{2700}{\mu} = 900 = \mu = 3$

Question43

In the wave equation $y - 0.5 \sin \frac{2\pi}{\lambda}(400t - x)m$ the velocity of the wave will be:
[28-Jul-2022-Shift-1]

Options:

A. $200m / s$

B. $200\sqrt{2}m / s$

C. $400m / s$

D. $400\sqrt{2}m / s$

Answer: C

Solution:

Solution:

$y = 0.5 \sin\left(\frac{2\pi}{\lambda}400t - \frac{2\pi}{\lambda}x\right)$

$\omega = \frac{2\pi}{\lambda}400$

$K = \frac{2\pi}{\lambda}$

$v = \frac{\omega}{k}$ [$v = 400m / s$]

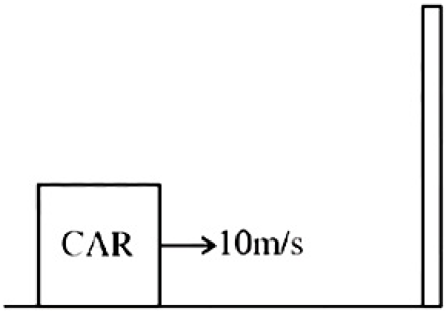
Question44

The frequency of echo will be _______ Hz if the train blowing a whistle of frequency 320 Hz is moving with a velocity of 36 km / h towards a hill from which an echo is heard by the train driver. Velocity of sound in air is 330m / s.
[28-Jul-2022-Shift-1]

Answer: 340

Solution:

Solution:
The hill will be a secondary source



f_1 = frequency of the car w.r.t. the hill

$f_1 = \left(\frac{v}{v - v_s}\right) f = \left(\frac{330}{320}\right) \times 320 = 330\,\text{Hz}$

f_2 = Frequency of the sound reflected by hill w.r.t. the car (echo)

$f_2 = \left(\frac{v + v_0}{v}\right) f_1 = \frac{(330 + 10)}{330} \times 330 = 340\,\text{Hz}$

Question45

Two light beams of intensities 4I and 9I interfere on a screen. The phase difference between these beams on the screen at point A is zero and at point B is π. The difference of resultant intensities, at the point A and B, will be ________ I.
[29-Jul-2022-Shift-1]

Answer: 24

Solution:

Solution:

$I_A = (\sqrt{I_1} + \sqrt{I_2})^2 = 25I$

$I_B = (\sqrt{I_1} - \sqrt{I_2})^2 = I$

So, $I_A - I_B = 24I$

Question46

The speed of a transverse wave passing through a string of length 50 cm and mass 10g is $60ms^{-1}$. The area of cross-section of the wire is $2.0mm^2$ and its Young's modulus is $1.2 \times 10^{11}Nm^{-2}$. The extension of the wire over its natural length due to its tension will be $x \times 10^{-5}m$. The value of x is _______.
[29-Jul-2022-Shift-2]

Solution:

$V_w = \sqrt{\frac{T}{\mu}}$

$60 = \sqrt{\frac{T}{10 \times 10^{-3}} \times 0.5}$

$T = \frac{(60)^2 \times 10^{-2}}{0.5} = 72N$

$\Delta\ell = \frac{F\ell}{AY} = \frac{72 \times 0.5}{2 \times 10^{-6} \times 1.2 \times 10^{11}}$

$= \frac{72 \times 5}{24} \times 10^{-5} = 15 \times 10^{-5}$

Question47

The mass per unit length of a uniform wire is 0.135g / cm. A transverse wave of the form $y = -0.21\sin(x + 30t)$ is produced in it, where x is in metre 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)
[26 Feb 2021 Shift 1]

Solution:

Solution:
Given, mass per unit length, $\mu = 0.135g / cm$
Transverse wave equation, $y = -0.21\sin(x + 30t)$
From given equation, $\omega = 30rad\ / s, k = 1$
Speed of wave, $v = \frac{\omega}{k} = \frac{30}{1} = 30ms^{-1}$
Also, $v = \sqrt{\frac{T}{\mu}}$
$\Rightarrow T = v^2\mu$
$T = (30)^2 \times \frac{0.135 \times 10^{-3}}{10^{-2}}$
$= 900 \times 0.0135$
$= 12.15N$
$= 1215 \times 10^{-2}N$
Hence, $x = 1215$

Question48

Which of the following equations represents a travelling wave?
[24 Feb 2021 Shift 2]

Options:

A. $y = A\sin(15x - 2t)$

B. $y = Ae^{-x^2}(vt + \theta)$

C. $y = Ae^{x}\cos(\omega t - \theta)$

D. $y = A\sin x \cos \omega t$

Answer: A

Solution:

Solution:
The equation of a travelling wave in standard form,
$y = A\sin(\omega t \pm kx)$
Only option (a), i.e. $y = A\sin(15x - 2t)$ satisfies this equation.

Question49

A tuning fork A of unknown frequency produces 5 beats/s with a fork of known frequency 340Hz. When fork A is filled, the beat frequency decreases to 2 beats\/s. What is the frequency of fork A ? [26 Feb 2021 Shift 2]

Options:

A. 342Hz

B. 345Hz

C. 335Hz

D. 338Hz

Answer: C

Solution:

340Hz
Let beat frequency of tuning fork A is f_A
and f_A' be the frequency of tuning fork A after filling.
In first case, beat frequency $= 5$
$\Rightarrow f_A = 340 \pm 5$
$\Rightarrow f_A = 345\text{Hz}$ or 335Hz
After filling tuning fork A, $f_A' = 340 \pm 2$
$\Rightarrow f_A' = 342$ or 338Hz
As on filling, frequency of A increases.
Hence, original frequency of tuning fork A is 335Hz.

Question50

Two cars are approaching each other at an equal speed of 7.2km / h. When they see each other, both blow horns having frequency of 676Hz. The beat frequency heard by each driver will be .... Hz.

[Velocity of sound in air is 340m / s.]
[24 Feb 2021 Shift 2]

Solution:

Given, $v_A = v_B = 7.2 kmh^{-1}$
$= \frac{72}{10} \times \frac{5}{18} = 2 ms^{-1}$
y of source, $f_s = 676 Hz$
Speed of sound in air, $v = 340 ms^{-1}$
Let f_0 be the frequency heard by each driver.
By using Doppler effect for A,
$(v - v_A) f_s = (v + v_B) f_0$
$\Rightarrow f_0 = \left(\frac{v + v_A}{v - v_B}\right) f_s = \left(\frac{340 + 2}{340 - 2}\right) 676 = \frac{342}{338} \times 676 = 684 Hz$
Now, beat frequency $= f_0 - f_s = 684 - 676 = 8 Hz$

Question51

A sound wave of frequency 245Hz travels with the speed of $300 ms^{-1}$ along the positive X -axis. Each point of the wave moves to and from through a total distance of 6cm. What will be the mathematical expression of this travelling wave?
[17 Mar 2021 Shift 2]

Options:

A. $y(x, t) = 0.03[\sin 5.1 x - (0.2 \times 10^3) t]$

B. $y(x, t) = 0.06[\sin 5.1 x - (1.5 \times 10^3) t]$

C. $y(x, t) = 0.06[\sin 0.8 x - (0.5 \times 10^3) t]$

D. $y(x, t) = 0.03[\sin 5.1 x - (1.5 \times 10^3) t]$

Answer: D

Solution:

Given,
The frequency of the sound wave, $f = 245 Hz$
The speed of the travelling wave, $v = 300 m / s$
As, total distance of to and fro motion is 6cm.
Hence, the amplitude of the wave,
$A = 6 / 2 = 3 cm = 0.03 m$
As we know,
Angular frequency is given as
$\omega = 2\pi f$
Substituting the value of f, we get

$\omega = 2\pi(245)$
$\omega = 1.54 \times 10^3 \text{rad} \ / \ s$
Propagation constant is given as
$k = \frac{\omega}{v}$
Substituting the value of v and ω, we get
$k = \frac{1.54 \times 10^3}{300} \Rightarrow k = 5.1 m^{-1}$
General mathematical expression for a travelling wave is given as
$y = A \sin(kx - \omega t)$
Substituting the values in the above equation, we get
$y = 0.03 \sin(5.1x - 1.5 \times 10^3 t)$

Question52

A closed 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)
[16 Mar 2021 Shift 2]

Answer: 4

Solution:

Solution:
First overtone of open pipe $= \frac{V_2}{L_2}$
First overtone of closed pipe at one end $= \frac{3v}{4L}$
As per question,
$\frac{3V}{4L} = \frac{V_2}{L}$
$\Rightarrow \sqrt{\frac{B}{\rho_1}} \cdot \frac{3}{4L} = \sqrt{\frac{B}{\rho_2}} \cdot \frac{1}{L_2} \qquad \left(\because V = \sqrt{\frac{B}{\rho}}\right)$
$\Rightarrow L_2 = \frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$....(i)
According to question, the length of the open pipe is
$\frac{x}{3}L\sqrt{\frac{\rho_1}{\rho_2}}$....(ii)
Comparing Eqs. (i) and (ii), we get
$x = 4$

Question53

The difference in the number of waves when yellow light propagates

through air and vacuum columns of the same thickness is one. The thickness of the air column is ______ mm.
[Refractive index of air = 1.0003, wavelength of yellow light in vacuum = 6000 Å]
[27 Jul 2021 Shift 2]

Answer: 2

Solution:

Solution:
Thickness $t = n\lambda$
So, $n\, \lambda_{vac} = (n+1)\lambda_{air}$
$n\,\lambda = (n+1)\dfrac{\lambda}{\mu_{air}}$
$n = \dfrac{1}{\mu_{air} - 1} = \dfrac{10^4}{3}$
$t = n\lambda$
$= \dfrac{10^4}{3} \times 6000 Å$
$= 2mm$

Question54

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 = 1s, where x and y are in meres. The shape of wave does not change during the propagation. The velocity of the wave will be ____m / s.
[20 Jul 2021 Shift 1]

Solution:

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

At time $t = t,\ y = \dfrac{1}{1+(x-vt)^2}$

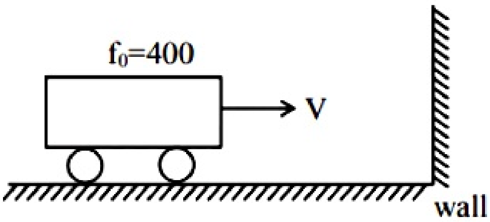
At $t = 1,\ y = \dfrac{1}{1+(x-v)^2}$ ....(i)

At $t = 1,\ y = \dfrac{1}{1+(x-2)^2}$ ....(ii)

Comparing (i) & (ii)
$v = 2m / s$

Question55

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 _____ km/h.



[20 Jul 2021 Shift 1]

Answer: 132

Solution:

Solution:
Wall as an observer
Frequency received by wall

$$f_1 = f_0\left(\frac{C}{C-V}\right)$$

Again wall as a source
Frequency received by observer on car

$$f_2 = f_1\left(\frac{C+V}{C}\right)$$

$$f_2 = f_0\left(\frac{C+V}{C-V}\right)$$

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

$$\frac{5}{4} = \frac{C+V}{C-V}$$

$$C = 9V$$

$$V = \frac{C}{9} = \frac{330}{9}\text{m / s}$$

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

Question56

A one metre long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air at STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is _____ Hz.
[NA 8 Jan. 2020 (I)]

Solution:

Solution:
Given :
$V_{air} = 300m/s, \rho_{gas} = 2\rho$ air
Using, $V = \sqrt{\frac{B}{\rho}}$
$$\frac{V_{gas}}{V_{air}} = \frac{\sqrt{\frac{B}{2\rho_{air}}}}{\sqrt{\frac{B}{\rho_{air}}}}$$
$$\Rightarrow V_{gas} = \frac{V_{air}}{\sqrt{2}} = \frac{300}{\sqrt{2}} = 150\sqrt{2}m/s$$
And f_{nth} harmonic $= \frac{nv}{2L}$ (in open organ pipe)
($L = 1$ metre given)
$$\therefore f_{2nd} \text{ harmonic} - f_{fundamental} = \frac{2v}{2 \times 1} - \frac{v}{2 \times 1} = \frac{v}{2}$$
$$\therefore f_{2n} \text{ harmonic} - f_{fundamental} = \frac{150\sqrt{2}}{2} = \frac{150}{\sqrt{2}} \approx 106Hz$$

Question57

A transverse wave travels on a taut steel wire with a velocity of v when tension in it is 2.06×10^4N . When the tension is changed to T , the velocity changed to $\frac{v}{2}$. The value of T is close to:
[8 Jan. 2020 (II)]

Options:

A. 2.50×10^4N

B. 5.15×10^3N

C. 30.5×10^4N

D. 10.2×10^2N

Answer: B

Solution:

Solution:
The velocity of a transverse wave in a stretched wire is given by
$$v = \sqrt{\frac{T}{\mu}}$$
Where, T = Tension in the wire
μ = linear density of wire
$(\because V \propto T)$
$$\therefore \frac{v_1}{v_2} = \sqrt{\frac{T_1}{T_2}}$$
$$\Rightarrow \frac{v}{v} \times 2 = \sqrt{\frac{2.06 \times 10^4}{T_2}}$$
$$\Rightarrow T_2 = \frac{2.06 \times 10^4}{4} = 0.515 \times 10^4 N$$
$$\Rightarrow T_2 = 5.15 \times 10^3 N$$

Question58

Speed of a transverse wave on a straight wire (mass 6.0 g, length 60cm and area of cross-section $1.0 mm^2$) is 90 ms^{-1}. If the Young's modulus of wire is $16 \times 10^{11} N\, m^{-2}$ the extension of wire over its natural length is:
[7 Jan. 2020 (I)]

Options:

A. 0.03 mm

B. 0.02 mm

C. 0.04 mm

D. 0.01 mm

Answer: A

Solution:

Solution:
Given, $l = 60cm$, $m = 6g$, $A = 1mm^2$, $v = 90m/s$ and $Y = 16 \times 10^{11} N\, m^{-2}$
Using, $v = \sqrt{\frac{T}{m} \times l} \Rightarrow T = \frac{mv^2}{l}$
Again from, $Y = \frac{T}{A} \Delta L / L_0$
$\Delta L = \frac{T l}{Y A} = \frac{mv^2 \times l}{l (Y A)}$
$= \frac{6 \times 10^{-3} \times 90^2}{16 \times 10^{11} \times 10^{-6}} = 3 \times 10^{-4} m$
$= 0.03mm$

Question59

A wire of length L and mass per unit length $6.0 \times 10^{-3} kgm^{-1}$ is put under tension of 540 N. Two consecutive frequencies that it resonates at are: 420 Hz and 490 Hz.
Then L in meters is:
[9 Jan. 2020 (II)]

Options:

A. 2.1 m

B. 1.1 m

C. 8.1 m

D. 5.1 m

Answer: A

Solution:

Solution:
Fundamental frequency, f = 70 Hz.
The fundamental frequency of wire vibrating under tension T is given by
$f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$
Here, μ = mass per unit length of the wire
L = length of wire
$70 = \frac{1}{2L}\sqrt{\frac{540}{6 \times 10^{-3}}}$
$\Rightarrow L \approx 2.14m$

Question60

There harmonic waves having equal frequency v and same intensity I_0, have phase angles 0, $\frac{\pi}{4}$ and $-\frac{\pi}{4}$ respectively. When they are superimposed the intensity of the resultant wave is close to:
[9 Jan. 2020 I]

Options:

A. $5.8I_0$

B. $0.2I_0$

C. $3I_0$

D. I_0

Answer: A

Solution:

Question61

A stationary observer receives sound from two identical tuning forks, one of which approaches and the other one recedes with the same speed (much less than the speed of sound). The observer hears 2 beats/sec. The oscillation frequency of each tuning fork is v_0 = 1400 Hz and the velocity of sound in air is 350 m/s. The speed of each tuning fork is close to:
[7 Jan. 2020 I]

Options:

A. $\frac{1}{2}m / s$

B. $1 m / s$

C. $\frac{1}{4} m / s$

D. $\frac{1}{8} m / s$

Answer: C

Solution:

Solution:
From Doppler's effect, frequency of sound heard (f_1) when source is approaching

$$f_1 = f_0 \frac{c}{c - v}$$

Beat frequency $= f_1 - f_2$

$$\Rightarrow 2 = f_1 - f_2 = f_0 c \left[\frac{1}{c - v} - \frac{1}{c + v} \right]$$

$$= f_0 c \frac{2v}{c^2 \left[1 - \frac{v^2}{c^2} \right]}$$

For c > > v

$$\Rightarrow v = \frac{2c}{2f_0} = \frac{c}{f_0} = \frac{350}{1400} = \frac{1}{4} m / s$$

Question62

Assume that the displacement (s) of air is proportional to the pressure difference (Δp) created by a sound wave. Displacement (s) further depends on the speed of sound(v), density of air (ρ) and the frequency (f). If Δp~ 10Pa, v ~ 300m / s, ρ ~ 1kg / m³ and f ~ 1000Hz, then s will be of the order of (take the multiplicative constant to be 1)
[Sep. 05, 2020 (I)]

Options:

A. $\frac{3}{100} mm$

B. $10 mm$

C. $\frac{1}{10} mm$

D. $1 mm$

Answer: A

Solution:

As we know

de, $\Delta P_0 = aKB = S_0 KB = S_0 \times \omega V \times \rho V^2$

$$\left[\because K = \frac{\omega}{V}, V = \sqrt{\frac{B}{\rho}} \right]$$

$$\Rightarrow S_0 = \frac{\Delta P_0}{\rho V \omega} \approx \frac{10}{1 \times 300 \times 1000} m = \frac{1}{30} mm \approx \frac{3}{100} mm$$

Question63

For a transverse wave travelling along a straight line, the distance between two peaks (crests) is 5m, while the distance between one crest and one trough is 1.5m. The possible wavelengths (in m) of the waves are :
[Sep. 04, 2020 (I)]

Options:

A. 1, 3, 5, ...

B. $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \ldots\ldots$

C. 1, 2, 3, ...

D. $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, \ldots\ldots$

Answer: B

Solution:

Solution:
Given : Distance between one crest and one trough $= 1.5\mathrm{m}$
$= (2n_1 + 1)\frac{\lambda}{2}$
Distance between two crests $= 5\mathrm{m} = n_2\lambda$
$\frac{1.5}{5} = \frac{(2n_1 + 1)}{2n_2} \Rightarrow 3n_2 = 10n_1 + 5$
Here n_1 and n_2 are integer.
If
$n_1 = 1, \quad n_2 = 5 \quad \therefore \lambda = 1$
$n_1 = 4, \quad n_2 = 15 \quad \therefore \lambda = 1/3$
$n_1 = 7, \quad n_2 = 25 \quad \therefore \lambda = 1/5$
Hence possible wavelengths $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}$ metre.

Question64

In a resonance tube experiment when the tube is filled with water up to a height of 17.0 cm from bottom, it resonates with a given tuning fork. When the water level is raised the next resonance with the same tuning fork occurs at a height of 24.5 cm. If the velocity of sound in air is 330 m/s, the tuning fork frequency is :
[Sep. 05, 2020 (I)]

Options:

A. 2200 Hz

B. 550 Hz

C. 1100 Hz

D. 3300 Hz

Answer: A

Solution:

Solution:
Here, $l_1 = 17\text{cm}$ and $l_2 = 24.5\text{cm}$, $V = 330\text{m / s}$
$f = ?$
$\lambda = 2(l_2 - l_1) = 2 \times (24.5 - 17) = 15\text{cm}$
Now, from $v = f\lambda \Rightarrow 330 = \lambda \times 15 \times 10^{-2}$
$\therefore \lambda = \frac{330}{15} \times 100 = \frac{1100 \times 100}{5} = 2200\text{Hz}$

Question65

A uniform thin rope of length 12 m and mass 6 kg hangs vertically from a rigid support and a block of mass 2 kg is attached to its free end. A transverse short wave-train of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wave train (in cm) when it reaches the top of the rope ?
[Sep. 03, 2020 (I)]

Options:

A. 3

B. 6

C. 12

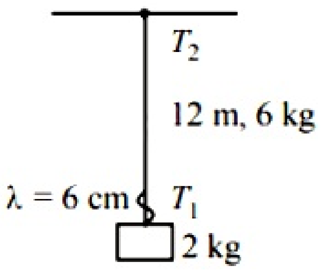
D. 9

Answer: C

Solution:

Using, $V = f\lambda$

λ_1 λ_2 $\frac{V_2}{V_1}\lambda_1$



Again using,

$n = \frac{V}{\lambda} = \sqrt{\frac{T}{M}}\lambda_2 = \sqrt{\frac{T_2}{T_1}}\lambda_1$ $T_2 = 8g(\text{ Top })$

$= \sqrt{\frac{8g}{2g}}\lambda_1 = 2\lambda_1 = 12\text{cm}$ $T_1 = 2g(\text{ Bottom })$

Question66

Two identical strings X and Z made of same material have tension T_X and T_Z in them. If their fundamental frequencies are $450 Hz$ and $300 Hz$, respectively, then the ratio T_X / T_Z is:
[Sep. 02, 2020 (I)]

Options:

A. 2.25

B. 0.44

C. 1.25

D. 1.5

Answer: A

Solution:

Solution:
Using $f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$
where, T = tension and $\mu = \frac{\text{mass}}{\text{length}}$
$f_x = \frac{1}{2l}\sqrt{\frac{T_x}{\mu}}$ and $f_z = \frac{1}{2l}\sqrt{\frac{T_z}{\mu}}$
$\frac{f_x}{f_z} = \frac{450}{300} = \sqrt{\frac{T_x}{T_z}}$
$\therefore \frac{T_x}{T_z} = \frac{9}{4} = 2.25$

Question67

A wire of density $9 \times 10^{-3} kg cm^{-3}$ is stretched between two clamps 1m apart. The resulting strain in the wire is 4.9×10^{-4}. The lowest frequency of the transverse vibrations in the wire is (Young's modulus of wire $Y = 9 \times 10^{10} N m^{-2}$), (to the nearest integer),__________.
[Sep. 02,2020 (II)]

Solution:

Solution:
Given,

Denisty of wire, $\sigma = 9 \times 10^{-3} kgcm^{-3}$
Young's modulus of wire, $Y = 9 \times 10^{10} N\,m^{-2}$
Strain $= 4.9 \times 10^{-4}$

$Y = \frac{\text{Stress}}{\text{Strain}} = \frac{T / A}{\text{Strain}}$

$\therefore \frac{T}{A} = Y \times \text{Strain} = 9 \times 10^{9} \times 4.9 \times 10^{-4}$

Also, mass of wire, $m = Al\,\sigma$

Mass per unit length, $\mu = \frac{m}{J} = A\sigma$

Fundamental frequency in the string

$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{T}{\sigma A}}$

$= \frac{1}{2 \times 1}\sqrt{\frac{9 \times 10^{9} \times 4.9 \times 10^{-4}}{9 \times 10^{3}}}$

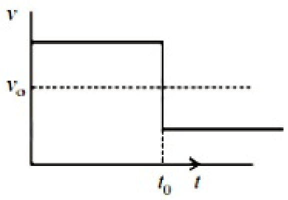
$= \frac{1}{2}\sqrt{49 \times 10^{9-4-3}} = \frac{1}{2} \times 70 = 35Hz$

Question68

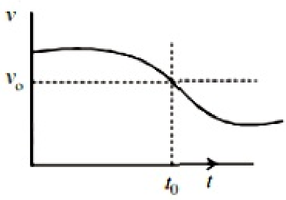
A sound source S is moving along a straight track with speed v, and is emitting sound of frequency v_0 (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by: (t_0 represents the instant when the distance between the source and observer is minimum)
[Sep. 06, 2020 (I)]

Options:

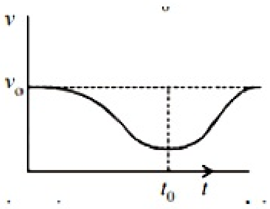
A.



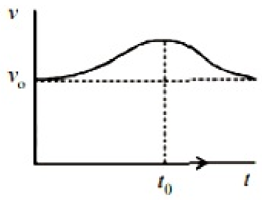
B.



C.



D.

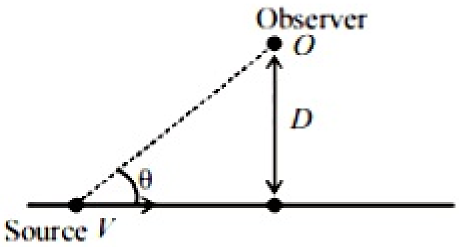


Answer: B

Solution:

Frequency heard by the observer

$$v_{observed} = \left(\frac{v_{sound}}{v_{sound} - v\cos\theta}\right) v_0$$



Initially θ will be less so $\cos\theta$ more.
$\therefore v_{observed}$ more, then it will decrease.

Question69

A driver in a car, approaching a vertical wall notices that the frequency of his car horn, has changed from 440 Hz to 480 Hz, when it gets reflected from the wall. If the speed of sound in air is 345 m/s, then the speed of the car is :
[Sep. 05, 2020 (II)]

Options:

A. 54 km/hr

B. 36 km/hr

C. 18 km/hr

D. 24 km/hr

Answer: A

Solution:

Solution:
Let f_1 be the frequency heard by wall,

$$f_1 = \left(\frac{v}{v - v_c}\right) f_0$$

Here, $v =$ Velocity of sound,
$v_c =$ Velocity of Car,
$f_0 =$ actual frequency of car horn
Let f_2 be the frequency heard by driver after reflection from wall.

$$f_2 = \left(\frac{v + v_c}{v}\right) f_1 = \left(\frac{v + v_c}{v - v_c}\right) f_0$$

$\Rightarrow 480 = \left[\frac{345 + v_c}{345 - v_c}\right] 440 \Rightarrow \frac{12}{11} = \frac{345 + v_c}{345 - v_c}$

$\Rightarrow v_c = 54 km / hr$

Question70

The driver of a bus approaching a big wall notices that the frequency of his bus's horn changes from 420 Hz to 490 Hz when he hears it after it gets reflected from the wall. Find the speed of the bus if speed of the sound is 330 ms^{-1}.
[Sep. 04, 2020 (II)]

Options:

A. 91 kmh^{-1}

B. 81 kmh^{-1}

C. 61 kmh^{-1}

D. 71 kmh^{-1}

Answer: A

Solution:

Solution:
From the Doppler's effect of sound, frequency appeared at wall

$f_w = \frac{330}{330 - v} . f$ ....(i)

Here, v = speed of bus,
f = actual frequency of source
Frequency heard after reflection from wall (f') is

$f' = \frac{330 + v}{330} . f_w = \frac{330 + v}{330 - v} . f$

$\Rightarrow 490 = \frac{330 + v}{330 - v} . 420$

$\Rightarrow v = \frac{330 \times 7}{91} \approx 25.38 m / s = 91 km / s$

Question71

Magnetic materials used for making permanent magnets (P) and magnets in a transformer (T) have different properties of the following, which property best matches for the type of magnet required?
[Sep. 02, 2020 (I)]

Options:

A. T : Large retentivity, small coercivity

B. P : Small retentivity, large coercivity

C. T : Large retentivity, large coercivity

D. P : Large retentivity, large coercivity

Answer: D

Solution:

Solution:
Permanent magnets (P) are made of materials with large retentivity and large coercivity. Transformer cores (T) are made of materials with low retentivity and low coercivity

----

Question72

A travelling harmonic wave is represented by the equation $y(x, t) = 10^{-3} \sin(50t + 2x)$, where x and y are in meter and t is in seconds. Which of the following is a correct statement about the wave? [12 Jan. 2019 I]

Options:

A. The wave is propagating along the negative x-axis with speed $25ms^{-1}$

B. The wave is propagating along the positive x -axis with speed $100ms^{-1}$

C. The wave is propagating along the positive x -axis with speed $25ms^{-1}$.

D. The wave is propagating along the negative x -axis with speed $100ms^{-1}$.

Answer: A

Solution:

Solution:
Comparing the given equation
$y = 10^{-3} \sin(50t + 2x)$ with standard equation,
$y = a \sin(\omega t - kx)$
$\Rightarrow$ wave is moving along − ve x -axis with speed
$v = \frac{\omega}{K} \Rightarrow v = \frac{50}{2} = 25m / sec$

Question73

Equation of travelling wave on a stretched string of linear density 5 g/m is $y = 0.03 \sin(450t - 9x)$ where distance and time are measured in SI units. The tension in the string is: [11 Jan 2019 (I)]

Options:

A. 10 N

B. 7.5 N

C. 12.5 N

D. 5 N

Answer: C

Solution:

Solution:
We have given,
$y = 0.03\sin(450t - 9x)$
Comparing it with standard equation of wave, we get $\omega = 450 k = 9$
$\therefore v = \frac{\omega}{k} = \frac{450}{9} = 50 m / s$
Velocity of travelling wave on a stretched string is given by
$v = \sqrt{\frac{T}{\mu}} \Rightarrow \frac{T}{\mu} = 2500$
$\mu =$ linear mass density
$\Rightarrow T = 2500 \times 5 \times 10^{-3}$
$\Rightarrow 12.5 N$

Question74

A heavy ball of mass M is suspended from the ceiling of a car by a light string of mass m (m < < M). When the car is at rest, the speeed of transverse waves in the string is 60 ms^{-1}. when the car has acceleration a, the wave-speed increases to 60.5 ms^{-1}. The value of a, in terms of gravitational acceleration g, is closest to:
[9 Jan. 2019 (I)]

Options:

A. $\frac{g}{30}$

B. $\frac{g}{5}$

C. $\frac{g}{10}$

D. $\frac{g}{20}$

Answer: B

Solution:

Solution:
Wave speed $V = \sqrt{\frac{T}{\mu}}$
when car is at rest $a = 0$
$\therefore 60 = \sqrt{\frac{Mg}{\mu}}$
Similarly when the car is moving with acceleration a,
$60.5 = \sqrt{\frac{M(g^2 + a^2)^{1/2}}{\mu}}$
$\frac{60.5}{60} = \sqrt{\sqrt{\frac{g^2 + a^2}{g^2}}}$

$\left(1 + \frac{0.5}{60}\right)^4 = \frac{g^2 + a^2}{g^2} = 1 + \frac{2}{60}$

$\Rightarrow g^2 + a^2 = g^2 + g^2 \times \frac{2}{60}$

$a = g\sqrt{\frac{2}{60}} = \frac{g}{\sqrt{30}}$ [which is closest to g/5]

Question75

A closed organ pipe has a fundamental frequency of 1.5 kHz. The number of overtones that can be distinctly heard by a person with this organ pipe will be: (Assume that the highest frequency a person can hear is 20,000 Hz) [10 Jan. 2019 (I)]

Options:

A. 6

B. 4

C. 7

D. 5

Answer: A

Solution:

Solution:

If a closed pipe vibration in N th mode then frequency of vibration $n = \frac{(2N-1)v}{4l} = (2N-1)n_1$

(where $n_1 =$ fundamental frequency of vibration)

Hence $20,000 = (2N-1) \times 1500$

$\Rightarrow N = 7.1 \approx 7$

$\therefore$ Number of over tones $=$ (No. of mode of vibration) $- 1 = 7 - 1 = 6$

Question76

A string of length 1 m and mass 5 g is fixed at both ends. The tension in the string is 8.0 N. The string is set into vibration using an external vibrator of frequency 100 Hz. The separation between successive nodes on the string is close to: [10 Jan. 2019 (I)]

Options:

A. 10.0 cm

B. 33.3 cm

C. 16.6 cm

D. 20.0 cm

Answer: D

Solution:

Solution:
Velocity of wave on string

$V = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{8}{5} \times 1000} = 40m / s$

Here, $T =$ tension and $\mu =$ mass / length

Wavelength of wave $\lambda = \frac{v}{n} = \frac{40}{100}m$

Separation b / w successive nodes,

$\frac{\lambda}{2} = \frac{40}{2 \times 100} = \frac{20}{100}m = 20cm$

Question77

A resonance tube is old and has jagged end. It is still used in the laboratory to determine velocity of sound in air. A tuning fork of frequency 512 Hz produces first resonance when the tube is filled with water to a mark 11 cm below a reference mark, near the open end of the tube. The experiment is repeated with another fork of frequency 256 Hz which produces first resonance when water reaches a mark 27 cm below the reference mark. The velocity of sound in air, obtained in the experiment, is close to:
[12 Jan. 2019 II]

Options:

A. 322 ms^{-1}

B. 341 ms^{-1}

C. 335 ms^{-1}

D. 328 ms^{-1}

Answer: D

Solution:

Solution:

Question78

A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1 If the speed of the train is reduced to 17 m/s, the frequency registered is f_2 If speed of sound is 340 m/s, then the ratio f_1 / f_2 is:
[10 Jan. 2019 I]

Options:

A. 18/17

B. 19/18

C. 20/19

D. 21/20

Answer: B

Solution:

Solution:
According to Doppler's effect, when source is moving but observer at rest

$$f_{app} = f_0\left[\frac{V}{V - V_s}\right] \Rightarrow f_1 = f_0\left[\frac{340}{340 - 34}\right]$$

and, $f_2 = f_0\left[\frac{340}{340 - 17}\right]$

$\therefore \frac{f_1}{f_2} = \frac{340 - 17}{340 - 34} = \frac{323}{306}$ or $\frac{f_1}{f_2} = \frac{19}{18}$

Question79

A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 km/h. If the wave speed is 330 m/s, the frequency heard by the running person shall be close to:
[9 Jan. 2019 II]

Options:

A. 666 Hz

B. 753 Hz

C. 500 Hz

D. 333 Hz

Answer: A

Solution:

Solution:
Frequency of the sound produced by open flute.

$$f = 2\left(\frac{v}{2l}\right) = \frac{2 \times 330}{2 \times 0.5} = 660 Hz$$

Velocity of observer, $v_0 = 10 \times \frac{5}{18} = \frac{25}{9} m/s$

As the source is moving towards the observer therefore, according to Doppler's effect.

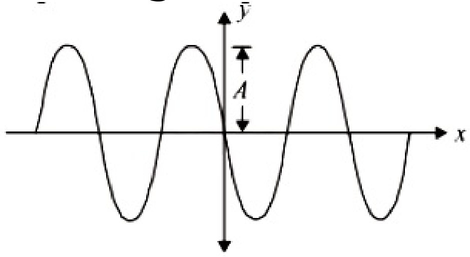
$\therefore$ Frequency detected by observer

$$f' = \left[\frac{v + v_0}{v}\right] f = \left[\frac{\frac{25}{9} + 330}{330}\right] 660$$

$= \frac{2995}{9 \times 330} \times 660$ or, $f' = 665.55 \simeq 666 Hz$

Question80

A progressive wave travelling along the positive x -direction is represented by $y(x, t) = A \sin(kx - \omega t + \phi)$. Its snapshot at $t = 0$ is given in the figure.



For this wave, the phase ϕ is:
[12 April 2019 I]

Options:

A. $-\frac{\pi}{2}$

B. π

C. 0

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

Answer: B

Solution:

Solution:
At $t = 0$, $x = 0$, $y = 0$
$\phi = \pi$ rad

Question81

A small speaker delivers 2W of audio output. At what distance from the speaker will one detect 120dB intensity sound ? [Given reference intensity of sound as $10^{-12} W/m^2$]
[12 April 2019 II]

Options:

A. 40 cm

B. 20 cm

C. 10 cm

D. 30 cm

Answer: A

Solution:

Solution:
Using, $\beta = 10$

or $120 = 10 \log 10 \left(\frac{I}{10^{-12}} \right)$ ....(i)

Also $I = \frac{P}{4\pi r^2} = \frac{2}{4\pi r^2}$ ....(ii)

On solving above equations, we get
r = 40 cm.

Question82

The pressure wave, $P = 0.01 \sin[1000t - 3x] \, N \, m^{-2}$, corresponds to the sound produced by a vibrating blade on a day when atmospheric temperature is 0°C. On some other day when temperature is T , the speed of sound produced by the same blade and at the same frequency is found to be $336 ms^{-1}$. Approximate value of T is:
[9 April 2019 I]

Options:

A. 4°C

B. 11°C

C. 12°C

D. 15°C

Answer: A

Solution:

Solution:
On comparing with $P = P_0 \sin(wt - kx)$, we have

$w = 1000 \, rad / s, \, K = 3m^{-1}$

$\therefore v_0 = \frac{w}{k} = \frac{1000}{3} = 333.3 m / s$

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

or $\frac{333.3}{336} = \sqrt{\frac{273 + 0}{273 + t}}$

$\therefore t = 4°C$

Question83

A tuning fork of frequency 480 Hz is used in an experiment for measuring speed of sound (v) in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air

column, l_1 = 30cm and l_2 = 70cm . Then, v is equal to :
[12 April 2019 (II)]

Options:

A. 332 ms^{-1}

B. 384 ms^{-1}

C. 338 ms^{-1}

D. 379 ms^{-1}

Answer: B

Solution:

Solution:
$V = f\lambda = f \times 2(l_2 - l_1)$
$= 480 \times 2(0.70 - 0.30)$
$= 384 m / s$

Question84

A string 2.0 m long and fixed at its ends is driven by a 240 Hz vibrator. The string vibrates in its third harmonic mode.
The speed of the wave and its fundamental frequency is:
[9 April 2019 (II)]

Options:

A. 180 m/s, 80 Hz

B. 320 m/s, 80 Hz

C. 320 m/s, 120 Hz

D. 180 m/s, 120 H

Answer: B

Solution:

Solution:
$\frac{3\lambda}{2} = 2$ or $\lambda = \frac{4}{3} m$
Velocity, $v = f_\lambda = 240 \times \frac{4}{3} = 320 m / sec$
Also $f_1 = \frac{240}{3} = 80 Hz$

Question85

A string is clamped at both the ends and it is vibrating in its 4^{th} harmonic. The equation of the stationary wave is Y $= 0.3\sin(0.157x)\cos(200At)$. The length of the string is: (All quantities are in SI units.)
[9 April 2019 (I)]

Options:

A. 20 m

B. 80 m

C. 40 m

D. 60 m

Answer: B

Solution:

Solution:
Given, $y = 0.3\sin(0.157x)\cos(200\pi t)$
So $k = 0.157$ and $w = 200\pi$
or $f = 100Hz$, $v = \frac{w}{k} = \frac{200\pi}{0.157} = 4000m/s$
Now, using $f = \frac{nv}{2l} = \frac{4v}{2l} = \frac{2v}{l}$
$\therefore l = \frac{2v}{f} = \frac{2 \times 4000}{100} = 80m$

Question86

A wire of length 2L, is made by joining two wires A and B of same length but different radii r and 2r and made of the same material. It is vibrating at a frequency such that the joint of the two wires forms a node. If the number of antinodes in wire A is p and that in B is q then the ratio p : q is :

[8 April 2019 (I)]

Options:

A. 3 : 5

B. 4 : 9

C. 1 : 2

D. 1 : 4

Answer: C

Solution:

As there must be node at both ends and at the joint of the wire A and B so

$$\frac{V_A}{V_B} = \sqrt{\frac{u_B}{u_A}} = \frac{r_B}{r_A} = 2 = \frac{\lambda_A}{\lambda_B}$$

$\Rightarrow \lambda_A = 2\lambda_B$

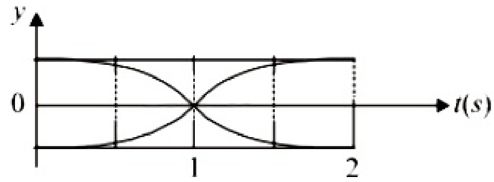
$\Rightarrow \frac{P}{q} = \frac{1}{2}$

Question87

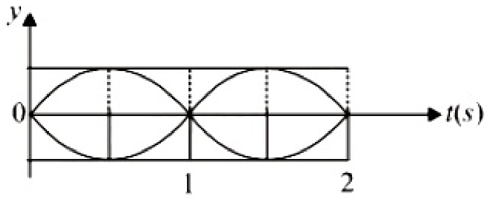
The correct figure that shows, schematically, the wave pattern produced by superposition of two waves of frequencies 9 Hz and 11 Hz is :
[10 April 2019 II]

Options:

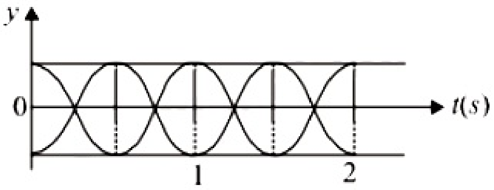
A.



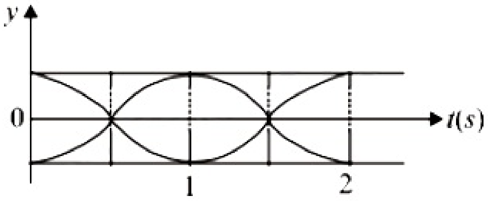
B.



C.



D.



Answer: C

Solution:

Solution:
Beat frequency = difference in frequencies of two waves
= 11 – 9 = 2 Hz

Question88

A submarine (A) travelling at 18 km/hr is being chased along the line of its velocity by another submarine (B) travelling at 27 km/hr. B sends a sonar signal of 500 Hz to detect A and receives a reflected sound of frequency v.
The value of v is close to :
(Speed of sound in water = 1500 ms^{-1})
[12 April 2019 I]

Options:

A. 504 Hz

B. 507 Hz

C. 499 Hz

D. 502 Hz

Answer: D

Solution:

Solution:

$$f_1 = f\left(\frac{v - v_o}{v - v_s}\right) = f\left(\frac{1500 - 5}{1500 - 7.5}\right)$$

No reflected signal,

$$f_2 = f_1\left(\frac{v + v_o}{v + v_s}\right) = f_1\left(\frac{1500 + 7.5}{1500 + 5}\right)$$

$$f_2 = 500\left(\frac{1500 - 5}{1500 - 7.5}\right)\left(\frac{1500 + 7.5}{1500 + 5}\right)$$

$$= 502Hz$$

Question89

Two sources of sound S_1 and S_2 produce sound waves of same frequency 660Hz. A listener is moving from source S_1 towards S_2 with a constant speed um / s and he hears 10 beats/s. The velocity of sound is 330 m/s. Then u equals:
[12 April 2019 II]

Options:

A. 5.5 m/s

B. 15.0 m/s

C. 2.5 m/s

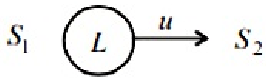
D. 10.0 m/s

Answer: C

Solution:

Solution:

$f_1 = f\frac{v - v_0}{v}$ and $f_2 = f\frac{v + v_0}{v}$



But frequency,

$f_2 - f_1 = f \times \frac{2v_0}{v}$

or $10 = 660 \times \frac{2u}{330}$

$\therefore u = 2.5m / s.$

Question90

A stationary source emits sounds waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 4801 Hz and 530 Hz. Their respective speeds are, in ms^{-1},
(Given speed of sound = 300 m/s)
[10 April 2019 I]

Options:

A. 12, 16

B. 12, 18

C. 16, 14

D. 8, 18

Answer: B

Solution:

Solution:

Frequency of sound source $(f_0) = 500Hz$

When observer is moving away from the source

Apparent frequency $f_1 = 480 = f_0\left(\frac{v - v_0'}{v}\right)$ ....(i)

And when observer is moving towards the source

$f_2 = 530 = f_0\left(\frac{v - v_0''}{v}\right)$ ......(ii)

From equation (i)

$480 = 500\left(\frac{300 - v_0'}{300}\right)$

$v_0' = 12m / s$

From equation (ii)

$530 = 500\left(1 + \frac{v_0^{n}}{v}\right)$

$\therefore V_0'' = 18m / s$

Question91

A source of sound S is moving with a velocity of 50 m/s towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crossing him? (Take velocity of sound in air 350 m/s)
[10 April 2019 II]

Options:

A. 750 Hz

B. 857 Hz

C. 1143 Hz

D. 807 Hz

Answer: A

Solution:

Solution:
When source is moving towards a stationary observer,

$$f_{app} = f_{source}\left(\frac{V-0}{V-50}\right)$$

$$1000 = f_{source}\left(\frac{350}{300}\right)$$

When source is moving away from observer

$$f' = f_{source}\left(\frac{350}{350+50}\right)$$

$$f' = \frac{1000 \times 300}{350} \times \frac{350}{400}$$

$$f' \approx 750\text{Hz}$$

Question92

Two cars A and B are moving away from each other in opposite directions. Both the cars are moving with a speed of 20 ms^{-1} with respect to the ground. If an observer in car A detects a frequency 2000 Hz of the sound coming from car B, what is the natural frequency of the sound source in car B?
(speed of sound in air = 340 ms^{-1})
[9 April 2019 II]

Options:

A. 2250 Hz

B. 2060 Hz

C. 2300 Hz

D. 2150 Hz

Answer: A

Solution:

Solution:

$f' = f\frac{v - v_0}{v + v_s}$

or $2000 = f\frac{340 - 20}{340 + 20}$

$\therefore f = 2250Hz$

Question93

A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is 2.7×10^3 kg/m^3 and its Young's modulus is 9.27×10^{10} Pa.
What will be the fundamental frequency of the longitudinal vibrations? [2018]

Options:

A. 5 kHz

B. 2.5 kHz

C. 10 kHz

D. 7.5 kHz

Answer: A

Solution:

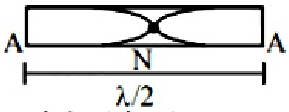
Solution:

In solids, Velocity of wave

$V = \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{9.27 \times 10^{10}}{2.7 \times 10^3}}$

$v = 5.85 \times 10^3 m / sec$

Since rod is clamped at middle fundamental wave shape is as follow



$\frac{\lambda}{2} = L \Rightarrow \lambda = 2L$

$\lambda = 1.2m (\because L = 60cm = 0.6m$ (given)$)$

Using $v = f\lambda$

$\Rightarrow f = \frac{v}{\lambda} = \frac{5.85 \times 10^3}{1.2}$

$= 4.88 \times 10^3 Hz \simeq 5KHz$

Question94

The end correction of a resonance column is 1cm. If the shortest length resonating with the tuning fork is 10cm, the next resonating length should be
[Online April 16, 2018]

Options:

A. 32cm

B. 40cm

C. 28cm

D. 36cm

Answer: A

Solution:

Solution:
For first resonance, $\frac{\lambda}{4} = l_1 + e = 11\text{cm}$
($\because$ end correction $e = 1\text{cm}$ given)
For second resonance, $\frac{3\lambda}{4} = l_2 + e$
$\Rightarrow l_2 = 3 \times 11 - 1 = 32\text{cm}$

Question95

A tuning fork vibrates with frequency 256 Hz and gives one beat per second with the third normal mode of vibration of an open pipe. What is the length of the pipe?
(Speed of sound of air is 340 ms^{-1})
[Online April 15, 2018]

Options:

A. 190 cm

B. 180 cm

C. 220 cm

D. 200 cm

Answer: D

Solution:

Solution:
According to question, tuning fork gives 1 beat/second with (N) 3^{rd} normal mode. Therefore, organ pipe will have frequency $(256 \pm 1)\text{Hz}$. In open organ pipe, frequency
$n = \frac{NV}{2l}$
or, $255 = \frac{3 \times 340}{2 \times l} \Rightarrow l = 2\text{m} = 200\text{cm}$

Question96

5 beats/ second are heard when a turning fork is sounded with a sonometer wire under tension, when the length of the sonometer wire is either 0.95m or 1m . The frequency of the fork will be:
[Online April 15, 2018]

Options:

A. 195Hz

B. 251Hz

C. 150Hz

D. 300Hz

Answer: A

Solution:

Probable frequencies of tuning fork be $n \pm 5$

Frequency of sonometer wire, $n \propto \frac{1}{l}$

$\therefore \frac{n+5}{n-5} = \frac{100}{95} \Rightarrow 95(n+5) = 100(n-5)$

or, $95n + 475 = 100n - 500$

or, $5n = 975$

or, $n = \frac{975}{5} = 195Hz$

Question97

Two sitar strings, A and B, playing the note 'Dha' are slightly out of tune and produce beats and frequency 5 Hz. The tension of the string B is slightly increased and the beat frequency is found to decrease by 3 Hz . If the frequency of A is 425 Hz, the original frequency of B is
[Online April 16, 2018]

Options:

A. 430 Hz

B. 428 Hz

C. 422 Hz

D. 420 Hz

Answer: D

Solution:

Solution:

$n_A = 425 Hz$, $n_B = ?$

Beat frequency x = 5 Hz which is decreasing (5 → 3) after increasing the tension of the string B.

Also tension of string B increasing so

$n_B \uparrow$ ($\because n \propto \sqrt{T}$)

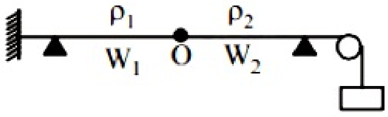
Hence $n_B \uparrow - n_A = x \downarrow \rightarrow$ correct

$n_B \uparrow - n_A = x \downarrow \rightarrow$ incorrect

$\therefore n_B = n_A - x = 425 - 5 = 420 Hz$

Question98

Two wires W_1 and W_2 have the same radius r and respective densities rho$_1$ and ρ_2 such that $\rho_2 = 4\rho_1$. They are joined together at the point O, as shown in the figure. The combination is used as a sonometer wire and kept under tension T . The point O is midway between the two bridges. When a stationary waves is set up in the composite wire, the joint is found to be a node. The ratio of the number of antinodes formed in W_1 to W_2 is :



[Online April 8, 2017]

Options:

A. 1 : 1

B. 1 : 2

C. 1 : 3

D. 4 : 1

Answer: B

Solution:

$n_1 = n_2$

T → Same

r→ Same

l → Same

Frequency of vibration

$$n = \frac{p}{2l}\sqrt{\frac{T}{\pi r^2 \rho}}$$

As T , r, and l are same for both the wires

$n_1 = n_2$

$$\frac{p_1}{\sqrt{\rho_1}} = \frac{p_2}{\sqrt{\rho_2}}$$

$$\Rightarrow \frac{p_1}{p_2} = \frac{1}{2} \qquad \because \rho_2 = 4\rho_1$$

Question99

A standing wave is formed by the superposition of two waves travelling in opposite directions. The transverse displacement is given by

$y(x, t) = 0.5 \sin\left(\frac{5\pi}{4}x\right) \cos(200\pi t)$

What is the speed of the travelling wave moving in the positive x direction ?
(x and t are in meter and second, respectively.)
[Online April 9, 2017]

Options:

A. 160 m/s

B. 90 m/s

C. 180 m/s

D. 120 m/s

Answer: A

Solution:

Solution:

Given, $y(x, t) = 0.5 \sin\left(\frac{5\pi}{4}x\right) \cos(200\pi t)$

comparing with equation $-y(x, t) = 2a \sin kx \cos \omega t$

$\omega = 200\pi,\ k = \frac{5\pi}{4}$

speed of travelling wave $v = \frac{\omega}{k} = \frac{200\pi}{5\pi / 4} = 160 m / s$

Question100

A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the supports is :(take $g = 10\ ms^{-2}$) [2016]

Options:

A. $2\sqrt{2}s$

B. $\sqrt{2}s$

C. $2\pi\sqrt{2}s$

D. 2 s

Answer: A

Solution:

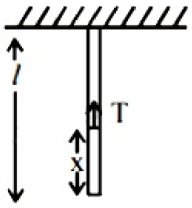
Solution:
We know that velocity in string is given by

$v = \sqrt{\frac{T}{\mu}}$ .....(i)

where $\mu = \frac{m}{1} = \frac{\text{mass of string}}{\text{length of string}}$

The tension $T = \frac{m}{l} \times x \times g$ ....(ii)

From (1) and (2)



$\frac{dx}{dt} = \sqrt{gx}$

$x^{-1/2} dx = \sqrt{g} dt$

$\therefore \int_0^l x^{-1/2} dx - \sqrt{g} \int_0^l dt$

$\Rightarrow 2\sqrt{l}$

$= \sqrt{g} \times t \therefore t = 2\sqrt{\frac{l}{g}} = 2\sqrt{\frac{20}{10}} = 2\sqrt{2}$

Question101

A pipe open at both ends has a fundamental frequency f in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now :
[2016]

Options:

A. 2f

B. f

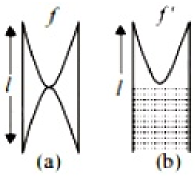
C. $\frac{f}{2}$

D. $\frac{3f}{4}$

Answer: B

Solution:

Solution:



The fundamental frequency in case (a) is $f = \frac{v}{2l}$

The fundamental frequency in case (b) is

$f' = \frac{v}{4(l/2)} = \frac{v}{2l} = f$

Question102

A toy-car, blowing its horm, is moving with a steady speed of 5 m/s, away from a wall. An observer, towards whom the toy car is moving, is able to hear 5 beats per second. If the velocity of sound in air is 340 m/s, the frequency of the horn of the toy car is close to :
[Online April 10, 2016]

Options:

A. 680 Hz

B. 510 Hz

C. 340 Hz

D. 170 Hz

Answer: D

Solution:

Solution:
From Doppler's effect

$f(\text{direct}) = f\left(\frac{340}{340-5}\right) = f_1$

$f(\text{by wall}) = f\left(\frac{340}{340+5}\right) = f_2$

Beats $= (f_1 - f_2)$

$5 = f\left(\frac{340}{340-5} - \frac{340}{340+5}\right)$

$\Rightarrow f = 170 Hz$

Question103

Two engines pass each other moving in opposite directions with uniform speed of 30 m/s. One of them is blowing a whistle of frequency 540 Hz. Calculate the frequency heard by driver of second engine before they pass each other. Speed of sound is 330 m/sec:
[Online April 9, 2016]

Options:

A. 450 Hz

B. 540 Hz

C. 270 Hz

D. 648 Hz

Answer: B

Solution:

Solution:
We know that the apperent frequency

$f' = \left(\frac{v - v_0}{v - v_s}\right) f$ from Doppler's effect

where $v_0 = v_s = 30m/s$, velocity of observer and source

Speed of sound $v = 330m/s$

$\therefore f' = \frac{330 + 30}{330 - 30} \times 540 = 648Hz$

$\because$ Frequency of whistle $(f) = 540Hz$

Question104

A train is moving on a straight track with speed 20 ms^{-1}. It is blowing its whistle at the frequency of 1000 Hz. The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound = 320 ms^{-1}) close to :
[2015]

Options:

A. 18%

B. 24%

C. 6%

D. 12%

Answer: D

Solution:

Solution:

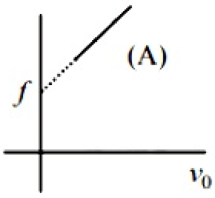
$f_1 = f\left[\frac{v}{v - v_s}\right] = f \times \frac{320}{300}Hz$

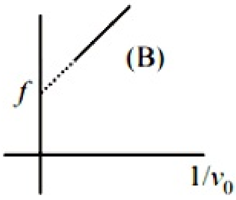
$f_2 = f\left[\frac{v}{v + v_s}\right] = f \times \frac{320}{340}Hz$

$\left(\frac{f_2}{f_1} - 1\right) \times 100 = \left(\frac{300}{340} - 1\right) \times 100 \simeq 12\%$

Question105

A source of sound emits sound waves at frequency f_0. It is moving towards an observer with fixed speed v_s($v_s < v$, where v is the speed of sound in air). If the observer were to move towards the source with speed v_0, one of the following two graphs (A and B) will given the correct variation of the frequency f heard by the observer as v_0 is changed.





The variation of f with v_0 is given correctly by :
[Online April 11, 2015]

Options:

A. graph A with slope $= \frac{f_0}{(v + v_s)}$

B. graph B with slope $= \frac{f_0}{(v - v_s)}$

C. graph A with slope $= \frac{f_0}{(v - v_s)}$

D. graph B with slope $= \frac{f_0}{(v + v_s)}$

Answer: C

Solution:

Solution:
According to Doppler's effect,
Apparent, frequency $f = \left(\frac{V + V_0}{V - V_S}\right) f_0$
Now, $f = \left(\frac{f_0}{V - V_S}\right) V_0 + \frac{V f_0}{V - V_s}$
So, slope $= \frac{f_0}{V - V_S}$
Hence, option (c) is the correct answer.

Question106

A bat moving at 10 ms^{-1} towards a wall sends a sound signal of 8000 Hz towards it. On reflection it hears a sound of frequency f. The value of f in Hz is close to (speed of sound = 320 ms^{-1})
[Online April 10, 2015]

Options:

A. 8516

B. 8258

C. 8424

D. 8000

Answer: A

Solution:

Reflected frequency of sound reaching bat

$= \left[\frac{V-(-V_0)}{V-V_s}\right]f = \left[\frac{V+V_0}{V-V_s}\right]f = \frac{V+10}{V-10}f$

$= \left(\frac{320+10}{320-10}\right) \times 8000 = 8516Hz$

Question107

A transverse wave is represented by

$$\mathbf{y = \frac{10}{\pi}\sin\left(\frac{2\pi}{T}t - \frac{2\pi}{\lambda}x\right)}$$

For what value of the wavelength the wave velocity is twice the maximum particle velocity?
[Online April 9, 2014]

Options:

A. 40 cm

B. 20 cm

C. 10 cm

D. 60 cm

Answer: A

Solution:

Solution:
Given, amplitude $a = 10cm$
wave velocity $= 2\times$ maximum particle velocity
i.e, $\frac{\omega\lambda}{2\pi} = 2\frac{a\omega}{\pi}$
or, $\lambda = 4a = 4 \times 10 = 40cm$

Question108

A pipe of length 85 cm is closed from one end. Find the number of possible natural oscillations of air column in the pipe whose frequencies lie below 1250 Hz. The velocity of sound in air is 340 m/s.
[2014]

Options:

A. 12

B. 8

C. 6

D. 4

Answer: C

Solution:

Solution:
Length of pipe = 85 cm = 0.85m
Frequency of oscillations of air column in closed organ pipe is given by,
$f = \frac{(2n-1)v}{4L}$
$f = \frac{(2n-1)v}{4L} \leq 1250$
$\Rightarrow \frac{(2n-1) \times 340}{0.85 \times 4} \leq 1250$
$\Rightarrow 2n - 1 \leq 12.5 \approx 6$

Question109

The total length of a sonometer wire between fixed ends is 110 cm. Two bridges are placed to divide the length of wire in ratio 6 : 3 : 2. The tension in the wire is 400 N and the mass per unit length is 0.01 kg/m. What is the minimum common frequency with which three parts can vibrate? [Online April 19, 2014]

Options:

A. 1100 Hz

B. 1000 Hz

C. 166 Hz

D. 100 Hz

Answer: B

Solution:

Solution:
Total length of sonometer wire, $l = 110$ cm = 1.1 m
Length of wire is in ratio, 6 : 3 : 2 i.e. 60 cm, 30 cm, 20 cm.
Tension in the wire, T = 400 N
Mass per unit length, m = 0.01 kg
Minimum common frequency = ?
As we know,
Frequency, $v = \frac{1}{2l}\sqrt{\frac{T}{m}} = \frac{1000}{11} Hz$
Similarly, $v_1 = \frac{1000}{6} Hz$
$v_2 = \frac{1000}{3} Hz$
$v_3 = \frac{1000}{2} Hz$
Hence common frequency $= 1000 Hz$

Question110

A source of sound A emitting waves of frequency 1800 Hz is falling towards ground with a terminal speed v. The observer B on the ground directly beneath the source receives waves of frequency 2150 Hz. The source A receives waves, reflected from ground of frequency nearly: (Speed of sound = 343 m/s)
[Online April 12, 2014]

Options:

A. 2150 Hz

B. 2500 Hz

C. 1800 Hz

D. 2400 Hz

Answer: B

Solution:

Solution:
Given $f_A = 1800Hz$
$v_t = v$
$f_B = 2150Hz$
Reflected wave frequency received by A, $f_A' = ?$
Applying doppler's effect of sound,
$f' = \frac{v_s f}{v_s - v_t}$
here, $v_t = v_s\left(1 - \frac{f_A}{f_B}\right)$
$= 343\left(1 - \frac{1800}{2150}\right)$
$v_t = 55.8372m / s$
Now, for the reflected wave,
$\therefore f_A' = \left(\frac{v_s + v_t}{v_s - v_t}\right) f_A$
$= \left(\frac{343 + 55.83}{343 - 55.83}\right) \times 1800$
$= 2499.44 \approx 2500Hz$

Question111

Two factories are sounding their sirens at 800 Hz. A man goes from one factory to other at a speed of 2m/s. The velocity of sound is 320 m/s. The number of beats heard by the person in one second will be:
[Online April 11, 2014]

Options:

A. 2

B. 4

C. 8

D. 10

Answer: D

Solution:

Solution:
Given: Frequency of sound produced by siren, f = 800 Hz
Speed of observer, u = 2 m/s
Velocity of sound, v = 320 m/s
No. of beats heard per second = ?
No. of extra waves received by the observer per second = ± 4λ
∴ No. of beats/ sec

$= \frac{2}{\lambda} - \left(-\frac{2}{\lambda}\right) = \frac{4}{\lambda}$

$= \frac{2 \times 2}{\frac{320}{800}} \left(\because \lambda = \frac{V}{f}\right)$

$= \frac{2 \times 2 \times 800}{320} = 10$

Question112

A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are 7.7×10^3 kg/m^3 and 2.2×10^{11} N/m^2 respectively?
[2013]

Options:

A. 188.5 Hz

B. 178.2 Hz

C. 200.5 Hz

D. 770 Hz

Answer: B

Solution:

Solution:
Fundamental frequency,

$f = \frac{v}{2l} = \frac{1}{2l}\sqrt{\frac{T}{\mu}} = \frac{1}{2l}\sqrt{\frac{T}{A\rho}} \left[\because v = \sqrt{\frac{T}{\mu}} \text{ and } \mu = \frac{m}{l}\right]$

Also, $Y = \frac{T\,l}{A\Delta l} \Rightarrow \frac{T}{A} = \frac{Y\,\Delta l}{l}$

$\Rightarrow f = \frac{1}{2l}\sqrt{\frac{y\Delta l}{l\,\rho}}$ ....(i)

$l = 1.5\text{m}, \frac{\Delta l}{l} = 0.01$

$\rho = 7.7 \times 10^3 \text{kg} / \text{m}^3$ (given)
$y = 2.2 \times 10^{11} \text{N} / \text{m}^2$ (given)

(i) we get, Putting the value of l, $\frac{\Delta l}{l}$, ρ and y in eq ^{n}. $f = \sqrt{\frac{2}{7} \times \frac{10^3}{3}}$ or $f \approx 178.2\text{Hz}$

Question113

In a transverse wave the distance between a crest and neighbouring trough at the same instant is 4.0cm and the distance between a crest and trough at the same place is 1.0cm. The next crest appears at the same place after a time interval of 0.4 s. The maximum speed of the vibrating particles in the medium is:
[Online April 25, 2013]

Options:

A. $\frac{3\pi}{2}$cm / s

B. $\frac{5\pi}{2}$cm / s

C. $\frac{\pi}{2}$cm / s

D. 2πcm / s

Answer: B

Solution:

Solution:

Question114

When two sound waves travel in the same direction in a medium, the displacements of a particle located at 'x' at time 't' is given by :
$\mathbf{y_1 = 0.05\cos(0.50\pi x - 100\pi t)}$
$\mathbf{y_2 = 0.05\cos(0.46\pi x - 92\pi t)}$
where y_1, y_2 and x are in meters and t in seconds. The speed of sound in the medium is :
[Online April 9, 2013]

Options:

A. 92 m/s

B. 200 m/s

C. 100 m/s

D. 332 m/s

Answer: B

Solution:

Standard equation

$y(x, t) = A\cos\left(\frac{\omega}{V}x - \omega t\right)$

From any of the displacement equation

Say y_1

$\frac{\omega}{V} = 0.50\pi$ and $\omega = 100\pi$

$\therefore \frac{100\pi}{V} = 0.5\pi$

$\therefore V = \frac{100\pi}{0.5\pi} = 200m / s$

Question115

A sonometer wire of length 114 cm is fixed at both the ends. Where should the two bridges be placed so as to divide the wire into three segments whose fundamental frequencies are in the ratio 1 : 3 : 4 ?

[Online April 23, 2013]

Options:

A. At 36 cm and 84 cm from one end

B. At 24 cm and 72 cm from one end

C. At 48 cm and 96 cm from one end

D. At 72 cm and 96 cm from one end

Answer: D

Solution:

Solution:

Total length of the wire, $L = 114cm$

$n_1 : n_2 : n_3 = 1 : 3 : 4$

Let L_1, $L_2{}^3$ and L_3 be the lengths of the three parts

As $n \propto \frac{1}{L}$

$\therefore L_1 : L_2 : L_3 = \frac{1}{1} : \frac{1}{3} : \frac{1}{4} = 12 : 4 : 3$

$\therefore L_1 = \left(\frac{12}{12 + 4 + 3} \times 114\right) = 72cm$

$L_2 = \left(\frac{4}{19} \times 114\right) = 24cm$

and $L_3 = \left(\frac{3}{19} \times 114\right) = 18cm$

Hence the bridges should be placed at $72cm$ and $72 + 24 = 96cm$ from one end.

Question116

A and B are two sources generating sound waves. A listener is situated at C. The frequency of the source at A is 500 Hz. A, now, moves towards C with a speed 4 m/s. The number of beats heard at C is 6. When A

moves away from C with speed 4 m/s, the number of beats heard at C is 18. The speed of sound is 340 m/s. The frequency of the source at B is :

[Online April 22, 2013]

Options:

A. 500 Hz

B. 506 Hz

C. 512 Hz

D. 494 Hz

Answer: C

Solution:

Solution:

Case 1 : When source is moving towards stationary listener

apparent frequency $\eta' = \eta\left(\frac{v}{v - v_s}\right) = 500\left(\frac{340}{336}\right) = 506\text{Hz}$

Case 2: When source is moving away from the stationary listener

$\eta" = \eta\left(\frac{v}{v + v_s}\right) = 500\left(\frac{340}{344}\right) = 494\text{Hz}$

In case 1 number of beats heard is 6 and in case 2 number of beats heard is 18 therefore frequency of the source at $B = 512\text{Hz}$

Question117

An engine approaches a hill with a constant speed. When it is at a distance of 0.9 km, it blows a whistle whose echo is heard by the driver after 5 seconds. If the speed of sound in air is 330 m/s, then the speed of the engine is :
[Online April 9, 2013]

Options:

A. 32 m/s

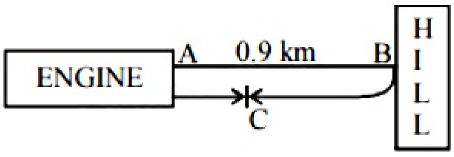
B. 27.5 m/s

C. 60 m/s

D. 30 m/s

Answer: D

Solution:



Let after 5 sec engine at point C

$t = \frac{AB}{330} + \frac{BC}{330}$ $5 = \frac{0.9 \times 1000}{330} + \frac{BC}{330}$

$\therefore BC = 750m$

Distance travelled by engine in 5sec

$= 900m - 750m = 150m$

Therefore velocity of engine

$= \frac{150m}{5sec} = 30m / s$

Question118

Following are expressions for four plane simple harmonic waves

(i) $y_1 = A\cos 2\pi\left(n_1 t + \frac{x}{\lambda_1}\right)$

(ii) $y_2 = A\cos 2\pi\left(n_1 t + \frac{x}{\lambda_1} + \pi\right)$

(iii) $y_3 = A\cos 2\pi\left(n_2 t + \frac{x}{\lambda_2}\right)$

(iv) $y_4 = A\cos 2\pi\left(n_2 t - \frac{x}{\lambda_2}\right)$

The pairs of waves which will produce destructive interference and stationary waves respectively in a medium, are
[Online May 7, 2012]

Options:

A. (iii, iv), (i, ii)

B. (i, iii), (ii, iv)

C. (i, iv), (ii, iii)

D. (i, ii), (iii, iv)

Answer: D

Solution:

Solution:
In case of destructive interference
Phase difference $\phi = 180°$ or π
So wave pair (i) and(ii) will produce destructive interference. Stationary or standing waves will produce by equations(iii) & (iv) as two waves travelling along the same line but in opposite direction.
$n' = n + x$

Question119

The disturbance y(x, t) of a wave propagating in the positive x -direction

is given by $y = \frac{1}{1 + x^2}$ at time t = 0 and by $y = \frac{1}{[1 + (x - 1)^2]}$ at t = 2s, where x and y are in meters. The shape of the wave disturbance does not change during the propagation. The velocity of wave in m / s is
[Online May 26, 2012]

Options:

A. 2.0

B. 4.0

C. 0.5

D. 1.0

Answer: C

Solution:

Solution:
The equation of wave at any time is obtained by putting $X = x - vt$
$y = \frac{1}{1 + x^2} = \frac{1}{1 + (x - vt)^2}$ ....(i)
We know at $t = 2sec$
$y = \frac{1}{1 + (x - 1)^2}$.;......(ii)
On comparing
(i) and (ii) we get $vt = 1$
$V = \frac{1}{t}$
As $t = 2sec$
$\therefore V = \frac{1}{2} = 0.5m / s$

Question120

A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of it is in water. The fundamental frequency of the air-column is now :
[2012]

Options:

A. f

B. f / 2

C. 3 f /4

D. 2 f

Answer: A

Solution:

Initially for open organ pipe, fundamental frequency

$v_0 = \frac{v}{2l_0}$ ....(i)
where l_0 is the length of the tube
v = speed of sound
But when it is half dipped in water, it becomes closed organ pipe of length $\frac{l_0}{2}$.
Fundamental frequency of closed organ pipe
$v_c = \frac{v}{4l_c}$ ......(ii)
New length, $l_c = \frac{l_0}{2}$
Thus $v_c = \frac{v}{4l_0/2} \Rightarrow v_c = \frac{v}{2l}$ ....(iii)
From equations (i) and (iii)
$v_0 = v_c$
Thus, $v_c = f$ ($\because v_0 = f$ is given)

Question121

An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz if the length of the column in cm is (velocity of sound = 330 m/s)
[Online May 26, 2012]

Options:

A. 125.00

B. 93.75

C. 62.50

D. 187.50

Answer: B

Solution:

Solution:
Given : Frequency of tuning fork, $n = 264Hz$
Length of column $L = ?$
For closed organ pipe
$n = \frac{v}{4l}$
$\Rightarrow l = \frac{v}{4n} = \frac{330}{4 \times 264} = 0.3125$
or, $l = 0.3125 \times 100 = 31.25cm$
In case of closed organ pipe only odd harmonics are possible.
Therefore value of l will be $(2n-1)l$
Hence option (b) i.e. $3 \times 31.25 = 93.75cm$ is correct.

Question122

A uniform tube of length 60.5 cm is held vertically with its lower end dipped in water. A sound source of frequency 500 Hz sends sound waves into the tube. When the length of tube above water is 16 cm and again

when it is 50 cm, the tube resonates with the source of sound. Two lowest frequencies (in Hz), to which tube will resonate when it is taken out of water, are (approximately).
[Online May 19, 2012]

Options:

A. 281, 562

B. 281, 843

C. 276, 552

D. 272, 544

Answer: D

Solution:

Solution:
Two lowest frequencies to which tube will resonates are $272 Hz$ and $544 Hz$

Question123

A wave represented by the equation $y_1 = a\cos(kx - \omega t)$ is superimposed with another wave to form a stationary wave such that the point $x - 0$ is node. The equation for the other wave is
[Online May 12, 2012]

Options:

A. $a\cos(kx - \omega t + \pi)$

B. $a\cos(kx + \omega t + \pi)$

C. $a\cos\left(kx + \omega t + \frac{\pi}{2}\right)$

D. $a\cos\left(kx - \omega t + \frac{\pi}{2}\right)$

Answer: B

Solution:

Solution:
Since the point x = 0 is a node and reflection is taking place from point x = 0. This means that reflection must be taking place from the fixed end and hence the reflected ray must suffer an additional phase change of π or a path change of $\frac{\lambda}{2}$.
So, if $y_{incident} = a\cos(kx - \omega t)$
$\Rightarrow y_{incident} = a\cos(-kx - \omega t + \pi)$
$= -a\cos(\omega t + kx)$
Hence equation for the other wave
$y = a\cos(kx + \omega t + \pi)$

Question124

This question has Statement 1 and Statement 2. Of the four choices given after the Statements, choose the one that best describes the two Statements.
Statement 1: Bats emitting ultrasonic waves can detect the location of a prey by hearing the waves reflected from it.
Statement 2: When the source and the detector are moving, the frequency of reflected waves is changed.
[Online May 12, 2012]

Options:

A. Statement 1 is false, Statement 2 is true.

B. Statement 1 is true, Statement 2 is false.

C. Statement 1 is true, Statement 2 is true, Statement2 is not the correct explanation of Statement 1.

D. Statement 1 is true, Statement 2 is true, Statement2 is the correct explanation of Statement 1.

Answer: C

Solution:

Solution:
Bats catch the prey by hearing reflected ultrasonic waves.
When the source and the detector (observer) are moving, frequency of reflected waves change. This is according to Doppler's effect.

Question125

The transverse displacement y(x, t) of a wave is given by
$y(x, t) = e^{-(ax^2 + bt^2 + 2\sqrt{ab})xt)}$ This represents a :
[2011]

Options:

A. wave moving in $-x$ direction with speed $\sqrt{\frac{b}{a}}$

B. standing wave of frequency $\sqrt{b}$

C. standing wave of frequency $\frac{1}{\sqrt{b}}$

D. wave moving in $+x$ direction speed $\sqrt{\frac{a}{b}}$

Answer: A

Solution:

Given

$y(x, t) = e^{-(ax^2 + bt^2 + 2\sqrt{ab})xt)}$

$= e^{-[(\sqrt{ax})^2 + (\sqrt{b}t)^2 + 2\sqrt{a}x \cdot \sqrt{b}t]}$

$= e^{-(\sqrt{a}x + \sqrt{b}t)^2}$

$= e^{-\left(x + \sqrt{\frac{b}{a}}t\right)^2}$

It is a function of type $y = f(x + vt)$

$\therefore y(x, t)$ represents wave travelling along $-$ ve x direction

$\Rightarrow$ Speed of wave $= \frac{w}{k} = \sqrt{\frac{b}{a}}$

Question126

A travelling wave represented by $y = A\sin(\omega t - kx)$ is superimposed on another wave represented by $y = A\sin(\omega t + kx)$. The resultant is [2011 RS]

Options:

A. A wave travelling along + x direction

B. A wave travelling along −x direction

C. A standing wave having nodes at $x = \frac{n\lambda}{2}$, $n = 0, 1, 2......$

D. A standing wave having nodes at $x = \left(n + \frac{1}{2}\right)\frac{\lambda}{2}$; $n = 0, 1, 2........$

Answer: D

Solution:

Solution:

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

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

This is an equation of standing wave. For position ofnodes

$\cos kx = 0$

$\Rightarrow \frac{2\pi}{\lambda}x = (2n + 1)\frac{\pi}{2}$

$\Rightarrow x = \frac{(2n + 1)\lambda}{4}$, $n = 0, 1, 2, 3, ...$

Question127

Statement - 1 : Two longitudinal waves given by equations: $y_1(x, t) = 2a\sin(\omega t - kx)$ and $y_2(x, t) = a\sin(2\omega t - 2kx)$ will have equal intensity.
Statement - 2 : Intensity of waves of given frequency in same medium is proportional to square of amplitude only.
[2011 RS]

Options:

A. Statement-1 is true, statement-2 is false.

B. Statement-1 is true, statement-2 is true, statement2 is the correct explanation of statement-1

C. Statement-1 is true, statement-2 is true, statement2 is not the correct explanation of statement-1

D. Statement-1 is false, statement-2 is true.

Answer: A

Solution:

Solution:
Intensity of a wave
$I = \frac{1}{2} p w^2 A^2 v$
Since, $I \propto A^2 \omega^2$
$\therefore I_1 \propto (2a)^2 \omega^2$
and $I_2 \propto a^2 (2\omega)^2$
$I_1 = I_2$
In the same medium, p and v are same.
Intensity depends on amplitude and frequency.

Question128

The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02(m) \sin \left[2\pi \left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)} \right) \right]$$

The tension in the string is
[2010]

Options:

A. 4.0 N

B. 12.5 N

C. 0.5 N

D. 6.25 N

Answer: D

Solution:

Solution:
$y = 0.02(m) \sin \left[2\pi \left(\frac{t}{0.04(s)} \right) - \frac{x}{0.50(m)} \right]$
Comparing it with the standard wave equation
$y = a \sin(\omega t - kx)$
we get
$\omega = \frac{2\pi}{0.04} \text{rad s}^{-1}$
and $k = \frac{2\pi}{0.50}$

Wave velocity, $v = \frac{w}{k}$

$\Rightarrow v = \frac{2\pi / 0.04}{2\pi / 0.5} = 12.5 m/s$

Velocity on a string is given by $v = \sqrt{\frac{T}{\mu}}$

$\therefore T = v^2 \times \mu = (12.5)^2 \times 0.04 = 6.25N$

Question129

Three sound waves of equal amplitudes have frequencies $(\nu - 1), \nu, (\nu + 1)$. They superpose to give beats. The number of beats produced per second will be :
[2009]

Options:

A. 3

B. 2

C. 1

D. 4

Answer: B

Solution:

Solution:
Maximum number of beats
= Maximum frequency – Minimum frequency
$= (\nu + 1) - (\nu - 1) = 2$ Beats per second

Question130

A motor cycle starts from rest and accelerates along a straight path at $2 m/s^2$. At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest? (Speed of sound = 330 ms^{-1})
[2009]

Options:

A. 98 m

B. 147 m

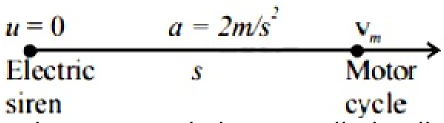
C. 196 m

D. 49 m

Answer: A

Solution:

Solution:



Let the motorcycle has travelled a distances, its velocity at that point

$v_m{}^2 - u^2 = 2as \therefore v_m{}^2 = 2 \times 2 \times s$

$\therefore v_m = 2\sqrt{s}$

The observed frequency will be

$v' = v\left[\frac{v - v_m}{v}\right]$

$0.94v = v\left[\frac{330 - 2\sqrt{s}}{330}\right] \Rightarrow s = 98.01m$

Question131

A wave travelling along the x -axis is described by the equation $y(x, t) = 0.005\cos(\alpha x - \beta t)$. If the wavelength and the time period of the wave are 0.08m and 2.0s, respectively, then α and β in appropriate units are
[2008]

Options:

A. $\alpha = 25.00\pi, \beta = \pi$

B. $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

C. $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$

D. $\alpha = 12.50\pi, \beta = \frac{\pi}{2.0}$

Answer: A

Solution:

Solution:
Given,
Wavelength, $l = 0.08m$
Time period, $T = 2.05$
$y(x, t) = 0.005\cos(\alpha x - \beta t)$ (Given)
Comparing it with the standard equation of wave
$y(x, t) = a\cos(kx - \omega t)$ we get

$k = \alpha = \frac{2\pi}{l}$ and $\omega = \beta = \frac{2\pi}{T}$

$\therefore \alpha = \frac{2\pi}{0.08} = 25\pi$ and $\beta = \frac{2\pi}{2} = \pi$

Question132

While measuring the speed of sound by performing a resonance column

experiment, a student gets the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then
[2008]

Options:

A. 18 > x

B. x > 54

C. 54 > x > 36

D. 36 > x > 18

Answer: B

Solution:

Solution:
Fundamental frequency for first resonant length
$v = \frac{v}{4l_1} = \frac{v}{4 \times 18}$ (in winter)
Fundamental frequency for second resonant length
$v' = \frac{3v'}{4l_2} = \frac{3v'}{4x}$ (in summer)
According to questions,
$\therefore \frac{v}{4 \times 18} = \frac{3v'}{4 \times x}$
$\therefore x = 3 \times 18 \times \frac{v'}{v}$
$\therefore x = 54 \times \frac{v'}{v} cm$
$v' > v$ because velocity of light is greater in summer as compared to winter ($v \propto \sqrt{T}$)
$\therefore x > 54cm$

Question133

A sound absorber attenuates the sound level by 20 dB. The intensity decreases by a factor of
[2007]

Options:

A. 100

B. 1000

C. 10000

D. 10

Answer: A

Solution:

Solution:
Loudness of sound. $L_1 = 10 \log(I_1 I_0)$;

$L_2 = 10 \log\left(\frac{I_2}{I_0}\right)$

$\therefore L_1 - L_2 = 10 \log\left(\frac{I_1}{I_0}\right) - 10 \log\left(\frac{I_2}{I_0}\right)$

or, $\Delta L = 10 \log\left(\frac{I_1}{I_0} \times \frac{I_0}{I_2}\right)$

or, $\Delta L = 10 \log\left(\frac{I_1}{I_2}\right)$

The sound level attenuated by $20dB$ ie
$L_1 - L_2 = 20dB$

or, $20 = 10 \log\left(\frac{I_1}{I_2}\right)$ or, $2 = \log\left(\frac{I_1}{I_2}\right)$

or, $\frac{I_1}{I_2} = 10^2$ or, $I_2 = \frac{I_1}{100}$

⇒ Intensity decreases by a factor 100 .

Question134

A string is stretched between fixed points separated by 75.0 cm. It is observed to have resonant frequencies of 420 Hz and 315 Hz. There are no other resonant frequencies between these two. Then, the lowest resonant frequency for this string is [2006]

Options:

A. 105 Hz

B. 1.05 Hz

C. 1050 Hz

D. 10.5 Hz

Answer: A

Solution:

Solution:
It is given that $315Hz$ and $420Hz$ are two resonant frequencies, let these be n^{th} and $(n+1)^{th}$ harmonies, then we have $\frac{nv}{2l} = 315$

and $(n+1)\frac{v}{2l} = 420$

$\Rightarrow \frac{n+1}{n} = \frac{420}{315}$

$\Rightarrow n = 3$

Hence $3 \times \frac{v}{2l} = 315 \Rightarrow \frac{v}{2l} = 105Hz$

The lowest resonant frequency is when $n = 1$
Therefore lowest resonant frequency $= 105Hz$

Question135

A whistle producing sound waves of frequencies 9500 HZ and above is approaching a stationary person with speed v ms^{-1}. The velocity of sound in air is 300ms^{-1}. If the person can hear frequencies upto a maximum of 10, 000HZ , the maximum value of v upto which he can hear whistle is
[2006]

Options:

A. $15\sqrt{2}ms^{-1}$

B. $\frac{15}{\sqrt{2}}ms^{-1}$

C. $15ms^{-1}$

D. $30ms^{-1}$

Answer: C

Solution:

Solution:
Apparent frequency $v' = v[vv - v_s]$
$\Rightarrow 10000 = 9500\left[\frac{300}{300 - v}\right] \Rightarrow 300 - v = 300 \times 0.95$
$\Rightarrow v = 300 - 285 = 15ms^{-1}$

Question136

When two tuning forks (fork 1 and fork 2) are sounded simultaneously, 4 beats per second are heard. Now, some tape is attached on the prong of the fork 2. When the tuning forks are sounded again, 6 beats per second are heard. If the frequency of fork 1 is 200 Hz, then what was the original frequency of fork 2?
[2005]

Options:

A. 202 Hz

B. 200 Hz

C. 204 Hz

D. 196 Hz

Answer: D

Solution:

Solution:
Frequency of fork 1, no = 200 Hz
No. of beats heard when fork 2 is sounded with fork 1 = $\Delta n = 4$
Now on loading (attaching tape) on unknown fork, the mass of tuning fork increases, So the beat frequency increases

(from 4 to 6 in this case) then the frequency of the unknown fork 2 is given by,
$n = n_0 - \Delta n = 200 - 4 = 196 Hz$

Question137

An observer moves towards a stationary source of sound, with a velocity one-fifth of the velocity of sound. What is the percentage increase in the apparent frequency ?
[2005]

Options:

A. 0.5%

B. zero

C. 20 %

D. 5 %

Answer: C

Solution:

Solution:
Apparent frequency
$n' = n\left[\frac{v + v_0}{v}\right] = n\left[v + \frac{v}{5}v\right] = n\left[\frac{6}{5}\right]\frac{n'}{n} = \frac{6}{5}$
The percentage increase in apparent frequency $\frac{n' - n}{n} = \frac{6-5}{5} \times 100 = 20\%$

Question138

The displacement y of a particle in a medium can be expressed as, $y = 10^{-6} \sin\left(100t + 20x + \frac{\pi}{4}\right)$ m where t is in second and x in meter. The speed of the wave is
[2004]

Options:

A. 20 m/s

B. 5 m/s

C. 2000 m/s

D. 5π m/s

Answer: B

Solution:

Solution:

Given, $y = 10^{-6} \sin\left(100t + 20x + \frac{\pi}{4}\right)$ m

Comparing it with standard equation, we get

$\omega = 100$ and $k = 20$

$v = \frac{\omega}{k} = \frac{100}{20} = 5m / s$

Question139

The displacement y of a wave travelling in the x -direction is given by $y = 10^{-4} \sin\left(600t - 2x + \frac{\pi}{3}\right)$ metres where x is expressed in metres and tin seconds. The speed of the wave - motion, in ms^{-1}, is
[2003]

Options:

A. 300

B. 600

C. 1200

D. 200

Answer: A

Solution:

Solution:

$y = 10^{-4} \sin\left(600t - 2x + \frac{\pi}{3}\right)$

On comparing with standard equation

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

we get $\omega = 600$; $k = 2$

Velocity of wave

$v = \frac{\omega}{k} = \frac{600}{2} = 300ms^{-1}$

Question140

A tuning fork of known frequency 256 Hz makes 5 beats per second with the vibrating string of a piano. The beat frequency decreases to 2 beats per second when the tension in the piano string is slightly increased. The frequency of the piano string before increasing the tension was
[2003]

Options:

A. (256 + 2) Hz

B. (256 – 2) Hz

C. (256 – 5) Hz

D. (256 + 5) Hz

Answer: C

Solution:

Solution:
It is given that tuning fork of frequency 256 Hz makes 5 beats/second with the vibrating string of a piano.
Therefore, possible frequency of the piano are (256 ± 5) Hz. i.e., either 261Hz or 251 Hz. When the tension in the piano string increases, its frequency will increases. As the original frequency was 261Hz, the beat frequency should decreases, we can conclude that the frequency of piano string is 251Hz

----

Question141

When temperature increases, the frequency of a tuning fork [2002]

Options:

A. increases

B. decreases

C. remains same

D. increases or decreases depending on the material

Answer: B

Solution:

Solution:
The frequency of a tuning fork is given by

$$f = \frac{m^2 k}{4\sqrt{3}\pi l^2}\sqrt{\frac{Y}{\rho}}$$

As temperature increases, the length or dimension of the prongs increases and also young's modulus increases therefore f decreases.

Question142

Tube A has both ends open while tube B has one end closed, otherwise they are identical. The ratio of fundamental frequency of tube A and B is [2002]

Options:

A. 1 : 2

B. 1 : 4

C. 2 : 1

D. 4 : 1

Answer: C

Solution:

Solution:
The fundamental frequency for tube B closed at one end is given by
$v_B = \frac{v}{4l} \quad \left[\because l = \frac{\lambda}{4}\right]$
Where l = length of the tube and v is the velocity of sound in air.
The fundamental frequency for tube A open with both ends is given by
$v_A = \frac{v}{2l} \quad \left[\because l = \frac{\lambda}{2}\right]$
$\therefore \frac{v_A}{v_B} = \frac{v}{2l} \times \frac{4l}{v} = \frac{2}{1}$

Question143

A wave $y = a\sin(\omega t - kx)$ on a string meets with another wave producing a node at $x = 0$. Then the equation of the unknown wave is [2002]

Options:

A. $y = a\sin(\omega t + kx)$

B. $y = -a\sin(\omega t + kx)$

C. $y = a\sin(\omega t - kx)$

D. $y = -a\sin(\omega t - kx)$

Answer: B

Solution:

Solution:
To form a node there should be superposition of this wave with the reflected wave. The reflected wave should travel in opposite direction with a phase change of π. The equation of the reflected wave will be
$y = a\sin(\omega t + kx + \pi)$
$\Rightarrow y = -a\sin(\omega t + kx)$

Question144

A tuning fork arrangement (pair) produces 4 beats/sec with one fork of frequency 288 cps. A little wax is placed on the unknown fork and it then produces 2 beats/sec. Thefrequency of the unknown fork is [2002]

Options:

A. 286 cps

B. 292 cps

C. 294 cps

D. 288 cps

Answer: B

Solution:

Frequency of unknown fork = known frequency ± Beat frequency = 288 + 4 cps or 288 – 4 cps i.e. 292 cps or 284 cps. When a little wax is placed on the unknown fork, it produces 2 beats/sec. When a little wax is placed on the unknown fork, its frequency decreases and simultaneously the beat frequency decreases confirming that the frequency of the unknown fork is 292 cps.
Note : Had the frequency of unknown fork been 284 cps, then on placing wax its frequency would have decreased thereby increasing the gap between its frequency and the frequency of known fork. This would produce high beat frequency

----