SEC: SR AZ | PHYSICS | DATE: 24-08-23

WAVES

1. The equation of a wave travelling on a string is $y=4\sin\frac{\pi}{2}\left(8t-\frac{x}{8}\right)$ if x and y are in centimetre, then velocity of wave is
   1. $64 cm/s$ in $-ve$ $x-direction$
   2. $32 cm/s$ in $-ve$ $x-direction$
   3. $32 cm/s$ in $+ve$ $x-direction$
   4. $64 cm/s$ in $+ve$ $x-direction$
2. A string of length $2L$, obeying Hooke's law, is stretched so that its extension is L. The speed of the transverse wave travelling on the string is v. If the string is further stretched so that the extension in the string becomes 4L. The speed of transverse wave travelling on the string will be
   1. $\frac{1}{\sqrt{2}}v$
   2. $\sqrt{2}v$
   3. $\frac{1}{2}v$
   4. $2\sqrt{2}v$
3. A band playing music at frequency f is moving towards a wall at a speed v_b. A motorist is following the band with a speed v_m. If v is the speed of sound, the expression for the beat frequency heard by the motorist is
   1. $\frac{v+v_m}{v+v_b}f$
   2. $\frac{v+v_m}{v-v_b}f$
   3. $\frac{2v_b(v+v_m)}{v^2-v_b^2}f$
   4. $\frac{2v_m(v+v_b)}{v^2-v_b^2}f$
4. Speed of sound wave is v. If a reflector moves towards a stationary source emitting waves of frequency f with speed u, the frequency of reflected wave will be
   1. $\frac{v-u}{v+u}f$
   2. $\frac{v-u}{v}f$
   3. $\frac{v+u}{v-u}f$
   4. $\frac{v-u}{v}f$
5. An increase in intensity level of 1 dB implies an increase in intensity of (given antilog$_{10}$ 0.1-1.2589)
   1. 1%
   2. 3.01%
   3. 26%
   4. 0.1%
6. A closed organ pipe and an open organ pipe have their first overtones identical in frequency. Their length are in the ratio
   1. 1: 2
   2. 2: 3
   3. 3: 4
   4. 4: 5
7. Two closed-end pipes, when sounded together produce 5 beats/s. If their lengths are in the ratio 100: 101, then fundamental notes (in Hz) produced by them are
   1. 245, 250
   2. 250, 255
   3. 495, 500
   4. 500, 505
8. Two vibrating tuning forks produce progressive waves given by, $y_1=4\sin(500\pi t)$ and $y_2=2\sin(506\pi t)$. These tuning forks are held near the ear of person. The person will hear
   1. 3 beats/s with intensity ratio between maxima and minima equal to 2
   2. 3 beats/s with intensity ratio between maxima and minima equal to 9
   3. 6 beats/s with intensity ratio between maxima and minima equal to 2
   4. 6 beats/s with intensity ratio between maxima and minima equal to 9
9. Two uniform strings A and B made of steel are made to vibrate under the same tension. If the first overtone of A is equal to the second overtone of B and if the radius of A is twice that of B, the ratio of the length of the strings is
   1. 2: 1
   2. 3:2
   3. 3: 4
   4. 1: 3

10. In a resonance tube experiment, the first two resonances are observed at length 10.5 cm and 29.5cm. The third resonance is observed at the length __________ cm.

1. 47.5 2. 58.5 3. 48.5 4. 82.8

11. The two waves are represented by $y_1 = 10^{-6}\sin\left(100t + \frac{x}{50} + 0.5\right)m$, $y_2 = 10^{-2}\cos\left(100t + \frac{x}{50}\right)m$ where x is in metres and t in seconds. The phase difference between the waves is approximately:

1. 1.07rad 2. 2.07rad 3. 0.5rad 4. 1.5rad

12. The difference in the speeds of sound in air at $-5^\circ C$, 60cm pressure of mercury and $30^\circ C$, 75cm pressure of mercury is (velocity of sound in air at $0^\circ C$ is 332 m/s)

1. 15.25m/s 2. 21.35m/s 3. 18.3m/s 4. 3.05m/s

13. 25 tuning forks are arranged in decreasing order of frequency any two successive forks produce 3beats/sec. If the frequency of the first tuning fork is the octave of last, then frequency of 20th fork is

1. 72Hz 2. 288Hz 3. 84Hz 4. 87Hz

14. The displacement y in centimetre of a particle is $y = 3\sin 314t + 4\cos 314t$. Amplitude and initial phase are

1. $5cm, \tan^{-1}\frac{4}{3}$ 2. $3cm, \tan^{-1}\frac{3}{4}$ 3. $4cm, \tan^{-1}\frac{4}{9}$ 4. $4cm, 0$

15. At t=0, the shape of a travelling pulse is given by $y(x,0) = \frac{4\times10^{-3}}{8-(x)^2}$ where x and y are in metres. The wave function for the travelling pulse if the velocity of propagation is 5m/s in the direction is given by

1. $y(x,t) = \frac{4\times10^{-3}}{8-(x^2-5t)}$ 2. $y(x,t) = \frac{4\times10^{-3}}{8-(x-5t)^2}$

3. $y(x,t) = \frac{4\times10^{-3}}{8-(x+5t)^2}$ 4. $y(x,t) = \frac{4\times10^{-3}}{8-(x^2+5t)}$

16. The linear density of a vibrating string is $10^{-4}\,kg/m$. A transverse wave is propagating on the string, which is described by the equation $y = 0.02\sin(x+30t)$, where x and y are in metre and time t in seconds. Then tension in the string is

1.0.09N 2. 0.36N 3. 0.9N 4. 3.6N

17. Two pulses in a stretched string whose centres are initially 8cm apart are moving towards each other as shown in fig 7.80. The speed of each pulse is 2cm/s. After 2s the total energy of the pulses will be

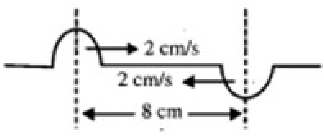


Fig. 7.80

1. Zero 2. Purely kinetic
3. Purely potential 4. Partly kinetic and partly potential

18. An organ pipe P_1 closed at one end vibrating in its first harmonic and another pipe P_2 open at both the ends vibrating in its third harmonic are in resonance with a given tuning fork. The ratio of the length of P_1 to that of P_2 is

1. 8/3 2. 3/8 3. 1/6 4. 1/3

19. The ratio of intensities between two coherent sound sources is 4:1. The difference of loudness in decibels (dB) between maximum and minimum intensities when they interfere in space is
1. 10 log (2)   2. 20 log (3)   3. 10 log(3)   4. 20 log(2)

20. A travelling wave in a stretched string is described by the equation $y = A\sin(kx - \omega t)$.The maximum particle velocity is
1. $A\omega$ 2. ω/k 3. $d\omega/dk$ 4. x/t

21. A man is watching two trains, one leaving and the other coming in with equal speed of $4m/s$. If they sound their whistles, each of frequency 240Hz, the number of beats heard by the man (velocity of sound in air is 320m/s) will be equal to ____

22. The equation of a stationary wave is $y = 0.8\cos\left(\frac{\pi x}{20}\right)\sin 200\pi t$ where x is in cm and t is in s. The separation between consecutive nodes will be _______ cm.

23. A sonometer wire supports a 4 kg load and vibrates in fundamental mode with a tuning fork of frequency 416 Hz. The length of the wire between the bridges is now doubled. In order to maintain fundamental mode, the load should be changes to _____ kg.

24. An air column in a pipe which is closed at one end will be in resonance with a vibrating tinning fork of frequency 264Hz. The length of the air coloumn in cm is (velocity of sound in air= 330m/s) ______

25. The displacement y of a particle executing periodic motion is given by $y = 4\cos^2\frac{t}{2}\sin 1000t$ How many independent harmonic motion may be considered to superpose to result this expression ______

26. A stretched rope having linear mass density $5\times10^{-2}\,kg/m$ is under a tension of 80N. The power that has to be supplied to the rope to generate harmonic waves at a frequency of 60Hz and an amplitude of $\frac{2\sqrt{2}}{15\pi}m$ is ______ W.

27. A stretched string of length 1m fixed at both ends, having a mass of $5\times10^{-4}kg$ is under a tension of 20N. It is plucked at a point situated at 25cm from one end. The stretched string would vibrate with a frequency of _____ Hz.

28. A tube, closed at one end and containing air, produces, when excited, the fundamental mode of frequency 512 Hz. If the tube is open at both ends the fundamental frequency that can be excited is (in Hz) __________

29. An open pipe is suddenly closed at one end and with the result frequency of third harmonic of the closed pipe is found to be higher by 100Hz than the fundamental frequency of the open pipe. The fundamental frequency of the open pipe is _______ Hz.

30. A whistle giving out 450Hz approaches a stationary observer at a speed of 33m/s. The frequency heard by the observer in Hz is (speed sound= 330m/s) _____.

KEY:

1-10	**4**	**4**	**3**	**3**	**3**	**3**	**4**	**2**	**4**	**3**
11-20	**1**	**2**	**4**	**1**	**2**	**1**	**2**	**3**	**2**	**1**
21-30	**6**	**20**	**16**	**31**	**3**	**512**	**200**	**1024**	**200**	**500**

Solutions:

1. $y = 4\sin\left(4\pi t - \frac{\pi}{16}x\right)$

   $\omega = 4\pi, k = \pi/16$

   $v = \frac{\omega}{k} = \frac{4\pi}{\pi/16} = 64\, cm/s$

   in positive x-direction.

2. $v = \sqrt{\frac{T}{\mu}}$

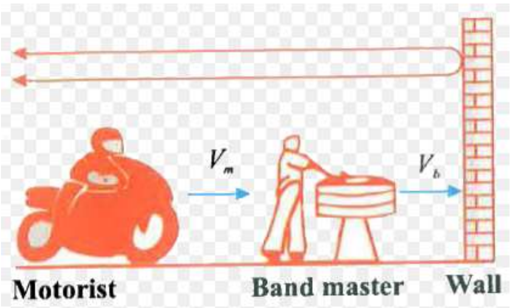
3. The motorist receives two sound waves; direct one and that reflected from the wall.

   $f^1 = \frac{v+v_m}{v+v_b} f$

   For reflected sound waves:

   Frequency of sound wave reflected from the wall is

   $f^{11} = \frac{v}{v-v_b} \times f$

   Frequency of the reflected waves as received by the moving motorist is

   $f^{111} = \frac{v+v_m}{v} \times f^{11} = \frac{v+v_m}{v-v_b} \times f$

   Therefore, the beat frequency is

   $f^{111} - f^1 = \frac{v+v_m}{v-v_b} \times f - \frac{v+v_m}{v+v_b} f$

   $= \frac{2v_b\left(v+v_m\right)}{v^2+v^2{}_b} f$

4. Apparent frequency for reflector (which will act here as an observer) would be $f_1 = \left(\frac{v+u}{v}\right) f$

   where f is the actual frequency of source. The reflector will now behave as a source. The apparent frequency will now become

   $f_2 = \left(\frac{v}{v-u}\right) f_1$

   Substituting the value of f_1 we get

   $f_2 = \left(\frac{v+u}{v-u}\right) f$

5. Intensity level is decibel is given by

$L = 10\log_{10}\frac{I}{I_0}$

$L + 1 = 10\log_{10}\frac{I_1}{I_0}$

Subtracting, $1 = 10\log_{10}\frac{I_1}{I_0} - 10\log_{10}\frac{I}{I_0}$

or $\frac{1}{10} = \log_{10}\frac{I_1}{I}$

or $0.1 = \log_{10}\frac{I_0}{I}$

or $\frac{I_1}{I} = 1.26$

6. $3\times\frac{v}{4l_c} = 2\times\frac{v}{2l_0}\ or\ \frac{l_c}{l_0} = \frac{3}{4}$

7. $\frac{f_1}{f_2} = \frac{101}{100}$

$f_1 - f_2 = 5$

$\frac{101}{100}f_2 - f_2 = 5\ or\ f_2 = 500Hz$

$and\quad f_1 = f_2 + 5 = 505Hz$

8. $v_1 = 250Hz, v_2 = 252Hz, v_2 - v_1 = 3$

Now,

$\frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(4+2)^2}{(4-2)^2} = \frac{36}{4} = 9$

9. According to equation

$2n_1 = 3n_2$

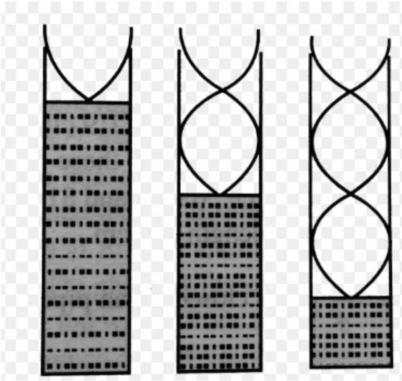
or $\frac{2}{2l}\sqrt{\frac{T}{m_1}} = \frac{3}{2l_2}\sqrt{\frac{T}{m_2}}$

or $\frac{l_1}{l_2} = \frac{2}{3}\sqrt{\frac{m_2}{m_1}} = \frac{2}{3}\sqrt{\frac{a_2\rho}{a_1\rho}}$

or $\frac{l_1}{l_2} = \frac{2}{3}\sqrt{\frac{r_2^{\ 2}}{r_1^{\ 2}}} = \frac{2}{3}\sqrt{\left(\frac{1}{2}\right)^2}$

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

10. $\lambda/2 = 29.5 - 10.5 = 19cm$



3^{rd} resonance= 19+29.5= 48.5cm

11. $y_1 = 10^{-6}\sin\left(100t + \frac{x}{50} + 0.5\right)m$

$y_2 = 10^{-2}\cos\left(100t + \frac{x}{50}\right)m$

$\Rightarrow y_2 = 10^{-2}\sin\left(100t + \frac{x}{50} + \frac{\pi}{2}\right)$

phase difference= $\frac{\pi}{2} - 0.5 = 1.07rad$

12. Velocity of sound is not affected by the change in pressure of air velocity of sound at $1^{\circ}C$,

$v_1 = \left(332 + 0.61t\right)m/s$

At $-5^{\circ}C, v_{-5^{\circ}C} = \left(332 - 0.61 \times 5\right)m/s$

At $-30^{\circ}C, v_{-30^{\circ}C} = \left(332 + 0.61 \times 30\right)m/s$

$\therefore v_{-30^{\circ}C} - v_{-5^{\circ}C} = \left(0.60 \times 35\right)m/s$

$= 21.35m/s$

13. $f_1 - f_{25} = 24 \times 3$

$also\ f_1 = 2f_{25}$

$\therefore 2f_{25} - f_{25} = 72$

$f_{25} = 72$

$Now\ f_{20} - f_{25} = 5 \times 3$

$f_{20} = f_{25} + 15 = 72 + 15 = 87Hz$

14. $a = \sqrt{3^3 + 4^2} = \sqrt{9 + 16} = \sqrt{25} = 5cm$

$\tan\phi = \frac{4}{3}\ or\ \phi = \tan^{-1}\left(\frac{4}{3}\right)$

15. $y\left(x,t\right) = f\left(x - vt\right)$

$y = \left(x,0\right) = \frac{4 \times 10^{-3}}{8 - x^2}$

For travelling wave in the x-direction

$y\left(x,t\right) = \frac{4 \times 10^{-3}}{8 - \left(x - 5t\right)^2}$

16. $y = 0.02\sin(x + 30t)$

Comparing with standard equation

$y = A\sin(Kx + \omega t), \omega = 30, K = 1$

Velocity of wave,

$$v = \frac{\omega}{K} = \frac{30}{1} = 30m/s$$

Expression $v = \sqrt{\frac{T}{m}} gives$

Tension $T = v^2 m = (30)^2 \times 10^{-4} = 0.09N$

17. After 2s, the two pulses will nullify each other. As string now becomes straight, there will be no deformation in the string. In such a situation, the string will not have potential energy at any point. The whole energy will be kinetic.

18. Given

$$\frac{v}{4l_1} = \frac{3v}{2l_2} \Rightarrow \frac{l_1}{l_2} = \frac{1}{6}$$

19. $\frac{I_1}{I_2} = \frac{4}{1}\ or\ \sqrt{\frac{I_1}{I_2}} = \frac{2}{1}$

$$\therefore \frac{I_{\max}}{I_{\min}} = \left[\frac{\sqrt{I_1/I_2} + 1}{\sqrt{I_1/I_2} - 1}\right]^2 = \left[\frac{2+1}{2-1}\right]^2 = 9$$

$$\therefore L_1 - L_2 = 10\log\left(\frac{I_{\max}}{I_{\min}}\right) = 10\log 9 = 20\log 3$$

20. $V = \frac{dy}{dt} = -A\omega\cos(kx - \omega t)$

$\therefore V_{\max} = A\omega$

21. Apparent frequency due to train which is coming in is $n_1 = \frac{v}{v - v_s} n$

Apparent frequency due to train which is leaving is $n_2 = \frac{v}{v + v_s} n$

So the number of beats is

$$n_1 - n_2 = \left(\frac{1}{316} - \frac{1}{324}\right) 320 \times 240 \Rightarrow n_1 - n_2 = 6$$

22. Standard equation

$$y = A\cos\frac{2\pi x}{\lambda}\sin\frac{2\pi vt}{\lambda}$$

By comparing this equation with given equation

$$\frac{2\pi x}{\lambda} = \frac{\pi x}{20} \Rightarrow \lambda = 40cm$$

Distance between two nodes $= \lambda/2 = 20cm$

23. For the given problem,

$$\frac{\sqrt{T}}{l} = cons\tan t$$

$T \alpha l^2$

24. $f = \frac{v}{4l}$ or

$l = \frac{v}{4f} = \frac{330}{4 \times 264} m$

$= 0.3125m = 31.25cm$

25. $y = 4\cos^2\left(\frac{t}{2}\right)\sin 1000t$

$= 2(1+\cos t)\sin 1000t$

$= 2\sin 1000t + 2\cos t \sin 1000t$

$= 2\sin 1000t + \sin(1000t + t) + \sin(1000 - t)$

$= 2\sin 1000t + \sin 1001t + \sin 999t$

$= y_1 + y_2 + y_3 = Three\ waves$

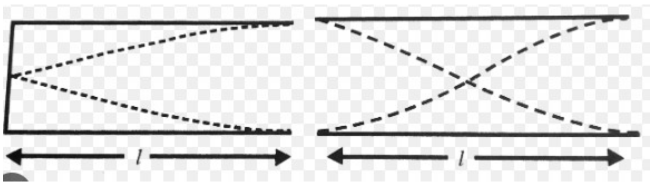
26. $P = \frac{1}{2}\mu\omega^2 A^2 v \quad where\ \ v = \sqrt{\frac{T}{\mu}}$

27. At 25cm, there will be antinode. So wire will vibrate in two loops.

$v = \frac{2}{2l}\sqrt{\frac{T \times l}{M}}\ or\ v = \sqrt{\frac{T}{Ml}} = \sqrt{\frac{20}{5 \times 10^{-4} \times 1}}$

$= \sqrt{4 \times 10^4}\,Hz = 200Hz$

28. $\lambda/4 = l\ (Fundamental\ \mathrm{mod}\,e), \lambda = 4l, c = v\lambda$



$\therefore v = \frac{c}{\lambda} = \frac{c}{4l} = 512Hz$

Given, $\lambda^1/2 = l$

Fundamental mode,

$\therefore \lambda^1 = 2l\ but\ \ c = v^1\lambda^1$

$\therefore v^1 = \frac{c}{\lambda^1} = \frac{c}{2l} = 2\left(\frac{c}{4l}\right)$

$= 2 \times 512 = 1024Hz$

29. For both ends open, fundamental frequency

$\frac{2\lambda_1}{4} = l \Rightarrow \lambda_1 = 2l$

$\therefore v_1 = \frac{c}{\lambda_1} = \frac{c}{2l}$........$(i)$

For one end closed the third harmonic

$\frac{3\lambda_2}{4} = l \Rightarrow \lambda_2 = \frac{4l}{3}$

$v_2 = \frac{c}{\lambda_2} = \frac{3c}{4l}$

Given $v_2 - v_1 = 100$

From eqs (i) *and* (ii)

$\frac{v_2}{v_1} = \frac{3/4}{1/2} = \frac{3}{2}$

on solving, we get $v_1 = 200 Hz$

30. $f^1 = f\left[\frac{v}{v - v_s}\right] = 450\left[\frac{330}{330-33}\right] = 500 Hz$