SOLVED EXAMPLES

Example 1.

The equation of a wave is

$$y(x,t) = 0.05\sin\left[\frac{\pi}{2}(10x - 40t) - \frac{\pi}{4}\right]\text{m}$$. Find

The particle velocity and acceleration at x = 0.5 m and t = 0.05 s

(1) 22.2 m/s, 140 m/s^2 (2) 222 m/s, 14 m/s^2

(3) 2.22 m/s, 140 m/s^2 (4) 22.2 m/s, 14 m/s^2

Solution :

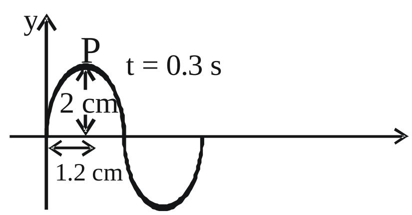
(3) The particle velocity and acceleration are;

$$\frac{dy}{dt} = -(20\pi)(0.05)\cos\left(\frac{5\pi}{2} - \pi - \frac{\pi}{4}\right) = 2.22\,\text{ms}^{-1}$$

$$\frac{d^2y}{dt^2} = -(20\pi)^2(0.05)\sin\left(\frac{5\pi}{2} - \pi - \frac{\pi}{4}\right) = 140\text{ ms}^{-2}$$

Example 2.

Fig. shows a snapshot of a sinusoidal travelling wave taken at t = 0.3 s. The wavelength is 7.5 cm and the amplitude is 2cm. If the crest P was x = 0 at t = 0, write the equation of travelling wave.



(1) $y = 2\sin(0.84x - 3.36t)$ (2) $y = 4\sin(0.84x - 3.36t)$

(3) $y = 2\cos(0.84x - 3.36t)$ (4) $y = 4\cos(0.84x - 3.36t)$

Solution :

(3) Given, A = 2 cm, $\lambda = 7.5\text{cm}$, $k = \frac{2\pi}{\lambda} = 0.84\text{cm}^{-1}$

The wave has travelled as distance of 1.2cm in 0.3s. Hence speed of the wave,

$$v = \frac{1.2}{0.3} = 4\text{cm}\,\text{s}^{-1}$$

$\therefore$ Angular frequency $\omega = v \times k = 3.36\text{rad}\,\text{s}^{-1}$

So, the wave is travelling along (+ve) x- direction and crest (maximum displacement) is at x = 0 at t=0

$\therefore$ $y(x,t) = A\cos(kx - \omega t)$

$\therefore$ The required equation is

$$y(x,t) = (2\text{cm})\cos\left[(0.84\text{cm}^{-1})x - (3.36\text{rad}\,\text{s}^{-1})t\right]$$

Example 3.

The displacement of a standing wave on a string is given by $y(x,t) = 0.4\sin(0.5x)\cos(30t)$, where x and y are in cm.

Find the frequency, amplitude and wave speed of the component waves

(1) 15 Hz, 2cm, 6 cm/s

(2) $\frac{15}{\pi}$ Hz, 0.2cm, 60 cm/s

(3) $\frac{15}{\pi}$ Hz, 2cm, 60 cm/s

(4) $\frac{15}{\pi}$ Hz, 0.2 cm, 6 cm/s

Solution :

(2) The given wave can be written as the sum of two component waves as

$$y(x,t) = 0.2\sin(0.5x - 30t) + 0.2\sin(0.5x + 30t)$$

The two wave component waves

$y_1(x,t) = 0.2\sin(0.5x - 30t)$ ...(+ve) x-direction

$y_2(x,t) = 0.2\sin(0.5x + 30t)$ ...(–ve) x-direction

Now, $\omega = 30$ rad s^{-1}, k = 0.5 cm^{-1}

frequency, $f = \frac{\omega}{2\pi} = \frac{15}{\pi}$ Hz

amplitude, A = 0.2 cm

wave speed, $V = \frac{\omega}{k} = \frac{30}{0.5} = 60\,cms^{-1}$

Example 4.

The speed of longitudinal wave in oxygen at 0°C and 1 atm (= 10^5 Pa). for which the bulk modulus is 1.41×10^5 Pa and density is 1.43 $kgm^{-3}$is

(1) 320 m/s (2) 310 m/s (3) 314 m/s (4) 324 m/s

Solution :

(3) $V_{O_2} = \sqrt{\frac{B}{\rho}} = \sqrt{\frac{1.41\times10^5}{1.43}} = 314ms^{-1}$

Example 5.

At what temperature will the speed of sound in hydrogen be the same as in oxygen at 100°C. Molar masses of oxygen and hydrogen are in the ratio 16:1

(1) 247.9°C (2) 249.7°C (3) –249.7°C (4) –247.9°C

Solution :

(3) $V = \sqrt{\frac{\gamma RT}{M}}$

$V_{H_2} = V_{O_2}$ $\Rightarrow \sqrt{\frac{\gamma_{H_2} RT_{H_2}}{M_{H_2}}} = \sqrt{\frac{\gamma_{O_2} RT_{O_2}}{M_{O_2}}}$

Now, $\gamma_{H_2} = \gamma_{O_2}$

$\therefore$ $T_{H_2} = \left(\frac{M_{H_2}}{M_{O_2}}\right)\times T_{O_2} = \frac{1}{16}(100+273)$ = 23.31 K

$\cong -249.7^{o}C$

Example 6.

Third overtone of a closed organ pipe is in unison with fourth harmonic of an open organ pipe. Find the ratio of the length of the pipes.

(1) 8/7 (2) 7/8 (3) 6/7 (4) 7/6

Solution :

(2) Third overtone of closed organ pipe means seventh harmonic. Given,

$$\left(f_3\right)_{closed} = \left(f_4\right)_{open}$$

$$7.\frac{v}{4l_c} = 4.\frac{v}{2l_o} \qquad \Rightarrow \frac{l_c}{l_o} = \frac{7}{8}$$

Example 7.

An open organ pipe has a fundamental frequency of 300 Hz. The first overtone of a closed organ pipe has the same frequency as the first overtone of the open pipe. How long is each pipe. (Speed of sound in air = 330ms^{-1}).

(1) 41.50 cm (2) 41.25 cm (3) 42.25 cm (4) 42.50 cm

Solution :

(2) Fundamental frequency of an open pipe,

$$f_1 = \frac{v}{2l_o}$$

$$l_o = \frac{v}{2f_1} = \frac{330}{2\times 300} = 0.55\text{m} = 55 \text{ cm}$$

Given, first overtone of closed pipe = first overtone of open pipe

Hence, $3\left(\frac{v}{4l_c}\right) = 2\left(\frac{v}{2l_o}\right)$

$$l_c = \frac{3}{4}l_o = \frac{3}{4}(0.55) = 0.4125 \text{ m} = 41.25 \text{ cm}$$

Example 8.

A siren emitting a sound of frequency 1000 Hz moves away from you toward a cliff at a speed of 10 ms^{-1}. What beat frequency would you hear? Take speed of sound in air as 330 ms^{-1}.

(1) 60 Hz (2) 50.7 Hz

(3) 60.7 Hz (4) 61 Hz

Solution :

(3) Frequency of sound reaching directly to us.

$$f_1 = \left(\frac{v}{v+v_s}\right)f = \left(\frac{330}{330+10}\right)1000 = 970.6\text{Hz}$$

Frequency of sound which is reflected off from the cliff.

$$f_2 = \left(\frac{v}{v-v_s}\right)f = \left(\frac{300}{330-10}\right)1000 = 1031.3\text{Hz}$$

Beat frequency $= f_2 - f_1 = 60.7$ Hz

MULTIPLE CHOICE QUESTIONS

LEVEL - I

1. At what temperature, the velocity of sound will be double its value at 273 K?
   (1) 2 × 273K (2) 4 × 273 K
   (3) 8 × 273 K (4) 16 × 273 K

2. Two sound waves travel in the same direction in a medium. The amplitude of each wave is A and the phase difference between the two waves is 120°. The resultant amplitude will be
   (1) A (2) 2A
   (3) 4A (4) $\sqrt{2}A$

3. The intensity ratio of two waves is 1:16. The ratio of their amplitudes is
   (1) 1:16 (2) 1:4
   (3) 4:1 (4) 2:1

4. A car approaching a crossing at a speed of 20 ms^{-1} sounds a horn of frequency 500 Hz when 80 m from the crossing. Speed of sound in air is 330 ms^{-1}. What frequency is heard by an observer 60 m from the crossing on the straight road which crosses car road at right angles.
   (1) 525 Hz (2) 525.5 Hz
   (3) 530 Hz (4) 520 Hz

5. A tunning fork P of frequency 256 Hz produces 4 beats/s with another tunning fork Q. When a small amount of wax is attached to Q, the number of beats heard per second is 2. The original frequency of the fork Q is
   (1) 258 Hz (2) 262 Hz
   (3) 260 Hz (4) 256 Hz

6. The frequency of a fork is 200 Hz. The distance through which sound travels by the time the fork makes 16 vibration is (velocity of sound in air is 340ms^{-1})
   (1) 34 m (2) 21.25 m
   (3) 425 m (4) 27.2 m

7. The intensity level of a sound wave is said to be 4 decibel. If the intensity of wave is doubled, then the intensity level of sound as expressed in decibel would be
   (1) 8 (2) 16
   (3) 7 (4) 14

8. An open organ pipe P_1 closed as one end vibrating in its first overtone and another pipe P_2 open at both ends vibrating in third overtone are in resonance with a given tunning fork. The ratio of the length of P_1 to that of P_2 is
   (1) 8/3 (2) 3/8
   (3) 1/2 (4) 1/3

9. What is the velocity of sound in water if bulk modulus of water is 2.0×10^{10} dyne/cm^2
   (1) $\sqrt{2}\times10^5 cms^{-1}$ (2) $\sqrt{2}ms^{-1}$
   (3) $1.4\sqrt{2}\times300ms^{-1}$ (4) $\sqrt{2}\times332ms^{-1}$

10. The velocity of sound in air at –136.5°C, if velocity of sound in air is 330 ms^{-1} at NTP is
   (1) 234ms^{-1} (2) 165ms^{-1}
   (3) $165\sqrt{2}ms^{-1}$ (4) –165ms^{-1}

11. Displacement of a particle at a time t and at a distance x cm from the origin is given by
   $y = 5 \sin \frac{\pi x}{3} \cos 40 \pi t$
   The separation between two adjacent nodes is
   (1) 1.5 cm (2) 3 cm
   (3) 6 cm (4) 4 cm

12. The ratio between amplitudes of two superposing waves is 3 : 2. The ratio between the maximum and minimum intensities of the resultant wave will be
   (1) 9 : 4 (2) 25 : 1
   (3) 13 : 5 (4) 5 : 1

13. If a tuning fork of frequency 512 is sounded with a vibrating string of frequency 505.5 the beats produced per sec will be
   (1) 6 (2) 7
   (3) 6.5 (4) Any of the above

14. The sound waves propagate in a metal bar may be
   (1) Longitudinal (2) Transverse
   (3) Torsional
   (4) Either longitudinal or transverse

15. The ratio of velocity of sound through a gas to the r.m.s. velocity of the gas molecules is

(1) γ (2) $\frac{\gamma}{3}$

(3) $\sqrt{\gamma}$ (4) $\sqrt{\frac{\gamma}{3}}$

16. The velocity of sound, through hydrogen is 1400 ms^{-1}. What will be the velocity of sound through a mixture of two parts by volume of hydrogen and one part of oxygen?

(1) $\frac{1400}{\sqrt{2}} ms^{-1}$ (2) $\frac{1400}{\sqrt{3}} ms^{-1}$

(3) $\frac{1400}{\sqrt{5}} ms^{-1}$ (4) $\frac{1400}{\sqrt{6}} ms^{-1}$

17. The intensity level of two sounds are 100 dB and 50 dB. What is the ratio of their intensities?

(1) 10^1 (2) 10^3

(3) 10^5 (4) 10^{10}

18. A tunning fork of frequency 500Hz is sounded on a resonance tube. The first, second and third resonances are obtained at 17 cm, 52 cm and 87 cm respectively. The velocity of sound in ms^{-1}

(1) 170 (2) 350

(3) 520 (4) 850

19. A car is moving with a velocity of 30 ms^{-1} towards a high wall. If frequency of siren of car is 600 Hz and velocity of sound is 330 ms^{-1}, then the apparent frequency of the echo of siren will be

(1) 500 Hz (2) 600 Hz

(3) 720 Hz (4) 760 Hz

20. At each of two stations A and B, a siren is sounding with a constant frequency of 250 Hz. A cyclist from A proceed straight towards B with a velocity of 12 km h^{-1} and hears 5 beats/s. The velocity of sound is nearly.

(1) 325 ms^{-1} (2) 330 ms^{-1}

(3) 333 ms^{-1} (4) 336ms^{-1}

21. 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

(1) 1:2 (2) 1:4

(3) 2:1 (4) 4:1.

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

(1) 286 cps (2) 292 cps

(3) 294 cps (4) 288 cps

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

(1) 10 (2) 100

(3) 1000 (4) 10000

24. 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 0.08 m and 2.0 s, respectively, then α and β in appropriate units are

(1) $\alpha = \frac{0.04}{\pi}, \beta = \frac{1.0}{\pi}$

(2) $\alpha = 12.50\,\pi, \beta = \frac{1\pi}{20}$

(3) $\alpha = 25.00\,\pi, \beta = \pi$

(4) $\alpha = \frac{0.08}{\pi}, \beta = \frac{2.0}{\pi}$

25. 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

(1) $54 > x > 36$ (2) $36 > x > 18$

(3) $18 > x$ (4) $x > 54$

LEVEL - II

1. A tunning fork P of frequency 512 Hz produces 6 beats per second with another tunning fork Q. When Q is slightly filed, the number of beats heard per second is 8. The original frequency of Q is

(1) 506 Hz (2) 518 Hz
(3) 515 Hz (4) 521 Hz

2. A sonometer wire supports a 4 kg load and vibrates in fundamental mode with a tunning 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 changed to

(1) 1 kg (2) 2 kg
(3) 8 kg (4) 16 kg

3. Small amplitude progressive waves in a stretched string have a speed of 100 cms^{-1} and frequency 100 Hz. The phase difference between the two points 2.75 cm apart on the string, in radian, is

(1) 0 (2) $\frac{11\pi}{2}$
(3) $\frac{\pi}{4}$ (4) $\frac{3\pi}{8}$

4. The speed of sound in air under ordinary condition is around 330 ms^{-1}. The speed of sound in hydrogen under similar conditions will be (in ms^{-1}) nearest to

(1) 330 (2) 1200
(3) 600 (4) 900

5. The apparent frequency of the whistle of an engine changes in the ratio of 6 : 5 as the engine passes a stationary observer. If the velocity of sound is 330 ms^{-1}, then the velocity of the engine is

(1) 3 ms^{-1} (2) 30 ms^{-1}
(3) 0.33 ms^{-1} (4) 660 ms^{-1}

6. What is the minimum length of a tube, open at both ends, that resonates with a tunning fork of frequency 350 Hz? (Velocity of sound in air = 350 ms^{-1})

(1) 50 cm (2) $\cong$ 50cm
(3) 100 cm (4) $\cong$ 100cm

7. The frequency of a sonometer wire is 100 Hz. If the length of the string is doubled and the tension is changed, the new frequency becomes 75 Hz. The ratio of original and final tensions is

(1) 4 : 3 (2) 4 : 9
(3) 9 : 4 (4) 3 : 4

8. The sound wave of frequency 500 Hz covers a distance of 1000 m in 5s between the points X and Y. Then the number of waves between X and Y is

(1) 500 (2) 1000
(3) 2500 (4) 5000

9. The equation of a stationary wave is $y = 4\sin\left(\frac{\pi x}{15}\right)\cos(96\pi t)$. The distance between a node and its next antinode is

(1) 7.5 units (2) 1.5 units
(3) 22.5 units (4) 30 units

10. The temperature at which sound travels in hydrogen with the same velocity as in oxygen at 1000°C is

(1) 82.34°C (2) –17°C
(3) –780.3°C (4) –193.4°C

11. A string is divided into three segments, so that the segments possess fundamental frequencies in the ratio 1 : 2 : 3. Then the lengths of the segments are in the ratio

(1) 6 : 3 : 2 (2) 4 : 3 : 2
(3) 4 : 2 : 1 (4) 3 : 2 : 1

12. Two open pipes of lengths 20 cm and 20.1 cm produce 5 beats/s. The velocity of sound in the gas is

(1) 402 ms^{-1} (2) 340 ms^{-1}
(3) 420 ms^{-1} (4) 330 ms^{-1}

13. The frequency of B is 3% greater than that of A. The frequency of C is 2% less than that of A. If B and C produce 8 beats/s, then the frequency of A is

(1) 136 Hz (2) 168 Hz
(3) 164 Hz (4) 160 Hz

14. Two wires are kept tight between the same pair of supports. The tensions in the wires are in the ratio 2:1 , the radii are in the ratio 3:1 and the densities are in the ratio 1 : 2. The ratio of their fundamental frequencies is

(1) 2 : 3 (2) 2 : 4
(3) 2 : 5 (4) 2 : 6

15. A man is watching two trains, one leaving and the other coming with equal speed of 4 ms^{-1}. The trains sound their whistle, each of natural frequency of 240 Hz if velocity of sound in air is 320ms^{-1}, then the number of beats heard by the man is

(1) 6 (2) 3
(3) 0 (4) 12

16. If the amplitude of sound is doubled and the frequency reduced to one fourth, the intensity of sound at the same place will be

(1) increased by a factor of 2
(2) decreased by a factor of 2
(3) decreased by a factor of 4
(4) unchanged

17. If a stone is dropped into a lake from a tower, the sound of splash is heard by a man after 11.5 s, then what is the height of tower?

(1) 1000 m (2) 100 m
(3) 500 m (4) 150 m

18. The equation of a sound wave in air is P = 0.01 cos(1000t – 3x), where P, x and t are in S.I units. The bulk modulus of elasticity is 1.4×10^5 Nm^{-2}. The displacement amplitude is

(1) 0.24 m (2) 0.24×10^{-7} m
(3) 8×10^{-7} m (4) 10 m

19. The velocity of sound is not affected by change in

(1) temperature (2) medium
(3) pressure (4) wavelength

20. A sound wave of pressure amplitude 14 pascal propagates through the air medium. The normal pressure of air is $1.0\times10^5 N/m^2$. The difference between maximum and minimum pressure in the medium is

(1) 5×10^5 N/m^2 (2) 10×10^5 N/m^2
(3) $10Nm^{-2}$ (4) none

21. A metal wire of linear mass density of 9.8 g/m is stretched with a tension of 10 kg wt between two rigid supports 1 metre apart. The wire passes at its middle point between the poles of a permanent magnet, and it vibrates in resonance when carrying an alternating current of frequency n. The frequency n of the alternating source is

(1) 25Hz (2) 50 Hz
(3) 100 Hz (4) 200 Hz

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

(1) 200 (2) 300
(3) 600 (4) 1200.

23. 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 strig]

(1) 256 + 5 Hz
(2) 256 + Hz
(3) 256 – 2 Hz
(4) 256 – 5 Hz

24. The displacement y of a particle in a medium can be expressed as: $y = 10^{-6}\sin(100t + 20x + \pi/4)$ m, where t is in second and x in metre. The speed of the wave is

(1) 2000 m/s (2) 5 m/s
(3) 20 m/s (4) 5π m/s

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

(1) 20 % (2) 5 %
(3) 0.5 % (4) zero.

LEVEL - III

1. A simple harmonic wave has the equation $y = 3.5\sin(314t - 1.57x)$

Another wave has the equation

$$y = 0.1\sin(314t - 1.57x + 1.57)$$

The phase difference between the two waves is

(1) π (2) $\frac{\pi}{2}$

(3) $\frac{2\pi}{3}$ (4) $\frac{\pi}{6}$

2. Two coherent sources are at distances x_1 = 0.2 m and x_2 = 0.08 m from a point. The intensity of resultant wave at that point if the frequency of each wave is f = 400 Hz and velocity of wave in the medium is V = 192 m/s is (Intensity of each wave is I_0 = 60 W/m^2)

(1) 100 W/m^2 (2) 110 W/m^2

(3) 120 W/m^2 (4) 130 W/m^2

3. The transverse displacement of a string (clamped at its both ends) is given by

$$y = 0.06\sin\left(\frac{2\pi}{3}x\right)\cos(120\pi t)$$

Where x and y are in metres and t is in seconds. The length of the string is 1.5 m and its mass is 3.0×10^{-2} kg. The tension in the string is

(1) 645 N (2) 670 N

(3) 648 N (4) 650 N

4. A one metre long stretched string having a mass of 40 g is attached to a tuning fork. The fork vibrates at 128 Hz in a direction perpendicular to the string. What should be the tension in the string if it is to vibrate in four loops?

(1) 163.50 N (2) 163.84 N

(3) 163.95 N (4) 163.90 N

5. Find the wavelength of a wave in water having a frequency of 242 Hz. Bulk modules of water $B_{water} = 2 \times 10^9$ Pa, $\rho_{water} = 1.0 \times 10^3 \text{kg/m}^3$,

(1) 5.84 m (2) 5.94 m

(3) 5.74 m (4) 5.80 m

6. A transverse wave described by $y = 0.02(\text{m})\sin\left[(1.0\text{m}^{-1})x + (30s^{-1})t\right]$

propogates on a stretched string having a linear mass density of 1.2×10^{-4} kg/m. The tension in the string is

(1) 0.105 N (2) 0.106 N

(3) 0.109 N (4) 0.108 N

7. A wave of wavelength 0.60 cm is produced in air and it travels at a speed of 300 m/s. Find the frequency.

(1) 500 Hz (2) 5000 Hz

(3) 50000 Hz (4) 500000 Hz

8. Two blocks each having a mass of 3.2 kg are connected by a wire CD and the system is suspended from the ceiling by another wire AB. The linear mass density of the wire AB is 0.01kg/m and that of CD is 8×10^{-3} kg/m. Find the speed of a transverse wave pulse produced in AB and in CD (g = 9.8 m/s^2)

(1) 79 m/s, 62.6 m/s (2) 62.6 m/s, 76 m/s

(3) 63 m/s, 78 m/s (4) 78 m/s, 63 m/s

9. If the lengths of the first and second resonating air columns are 16.5 cm and 51.5 cm respectively with a tuning fork of frequency 512 Hz, the velocity of sound in air is

(1) 358 m/s (2) 358.4 m/s

(3) 359 m/s (4) 359.4 m/s

10. The loudness level of ordinary conversation is 60 dB. The intensity of the ordinary conservation is

(1) 10^{-4} Wm^{-2} (2) 10^{-5} Wm^{-2}

(3) 10^{-6} Wm^{-2} (4) 10^{-7} Wm^{-2}

11. A particle is moving with velocity

$\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is

(1) $y^2 = x^2$ + constant

(2) $y = x^2$ + constant

(3) $y^2 = x$ + constant

(4) xy = constant.

ANS WERS(WAVE MOTION)

LEVEL - I

1.	(2)	6.	(4)	11.	(2)	16.	(4)	21.	(3)
2.	(1)	7.	(3)	12.	(2)	17.	(3)	22.	(2)
3.	(2)	8.	(2)	13.	(3)	18.	(2)	23.	(2)
4.	(2)	9.	(1)	14.	(4)	19.	(3)	24.	(3)
5.	(3)	10.	(3)	15.	(4)	20.	(3)	25.	(4)

LEVEL - II

1.	(1)	6.	(2)	11.	(1)	16.	(3)	21.	(2)
2.	(4)	7.	(2)	12.	(1)	17.	(3)	22.	(2)
3.	(2)	8.	(3)	13.	(4)	18.	(2)	23.	(4)
4.	(2)	9.	(1)	14.	(1)	19.	(3)	24.	(2)
5.	(2)	10.	(4)	15.	(1)	20.	(3)	25.	(1)

LEVEL - III

1.	(2)	3.	(3)	5.	(1)	7.	(3)	9.	(2)
2.	(3)	4.	(2)	6.	(4)	8.	(1)	10.	(3)
								11.	(1)

SOLUTIONS (LEVEL - III)

1. Phase difference

(314t – 1.57x + 1.57) – (314t – 1.57x)

$\Rightarrow$ 1.57

$\Rightarrow \frac{\pi}{2}$

2. Path difference = $x_1 - x_2$

= 0.2 – 0.08 = 0.12 m

Phase difference $\phi = \frac{2\pi}{\lambda}$ path difference

$= \frac{2\pi}{\lambda} \times 0.12$

$= \frac{2\pi}{v/f} \times 0.12$

$= \frac{2\pi}{192} \times 400 \times 0.12 = \frac{\pi}{2}$

Phase difference $\phi = \frac{\pi}{2}$

Resultant Intensity $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$= I_0 + I_0 + 2I_0 \cos\frac{\pi}{2}$

$= 2I_0 = 2 \times 60$

$I = 120 \ \frac{W}{m^2}$

3. $y = 0.06\sin\left(\frac{2\pi}{3}x\right)\cos 120\pi t$

The above equation of wave represents a standing wave.

Comparing with standard equation of standing wave,

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

we have

$A = 0.06\text{m}, \ \frac{2\pi}{\lambda} = \frac{2\pi}{3} \Rightarrow \lambda = 3\text{m}$

$\frac{2\pi}{\lambda} \cdot \nu = 120\pi$

$\Rightarrow \nu = \lambda \times 60 = 3 \times 60$

$\nu = 180$ m/s

Let tension in the string be T.

$\nu = \sqrt{\frac{T}{m}}$

$T = \nu^2 \cdot m$

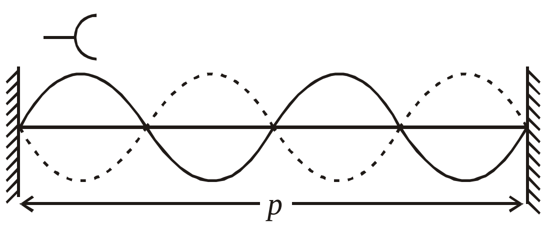
$= (180)^2 \times \frac{3.0 \times 10^{-2}}{1.5}$ {m = mass per unit length $= \frac{3.0 \times 10^{-2}}{1.5}$ }

T = 648 N

4. $l = 1$ m

Since it is vibrating in four loops

$\lambda + \lambda = l$



$\Rightarrow \lambda = \frac{l}{2} = \frac{1}{2} = 0.5\text{m}$

V = fλ

= 128 Hz × 0.5

V = 64 m/s

Let the tension be 'T;

$V = \sqrt{\frac{T}{m}}$

$T = V^2 m$

where m = linear mass density

$= (64)^2 \times \frac{40 \times 10^{-3}\text{kg}}{1\text{m}}$

T = 163.84 N

5. Speed of sound wave $V = \sqrt{\frac{B}{\rho}}$

$= \sqrt{\frac{2 \times 10^9}{10^3}}$ = 1414 m/s

Wave length $\lambda = \frac{V}{f} = \frac{1414}{242}$

$\lambda = 5.84\text{m}$

6. Wave equation is $y = 0.02 \sin(x + 30t)$

Equating with equation of wave $y = a \sin \frac{2\pi}{\lambda}(vt + x)$, we get

Velocity of wave v = 30 m/s

Velocity of wave in strecthed string.

Let the tension in the string be 'T'

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

$\Rightarrow T = v^2 m = (30)^2 \cdot 1.2 \times 10^{-4}\text{kg/m}$

T = 0.108 N

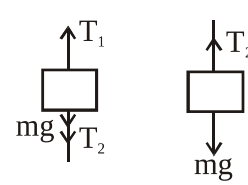
7. From relation

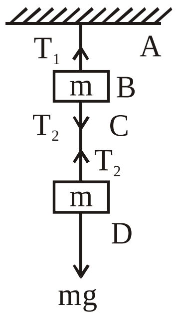
$\nu = f\lambda$

Frequency $f = \frac{\nu}{\lambda} = \frac{300}{0.60 \times 10^{-2}}$ = 50000 Hz

8. Let the tension in wire AB and CD be T_1 and T_2

T_1 and T_2 can be calculated as follows :





$m = 3.2$ kg

It is obvious from free body diagram that

$T_1 = T_2 + mg$ ....(1)

$T_2 = mg$ ....(2)

$\Rightarrow T_1 = mg + mg$

$T_1 = 2\,mg = 2 \times 3.2 \times 9.8$ N

$T_1 = 62.72$ N

$T_2 = 31.36$ N

Velocity of wave in wire AB is

$$V_1 = \sqrt{\frac{T_1}{m_1}} = \sqrt{\frac{62.72}{10 \times 10^{-3}}}$$

$V_1 = 79$ m/s

Velocity of wave in wire CD is

$$V_2 = \sqrt{\frac{T_2}{m_2}} = \sqrt{\frac{31.36}{8 \times 10^{-3}}}$$

$V_2 = 62.6$ m/s.

9. $l_1 = 16.5$ cm, $f = 512$ Hz

$l_2 = 51.5$ cm

$l_2 - l_1 = 51.5 - 16.5 = 35$ cm

$(l_2 - l_1) = 0.35$ m

Velocity of sound in air

$V = 2f\,(l_2 - l_1) = 2 \times 512 \times 0.35$

$V = 358.4$ m/s

10. Here L = 60 dB

Using $L = 10 \log_{10}\left(\frac{I}{I_0}\right)$, we get

$$\frac{I}{I_0} = \text{Antilog of } \left(\frac{L}{10}\right) = \text{Antilog of } \left(\frac{60}{10}\right)$$

$= \text{Antilog of } (6) = 10^6$

or $I = I_0 \times 10^6$

Since $I_0 = 10^{-12}$ Wm^{-2}

$\therefore$ $I = 10^{-12} \times 10^6 = 10^{-6}$ Wm^{-2}

11. $$\frac{dx}{dt} = ky$$

$$\frac{dy}{dt} = kx$$

$$\frac{dy}{dx} = \frac{x}{y}$$

$$ydy = xdx$$

$$y^2 = x^2 + \text{constant}.$$