## DPP – 4 (Waves)

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Q 1. A wave represented by the equation $y_1$ = A cos (kx - ωt), is superimposed with another wave to form a stationary wave such that the point x = 0 is a node. The equation of the other wave is:

(a) $y_2$= - A sin (kx - ω t) (b) $y_2$ = - A cos (kx + ω t)
(c) $y_2$ = A sin (kx + ω t) (d) $y_2$ = A cos (kx + ω t)

Q 2. The equation for the vibration of a string fixed at both ends vibrating in its third harmonic is given by y = 2cm sin [(0.6 $cm^{-1}$)x] cos[(500 π$s^{-1}$)t] . The length of the string is

(a) 24.6 cm (b) 12.5 cm (c) 20.6 cm (d) 15.7 cm

Q 3. The frequency of a sonometer wire is 100 Hz. When the weights producing the tensions are completely immersed in water the frequency becomes 80 Hz and on immersing the weights in a certain liquid the frequency becomes 60 Hz. The specific gravity of the liquid is

(a) 1.42 (b) 1.77 (c) 1.82 (d) 1.21

Q 4. A string of mass 0.2 kg/m and length 1= 0.6 m is fixed at both ends and stretched such that it has a tension of 80 N. The string vibrates in 3 segments with maximum amplitude of 0.5 cm. The maximum transverse velocity amplitude is:

(a) 1.57 m/s (b) 6.28 m/s (c) 3.14 m/s (d) 9.42 m/s

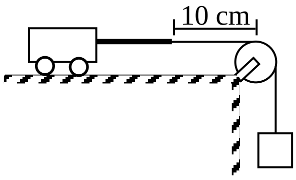
Q 5. A string fixed at both ends is vibrating in the lowest mode of vibration for which a point at quarter of its length from one end is a point of maximum amplitude. The frequency of vibration in this mode is 100 Hz. What will be the frequency emitted when it vibrates in the next mode such that this point is again a point of maximum displacement?

(a) 400 Hz (b) 200 Hz (c) 600 Hz (d) 300 Hz

Q 6. A standing wave is maintained in a homogeneous string of cross-sectional area s and density p. It is formed by the superposition of two waves travelling in opposite directions given by the equation $y_1$ = a sin(ωt – kx) and $y_2$ = 2a sin(ωt + kx) .The total mechanical energy confined between the sections corresponding to the adjacent antinodes is

(a) $\frac{3\pi\rho\omega^2a^2}{2k}$ (b) $\frac{\pi\rho\omega^2a^2}{2k}$ (c) $\frac{5\pi\rho s\omega^2a^2}{2k}$ (d) $\frac{3s\pi\rho\omega^2a^2}{2k}$

Q 7. A heavy string is tied at one end to a movable support and to a light thread at the other end as shown in figure. The thread goes over a fixed pulley and supports a weight to produce a tension. The lowest frequency with which the heavy string resonates is 120 Hz. If the movable support is pushed to the right by 10 cm so that the joint is placed on the pulley, then the minimum frequency at which the heavy string can resonate is–




(a) 120 Hz (b) 60 Hz (c) 240 Hz (d) 480 Hz

Q 8. A sonometer wire under tension T is in unison with a tuning fork of frequency 250 Hz. If now the sonometer wire is replaced by another hollow wire of the same diameter, the number of loops shall-
(a) Decrease (b) Increase
(c) Remain the same (d) Incomplete information

Q 9. A string vibrates according to equation y = 5 sin $\frac{\pi x}{3}$ cos 40πt. The potential energy of the string will be zero at times
(a) 1/40 sec, 1/80 sec (b) 1/80 sec, 3/80 sec
(c) 1/40 sec, 3/40 sec (d) None of these

Q 10. In stationary waves all particle between two adjacent nodes passes through the mean position-
(a) At different times with difference velocities
(b) At different times with same velocity
(c) At the same time with equal velocity
(d) At the same time with difference velocities

Q 11. Standing waves are produced in a 10 m long stretched string. If the string vibrates in 5 segment and the wave velocity is 20 m/s, the frequency is -
(a) 2 Hz (b) 4 Hz (c) 5 Hz (d) 10 Hz

Q 12. The equation of a stationary wave is y = 0.8 cos $\left(\frac{\pi x}{20}\right)$ sin 200 πt, where x is in cm and t is in sec. The separation between consecutive nodes will be-
(a) 20 cm (b) 10 cm (c) 40 cm (d) 30 cm

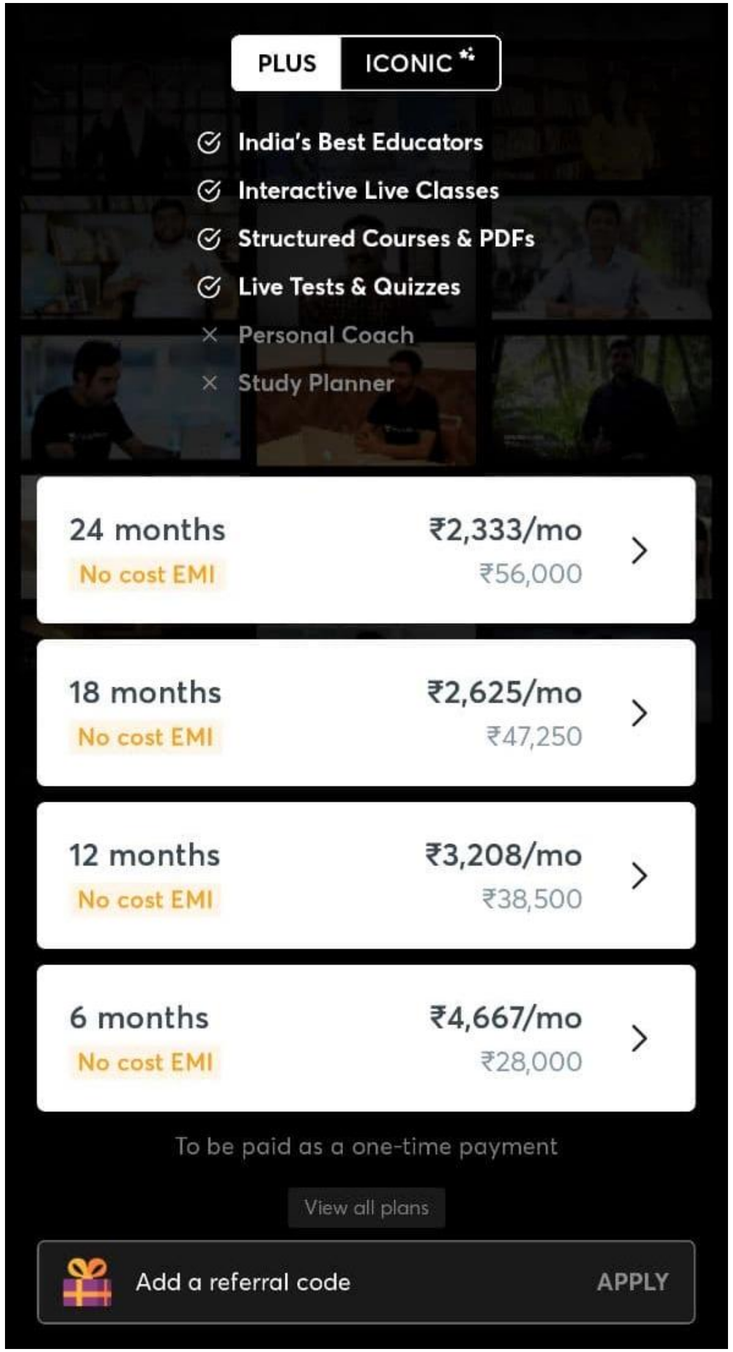
Q 13. **Statement-1 (S-1) :** A string is carrying sinusoidal wave. Consider a small segment of string then total energy of this small segment is conserved.
**Statement-2 (S-2) :** A standing wave pattern is formed in a string. The power transfer through each and every point on string is always zero.
Choose the correct option
(a) S-1 True, S-2 True (b) S-1 True, S-2 False
(c) S-1 False, S-2 True (d) S-1 False, S-2 False

Q 14. A standing wave y = A sin $\left(\frac{20}{3}\pi x\right)$cos (1000πt) is maintained in a taut string where y and x are expressed in meters. The distance between the successive points oscillating with the amplitude A/2 across a node is equal to
(a) 2.5cm (b) 25cm (c) 5cm (d) 10cm

Q 15. A string fixed at both ends has consecutive standing wave modes for which the distances between adjacent nodes are 18 cm and 16 cm respectively. The length of the string is–
(a) 144 cm (b) 152 cm (c) 176 cm (d) 200 cm.

# Answer Key

| | | | | |
|---|---|---|---|---|
| Q.1 b | Q.2 d | Q.3 b | Q.4 a | Q.5 d |
| Q.6 c | Q.7 c | Q.8 a | Q.9 b | Q.10 d |
| Q.11 c | Q.12 a | Q.13 d | Q.14 c | Q.15 a |

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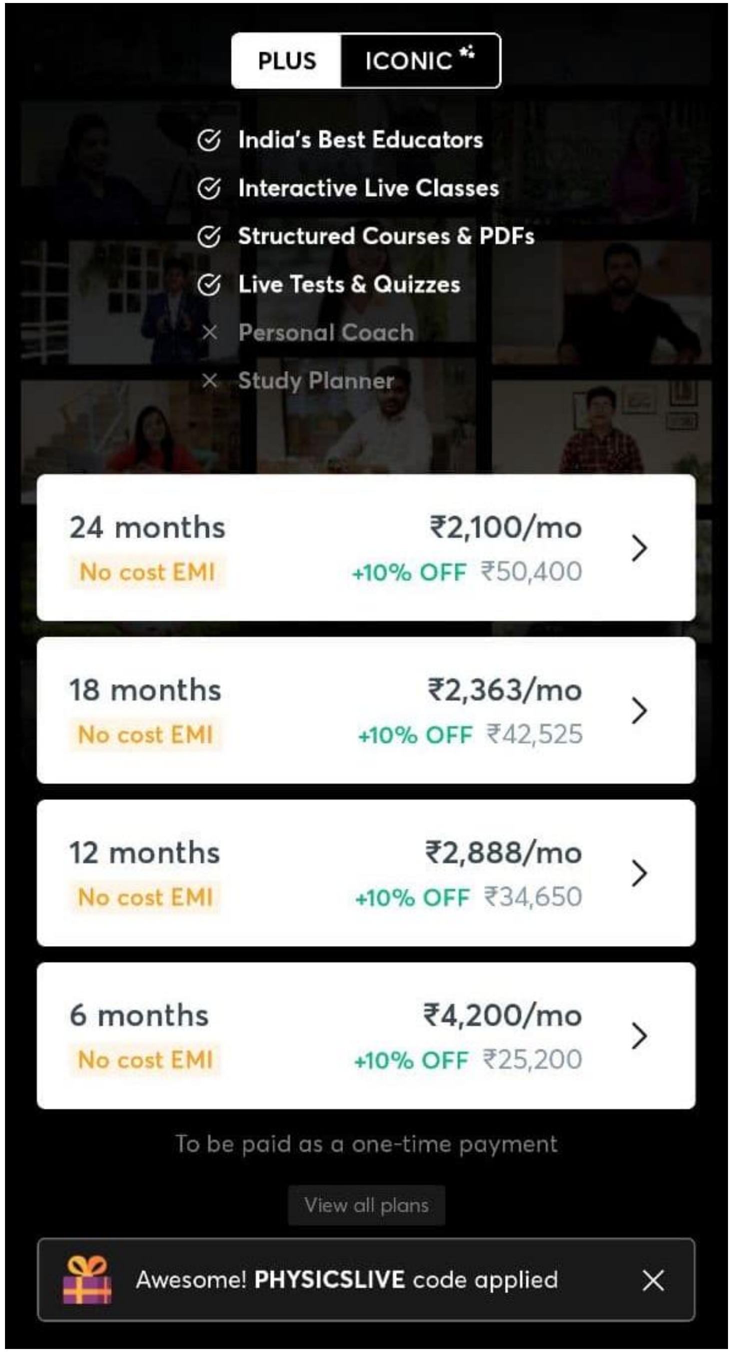


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# Written Solution

## DPP-4 Waves: Standing Waves

**By Physicsaholics Team**

Q1) A wave represented by the equation $y_1$ = A cos (kx - ωt), is superimposed with another wave to form a stationary wave such that the point x = 0 is a node. The equation of the other wave is:

Second wave must be in opposite direction

at $x=0$, $y_1 = A\cos(-\omega t) = A\cos\omega t$

for node at $x=0$

$y_1 + y_2 = 0$

(a) $y_2 = -A\sin(kx - \omega t)$

(b) $y_2 = -A\cos(kx + \omega t)$

at $x=0$, $y_2 = -A\cos\omega t$

(c) $y_2 = A\sin(kx + \omega t)$

at $x=0$

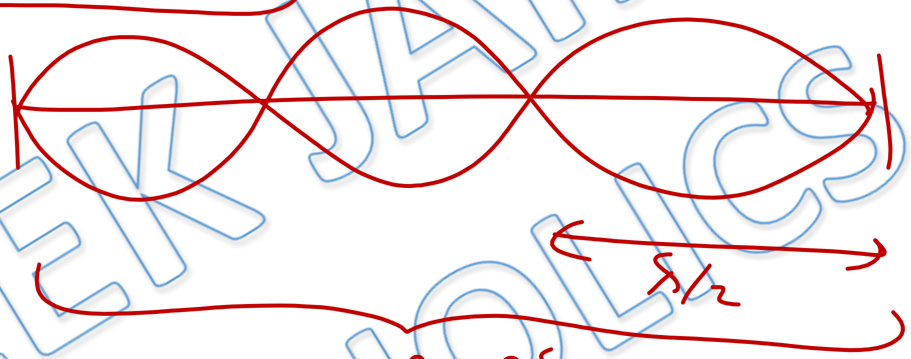
$y_2 = A\sin\omega t$

(d) $y_2 = A\cos(kx + \omega t)$

at $x=0$

$y_2 = A\cos\omega t$

Q2) The equation for the vibration of a string fixed at both ends vibrating in its third harmonic is given by $y = 2\text{cm} \sin[(0.6\ \text{cm}^{-1})x] \cos[(500\ \pi\text{s}^{-1})t]$ . The length of the string is




$K = .6 = \frac{2\pi}{\lambda}$

$\lambda = \frac{2\pi}{.6}$

$l = \frac{3\lambda}{2} = \frac{3}{2} \times \frac{2\pi \times 10}{6} = 5\pi\ \text{cm}$

(a) 24.6 cm (b) 12.5 cm (c) 20.6 cm (d) 15.7 cm ✓

Q3) The frequency of a sonometer wire is 100 Hz. When the weights producing the tensions are completely immersed in water the frequency becomes 80 Hz and on immersing the weights in a certain liquid the frequency becomes 60 Hz. The specific gravity of the liquid is

$f_0 = \frac{1}{2l}\sqrt{\frac{mg}{\mu}} = 100$ --- (I)

$\frac{1}{2l}\sqrt{\frac{mg(1-\frac{\rho_w}{\rho_s})}{\mu}} = 80$ --- (II)

$\frac{1}{2l}\sqrt{\frac{mg(1-\frac{\rho_l}{\rho_s})}{\mu}} = 60$ --- (III)

$\sqrt{1-\frac{\rho_w}{\rho_s}} = \frac{80}{100} = \frac{4}{5}$

$1-\frac{\rho_w}{\rho_s} = \frac{16}{25}$

$\frac{\rho_w}{\rho_s} = \frac{9}{25}$

$\frac{Eq (III)}{Eq (I)}$

$\Rightarrow \sqrt{1-\frac{\rho_l}{\rho_s}} = \frac{60}{100} = \frac{3}{5}$

(a) 1.42 (b) 1.77 (c) 1.82 (d) 1.21

$\Rightarrow 1-\frac{\rho_l}{\rho_s} = 9/25$

$\Rightarrow \frac{\rho_l}{\rho_s} = \frac{16}{25}$

$\rho_l = \frac{16}{25}\rho_s = \frac{16}{25}\times\frac{25\rho_w}{9}$

$\frac{\rho_l}{\rho_w} = \frac{16}{9} = 1.77$

Q4) A string of mass 0.2 kg/m and length 1= 0.6 m is fixed at both ends and stretched such that it has a tension of 80 N. The string vibrates in 3 segments with maximum amplitude of 0.5 cm. The maximum transverse velocity amplitude is:

→ Third harmonic

$$f_3 = \frac{3}{2l}\sqrt{\frac{F}{\mu}}$$

$$= \frac{3}{2 \times .6}\sqrt{\frac{800}{2}} = \frac{3}{2 \times .6} \times 200 = 50\,Hz.$$

$V_{max} = \omega A$ at mean position

(a) 1.57 m/s ✓

(b) 6.28 m/s

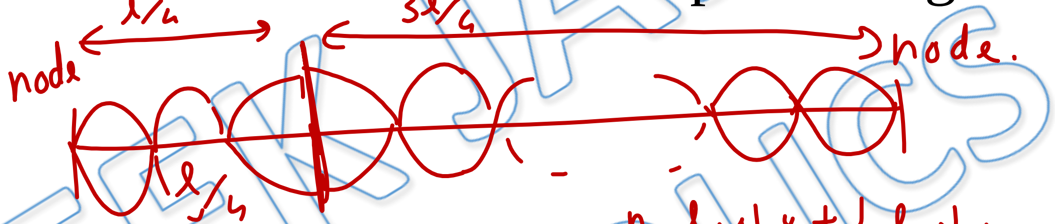
(c) 3.14 m/s

(d) 9.42 m/s

$$V_{max} = 2\pi \times 50 \times \frac{.5}{100}$$

$$= 1.57\ m/sec$$

Q5) A string fixed at both ends is vibrating in the lowest mode of vibration for which a point at quarter of its length from one end is a point of maximum amplitude. The frequency of vibration in this mode is 100 Hz. What will be the frequency emitted when it vibrates in the next mode such that this point is again a point of maximum displacement?




$n_1 \frac{\lambda}{2} + \frac{\lambda}{4} = l/4$

$n_2 \frac{\lambda}{2} + \frac{\lambda}{4} = \frac{3l}{4}$

$n_1$ loops Antinode + $\frac{1}{2}$ loop

$n_1$ loops + $\frac{1}{2}$ loop.

for smallest freq

(a) 400 Hz (b) 200 Hz (c) 600 Hz (d) 300 Hz

$\frac{2n_1+1}{2n_2+1} = \frac{1}{3} = \frac{3}{9} = \frac{5}{15} = \_ \_$ → for next possible freq

$2n_1+1 = 1$, $n_1 = 0$

$2n_2+1 = 3$, $n_2 = 1$

for smallest freq

no of loops = 2

⇒ 2nd Harmonic.

→ fundamental.

$2f_0 = 100 \Rightarrow f_0 = 50\,Hz$

for next possible freq →

$2n_1+1 = 3 \Rightarrow n_1 = 1$

$2n_2+1 = 9 \Rightarrow n_2 = 4$

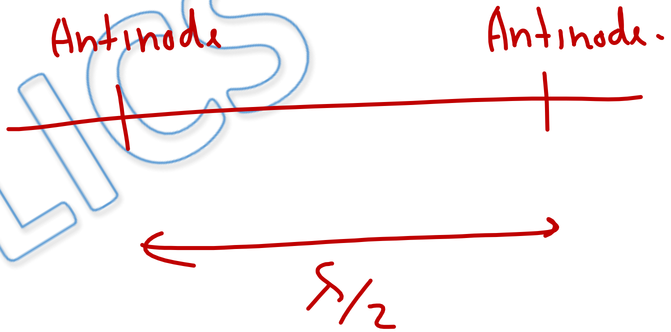
total no of loops = 4+1+1 = 6

$f_6 = 6f_0 = 300\,Hz$

Q6) A standing wave is maintained in a homogeneous string of cross-sectional area s and density p. It is formed by the superposition of two waves travelling in opposite directions given by the equation $y_1 = a \sin(\omega t - kx)$ and $y_2 = 2a \sin(\omega t + kx)$ .The total mechanical energy confined between the sections corresponding to the adjacent antinodes is

(a) $\frac{3\pi\rho\omega^2 a^2}{2k}$


(b) $\frac{\pi\rho\omega^2 a^2}{2k}$




(c) $\frac{5\pi\rho s\omega^2 a^2}{2k}$ ✓

(d) $\frac{3s\pi\rho\omega^2 a^2}{2k}$

Energy stored

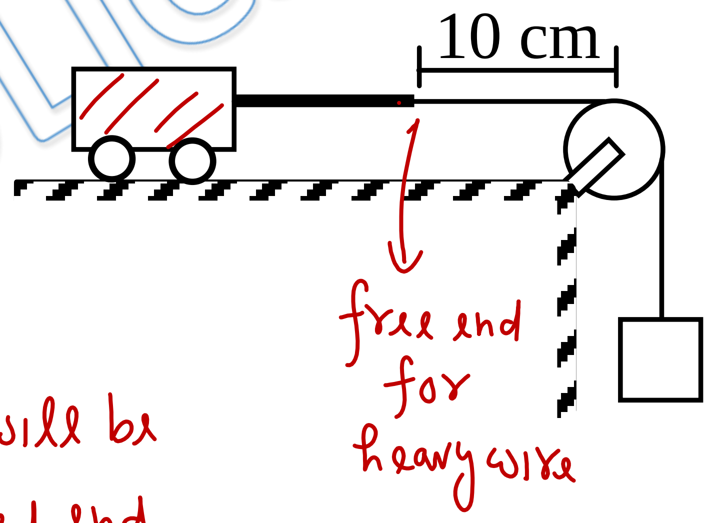
$$= P_1\frac{T}{2} + P_2\frac{T}{2} = (P_1+P_2)\frac{T}{2}$$

$$= \left[\frac{Fa^2\omega^2}{2V} + \frac{4Fa^2\omega^2}{2V}\right]\frac{T}{2} = \frac{5Fa^2\omega^2}{2V} \times \frac{T}{2}$$

$$= \frac{5\mu V^2 a^2\omega}{2V} \times \frac{2\pi}{2} = \frac{5\rho s V a^2\omega}{2} = \frac{5\rho s a^2\omega^2}{2K}$$

Q7) A heavy string is tied at one end to a movable support and to a light thread at the other end as shown in figure. The thread goes over a fixed pulley and supports a weight to produce a tension. The lowest frequency with which the heavy string resonates is 120 Hz. If the movable support is pushed to the right by 10 cm so that the joint is placed on the pulley, then the minimum frequency at which the heavy string can resonate is–

$f_0 = \frac{V}{4l} = 120\ Hz$




(a) 120 Hz (b) 60 Hz

(c) 240 Hz (d) 480 Hz

after shifting cart by 10 cm, joint will be on pulley & it will behave as fixed end.

$f_0 = \frac{V}{2l} = 240\ Hz.$

Q8) A sonometer wire under tension T is in unison with a tuning fork of frequency 250 Hz. If now the sonometer wire is replaced by another hollow wire of the same diameter, the number of loops shall-

$$f_t = \frac{n}{2l}\sqrt{\frac{F}{\mu}}$$

(a) Decrease

(b) Increase

(c) Remain the same

(d) Incomplete information

On replacing wire $\mu \downarrow$

$\Rightarrow n \downarrow$

Q9) A string vibrates according to equation y = 5 sin $\frac{\pi x}{3}$ cos 40πt. The potential energy of the string will be zero at times

(a) 1/40 sec, 1/80 sec

(b) 1/80 sec, 3/80 sec

(c) 1/40 sec, 3/40 sec

(d) None of these

whole wire is in mean position

$\cos 40\pi t = 0$

$40\pi t = (2n+1)\pi/2$

$t = (2n+1)\frac{1}{80}$

$t = \frac{1}{80}$ sec, $\frac{3}{80}$ sec, $\frac{5}{80}$ sec ...

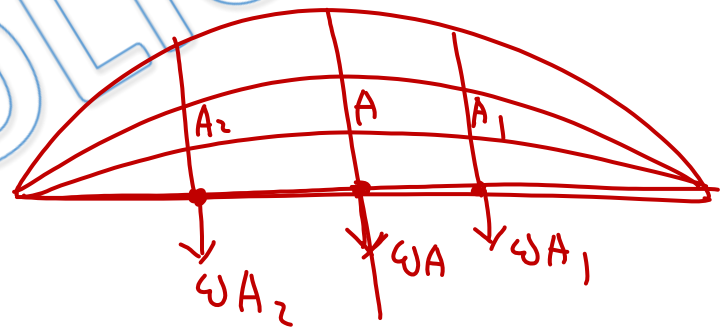
Q10) In stationary waves all particle between two adjacent nodes pass through the mean position-

(a) At different times with difference velocities

(b) At different times with same velocity

(c) At the same time with equal velocity

(d) At the same time with difference velocities



Q11) Standing waves are produced in a 10 m long stretched string. If the string vibrates in 5 segment and the wave velocity is 20 m/s, the frequency is -

fifth harmonic

$$f = \frac{5v}{2l} = \frac{5 \times 20}{2 \times 10}$$

$$= 5 \text{ Hz}$$

(a) 2 Hz (b) 4 Hz (c) 5 Hz (d) 10 Hz

Q12) 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 sec. The separation between consecutive nodes will be-

$K = \frac{\pi}{20}$

$\frac{\lambda}{2} = \frac{1}{2} \times \frac{2\pi}{K}$

$= \frac{\pi \times 20}{\pi}$

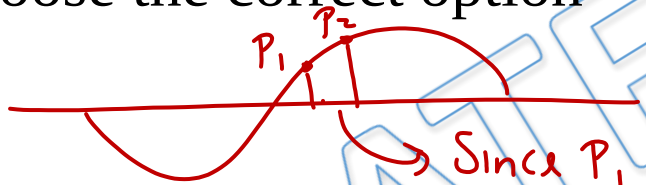
$= 20 \text{ cm}$

(a) 20 cm (b) 10 cm (c) 40 cm (d) 30 cm

Q13) **Statement-1 (S-1) :** A string is carrying sinusoidal wave. Consider a small segment of string then total energy of this small segment is conserved.

**Statement-2 (S-2) :** A standing wave pattern is formed in a string. The power transfer through each and every point on string is always zero.

Choose the correct option



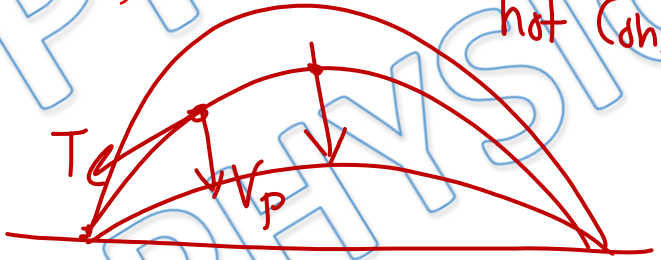

Since $P_1 \neq P_2$ energy in small segment is not conserved.

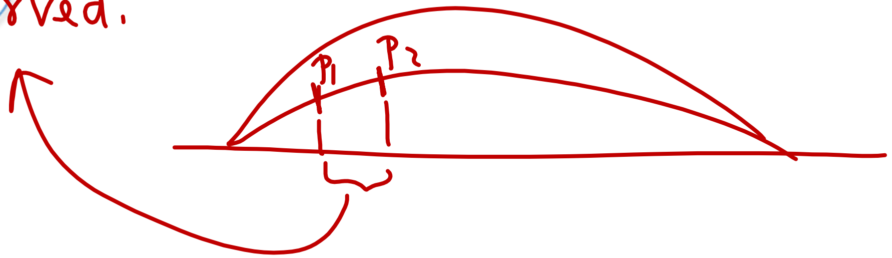
(a) S-1 True, S-2 True

(b) S-1 True, S-2 False

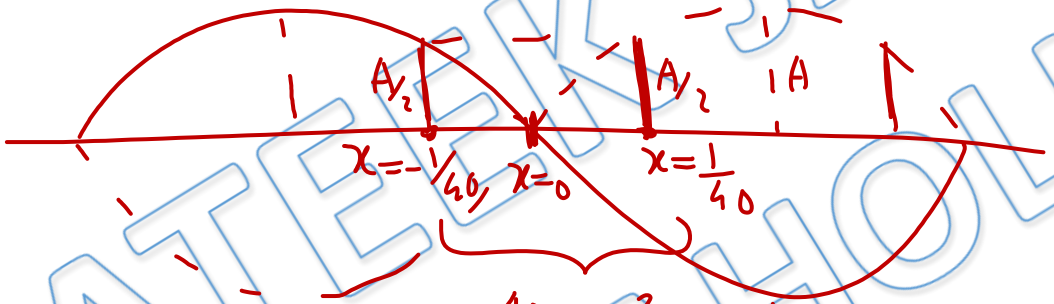
(c) S-1 False, S-2 True

(d) S-1 False, S-2 False



Q14) A standing wave $y = A \sin\left(\frac{20}{3}\pi x\right)\cos(1000\pi t)$ is maintained in a taut string where y and x are expressed in meters. The distance between the successive points oscillating with the amplitude A/2 across a node is equal to




$\Delta x = \frac{2}{40} = \frac{1}{20}$ m

$= 5$ cm

Amplitude $= A \sin \frac{20\pi x}{3}$

$\frac{A}{2} = A \sin \frac{20\pi x}{3}$

$\sin \frac{20\pi x}{3} = \frac{1}{2}$

$\frac{20\pi x}{3} = \frac{\pi}{6}$

$x = \frac{1}{40}$

(a) 2.5cm (b) 25cm (c) 5cm ✓ (d) 10cm

Q15) A string fixed at both ends has consecutive standing wave modes for which the distances between adjacent nodes are 18 cm and 16 cm respectively. The length of the string is-

$$\frac{l}{n} = 18 \quad \text{---(i)}$$

no of loops ← $n$

$$\frac{l}{n+1} = 16 \quad \text{---(ii)}$$

$$\frac{n+1}{n} = \frac{18}{16} = \frac{9}{8} \Rightarrow n = 8$$

(a) 144 cm ✓ (b) 152 cm (c) 176 cm (d) 200 cm.

$l = 18 \times n = 18 \times 8 = 144$ cm.

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Chalo Niklo