Resonance
Educating for better tomorrow

TARGET : JEE (ADVANCED) 2015

Course : VIJETA & VIJAY (ADP & ADR) **Date : 05-05-2015**

PHYSICS

DPP

DAILY PRACTICE PROBLEMS

NO. 09

TEST INFORMATION

DATE : 06.05.2015 **PART TEST(PT) - 04 (3 HOURS)**

Syllabus : Surface tension, Viscosity, , Fluid mechanics, Modern Physics-I & Nuclear Physics

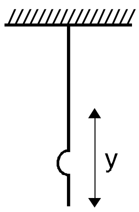
This DPP is to be discussed (08-05-2015)
PT-4 to be discussed (08-05-2015)

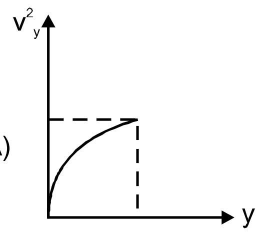
DPP Syllabus : String wave, Sound wave.

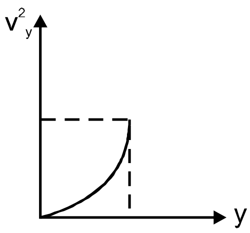
DPP No. # 09

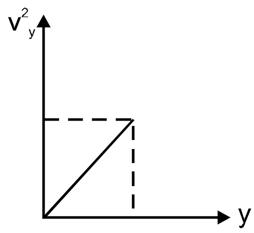
Total Total Marks : 151	Max. Time : 117½ min.	
Single choice Objective (–1 negative marking) Q. 1 to 16	(3 marks 2½ min.)	[48, 40]
Multiple choice objective (–1 negative marking) Q. 17 to 23	(4 marks, 3 min.)	[28, 21]
Single Digit Subjective Questions (no negative marking) Q.24 to Q.29	(4 marks 2½ min.)	[24, 15]
Double Digits Subjective Questions (no negative marking) Q. 30 to Q.31	(4 marks 2½ min.)	[8, 5]
Three Digits Subjective Questions (no negative marking) Q. 32	(4 marks 2½ min.)	[4, 2½]
Comprehension (–1 negative marking) Q.33 to 42	(3 marks 2½ min.)	[30, 25]
Match Listing (–1 negative marking) Q.43 to Q.45	(3 marks, 3 min.)	[9, 9]

1. A non–uniform rope of length ℓ hangs from a ceiling. Mass per unit length of rope (μ) changes as $\mu = \mu_0 e^y$, where y is the distance along the string from its lowest point. Then graph between square of velocity of wave and y will be best represented as :



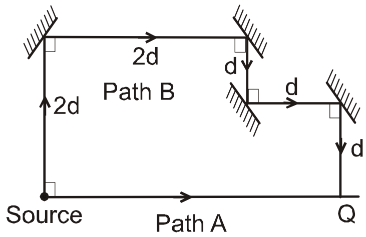
(A) 

(B) 

(C) 

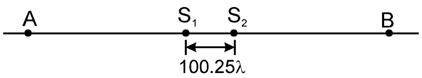
(D) None of these

2. A sound source emits two sinusoidal sound waves, both of wavelength λ, along paths A and B as shown in figure. The sound travelling along path B is reflected from five surfaces as shown and then merges at point Q, producing minimum intensity at that point. The minimum value of d in terms of λ is :



(A) $\frac{\lambda}{8}$ (B) $\frac{\lambda}{4}$ (C) $\frac{3\lambda}{8}$ (D) $\frac{\lambda}{2}$

3. S_1 and S_2 are two coherent sources of radiations separated by distance 100.25 λ, where λ is the wave length of radiation. S_1 leads S_2 in phase by $\pi/2$. A and B are two points on the line joining S_1 and S_2 as shown in figure. The ratio of amplitudes of component waves from source S_1 and S_2 at A and B are in ratio 1:2. The ratio of intensity at A to that of B $\left(\frac{I_A}{I_B}\right)$ is

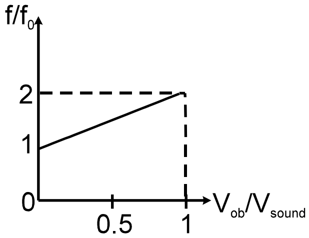


(A) ∞ (B) $\frac{1}{9}$ (C) 0 (D) 9

4. If ℓ_1 and ℓ_2 are the lengths of air column for two air column for two consecutive resonance position when a tuning fork of frequency f is sounded in a resonance tube, then end correction is :]

(A) $\frac{(\ell_2 - 3\ell_1)}{2}$ (B) $\frac{(\ell_2 + 3\ell_1)}{2}$ (C) $\frac{(\ell_2 + \ell_1)}{2}$ (D) $\frac{(3\ell_2 - \ell_1)}{4}$

5. A curve is plotted to represent the dependence of the ratio of the received frequency f to the frequency f_0 emitted by the source on the ratio of the speed of observer V_{ob} to the speed of sound V_{sound} in a situation in which an observer is moving towards a stationary sound source. The curve is best represented by :

(A)


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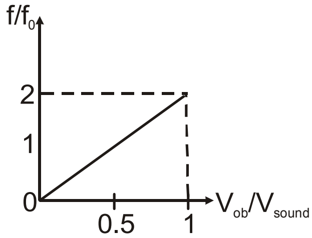
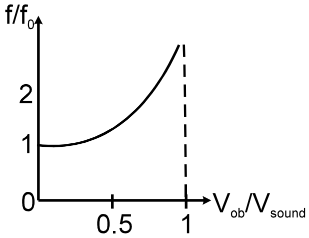


(C)


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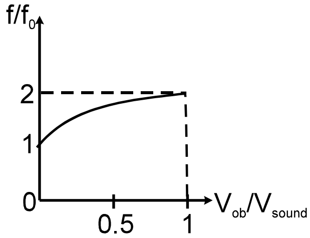
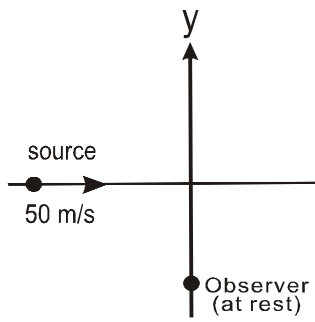
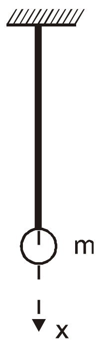


6. A sound source moving with speed 50 m/s along x–axis and observer at rest on y–axis. If the frequency observed by observer when source crosses the origin is 96 Hz, then the original frequency of source is : (speed of sound in given medium is 200 m/s)



(A) 90 Hz (B) 100 Hz (C) 80 Hz (D) 60 Hz

7. A mass m is suspended from the ceiling by a string with variable linear mass density (μ). A wave pulse is produced at the top by an oscillator which travels from top to bottom with constant wave speed. (x axis is positive downwards). then.



(A) $\frac{d\mu}{dx} > 0$ (B) $\frac{d\mu}{dx} < 0$ (C) $\frac{d\mu}{dx}$ = constant (D) $\frac{d\mu}{dx} = 0$

8. An open organ pipe containing air resonates in fundamental mode due to a tuning fork. The measured values of length ℓ (in cm) of the pipe and radius r (in cm) of the pipe are $\lambda = 94 \pm 0.1$, $r = 5 \pm 0.05$. The velocity of the sound in air is accurately known. The maximum percentage error in the measurement of the frequency of that tuning fork by this experiment, will be
(A) 0.16 (B) 0.64 (C) 1.2 (D) 1.6

9. A wire of length 'ℓ' having tension T and radius 'r' vibrates with fundamental frequency 'f'. Another wire of the same metal with length 2ℓ having tension 2 T and radius 2 r will vibrate with fundamental frequency:

(A) f (B) 2 f (C) $\frac{f}{2\sqrt{2}}$ (D) $\frac{f}{2}\sqrt{2}$

10. 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

11. Sinusoidal waves 5.00 cm in amplitude are to be transmitted along a string having a linear mass density equal to 4.00×10^{-2} kg/m. If the source can deliver a average power of 90 W and the string is under a tension of 100 N, then the highest frequency at which the source can operate is (take $\pi^2 = 10$) :

(A) 45.3 Hz (B) 50 Hz (C) 30 Hz (D) 62.3 Hz

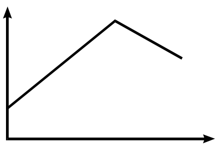
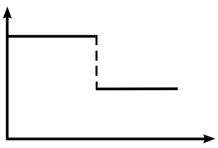
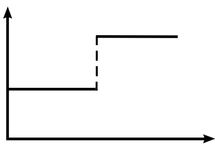
12. Two radio station that are 250m apart emit radio waves of wavelength 100m. Point A is 400m from both station. Point B is 450m from both station. Point C is 400m from one station and 450 m from the other. The radio station emit radio waves in phase. Which of the following statement is true ?

(A) There will constructive interference at A and B, and destructive interference at C.
(B) There will be destructive interference at A and B, and constructive interference at C.
(C) There will be constructive interference at B and C, and destructive interference at A.
(D) There will be destructive interference at A, B and C.

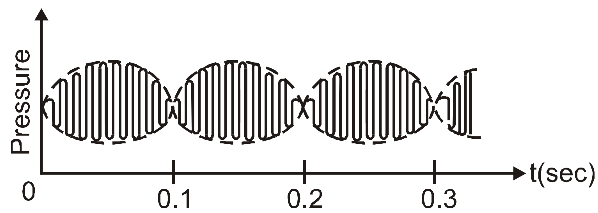
13. A point source of power 50π watts is producing sound waves of frequency 1875Hz. The velocity of sound is 330m/s, atmospheric pressure is 1.0×10^5 Nm^{-2}, density of air is $\frac{400}{99\pi}$ kgm^{-3}. Then the displacement amplitude at r = $\sqrt{330}$ m from the point source is ($\pi = 22/7$) :

(A) 0.5 μm (B) 0.2 μm (C) 1 μm (D) 2 μm

14. An observer approaches towards a stationary source of sound at constant velocity and recedes away at the same speed. The graph of wavelength observed with time is (assume wind spped is zero)

(A)  (B)  (C)  (D) 

15. Two sound waves are superimposed. The resulting pressure variation at a single point at a distance 'x' from the source is graphed below :



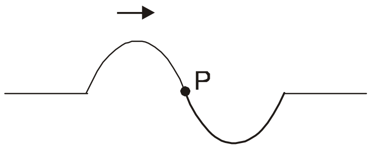
The beat frequency of the resulting sound wave is :

(A) 10 Hz (B) 20 Hz (C) 5 Hz (D) 40 Hz

16. A transverse periodic wave on a string with a linear mass density of 0.200 kg/m is described by the following equation y = 0.05 sin(420t – 21.0 x)
where x and y are in metres and t is in seconds. The tension in the string is equal to :

(A) 32 N (B) 42 N (C) 66 N (D) 80 N

17. A pulse on a string is shown in the figure. P is particle of the string. Then state which of the following are correct.

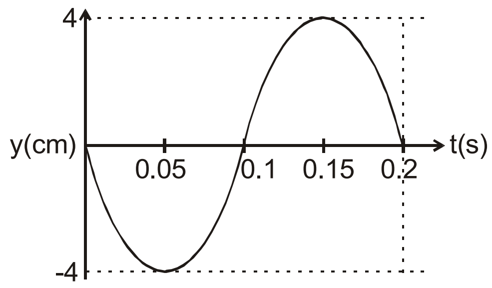


(A) If P is stationary point, then pulse consists of two waves travelling in opposite direction
(B) If P is moving upwards, then pulse is travelling in positive direction
(C) If P is moving downwards, then pulse is travelling in negative direction
(D) none of these is incorrect

18. A wire of density 9×10^3 kg/m^3 is stretched between two clamps 1 m apart and is stretched to an extension of 4.9×10^{-4} metre. Young's modulus of material is 9×10^{10} N/m^2. Then

(A) The lowest frequency of standing wave is 35 Hz
(B) The frequency of 1st overtone is 70 Hz
(C) The frequency of 1st overtone is 105 Hz
(D) The stress in the wire is 4.41×10^7 N/m^2

19. For a certain transverse standing wave on a long string, an antinode is formed at x = 0 and next to it, a node is formed at x = 0.10 m. the position y(t) of the string particle at x = 0 is shown in figure.



(A) Transverse displacement of the particle at x = 0.05m and t = 0.05 s is $-2\sqrt{2}$ cm.
(B) Transverse displacement of the particle at x = 0.04 m and t = 0.025 s is $-2\sqrt{2}$ cm.
(C) Speed of the travelling waves that interfere to produce this standing wave is 2 m/s.
(D) The transverse velocity of the string particle at x = $\frac{1}{15}$ m and t = 0.1 s is 20 π cm/s

20. A car moves towards a hill with speed v_c. It blows a horn of frequency f which is heard by an observer following the car with speed v_0. The speed of sound in air is v.

(A) the wavelength of sound reaching the hill is $\frac{v}{f}$

(B) the wavelength of sound reaching the hill is $\frac{v - v_c}{f}$

(C) The wavelength of sound of horn directly reaching the observer is $\frac{v + v_c}{f}$

(D) the beat frequency observed by the observer is $\frac{2v_c(v + v_o)f}{v^2 - v_c^2}$

21. An air column in a pipe closed at one end is made to vibrate in its second overtone by a tuning fork of frequency 440 Hz. The speed of sound wave in air is 330 m/s. End corrections may be neglected. Let P_0 denote the mean pressure at any point in the pipe, and ΔP_0 the maximum amplitude of pressure variation. Then :

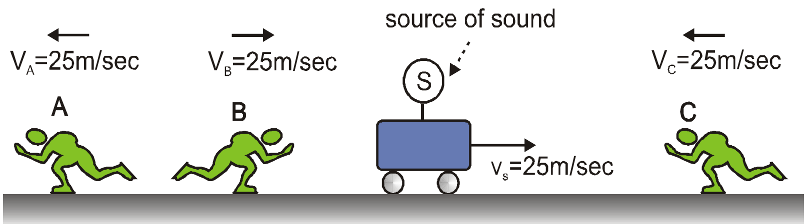
(A) length of the pipe is $\frac{15}{16}$ m

(B) length of the pipe is $\frac{9}{16}$ m

(C) the maximum pressure at the open end is P_0
(D) the minimum pressure at the open end is P_0

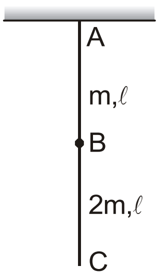
22. A train is moving with constant speed along a circular track. If length of the train is one fourth of length of circular track then which of the following is/are **correct** options (Assume that sound source is at engine and speed of engine is very very less then speed of sound) :
(A) Frequency observed by a passenger who is sitting in the middle of train (equidistant from front and rear end) will continuously increase.
(B) Frequency observed by a passenger who is sitting in the middle of train (equidistant from front and rear end) will remain constant but more than actual frequency.
(C) Frequency observed by a passenger who is sitting in the middle of train (equidistant from front and rear end) will remains constant and equal to actual frequency.
(D) Wavelength observed by the person who is on the rear end of train is more than the actual wavelength of sound wave.

23. Velocities of three persons A, B, C and sound source S are shown in diagram. Frequency of sound source is 600 Hz and sound speed is 325 m/sec. At given situation, which of the following options is / are **correct :**



(A) frequency observed by A is $\frac{3600}{7}$ Hz
(B) frequency observed by B is zero
(C) frequency observed by C is 700 Hz
(D) frequency observed by A and C is same

24. In the figure shown strings AB and BC have masses m and 2m respectively. Both are of same length ℓ. Mass of each string is uniformly distributed on its length. The string is suspended vertically from the ceiling of a room. A small jerk wave pulse is given at the end 'C'. It goes up to upper end 'A' in time 't'. If the value of t is given by $a\sqrt{\frac{\ell}{g}}+b\sqrt{\frac{\ell}{g}}\left(\sqrt{c}-\sqrt{d}\right)$ then a + b + c + d is

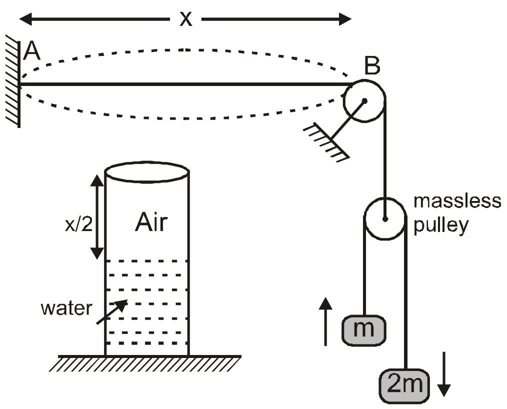


25. A uniform string of length ℓ, fixed at both ends is vibrating in its 2nd overtone. The maximum amplitude is 'a' and tension in string is 'T', if the energy of virbation contained between two consecutive nodes is $\frac{K}{8}\frac{a^2\pi^2T}{\ell}$ then 'K' is :

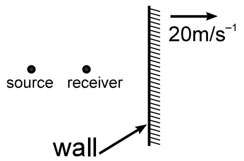
26. A rope, under tension of 200 N and fixed at both ends, oscillates in a second harmonic standing wave pattern. The displacement of the rope is given by y = (0.10 m) sin$\left(\frac{\pi x}{3}\right)$ sin(12 πt), where x = 0 at one end of the rope, x is in meters and t is in seconds. Find the length of the rope in meters.

27. A sound wave of wavelength 20π cm travels in air if the difference between the maximum and minimum pressures at a given point is 3.0×10^{-3} N/m^2.
Now sound level is increased by 20 dB, if the new amplitude of vibration of the particles of the medium at that given point is 20 k(in Å) then 'k' is: (The bulk modulus of air is 1.5×10^5 N/m^2) (wavelength is same in both cases)

28. AB wire (length x) is vibrating in its fundamental mode. Wire AB is in resonance with resonance tube in which air column (lenght x/2) is also vibrating with its fundamental mode. Sound speed is 400 m/sec and linear mass density of AB wire is 10^{-4} kg/m and g = 10 m/sec^2, value of mass m = [$\beta(10^{-1})$] kg, then find value of β. Neglect the masses of wires in comparison to block's mass 'm'.



29. A source of sound of frequency 300Hz and a reciever are located along the same line normal to the wall as shown in the figure. Both the source and the receiver are stationary and the wall receeds from the source with velocity 20ms^{-1}. If the beat frequency registered by the receiver is $\frac{240}{x}$ Hz then x is:
(Assume V_{sound} = 330 m/s).



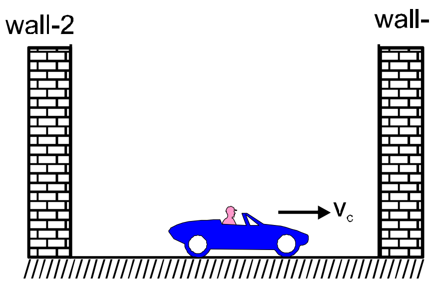
30. The speed of sound in a mixture of n_1 = 2 moles of He, n_2 = 2 moles of H_2 at temperature T = $\frac{972}{5}$ K is $\eta \times 10$ m/s. Find η. (Take R = $\frac{25}{3}$ J/mole-K)

31. A straight line source of sound of length L = 10m, emitts a pulse of sound that travels radially outward from the source. What is the power (in mW) intercepted by an acoustic cylindrical detector of surface area 2.4 cm^2, located at a perpendicular distance 7m from the source. The waves reach perpendicularly at the surface of the detector. The total power emitted by the source in the form of sound is 2.2×10^4 W.
(Use π = 22/7)

32. A string of length 1.5 m with its two ends clamped is vibrating in fundamental mode. Amplitude at the centre of the string is 4 mm. Minimum distance (in cm) between the two points having amplitude 2 mm is:

COMPREHENSION-1

A driver is riding a car with velocity v_C between two vertical walls on a horizontal surface as shown in figure. A source of sound of frequency 'f' is situated on the car. ($v_c << v$, where v is the speed of sound in air)



33. Beat frequency observed by the driver corresponding to sound waves reflected from wall-1 and wall-2 (reflected waves corresponding to waves directly coming from source) :

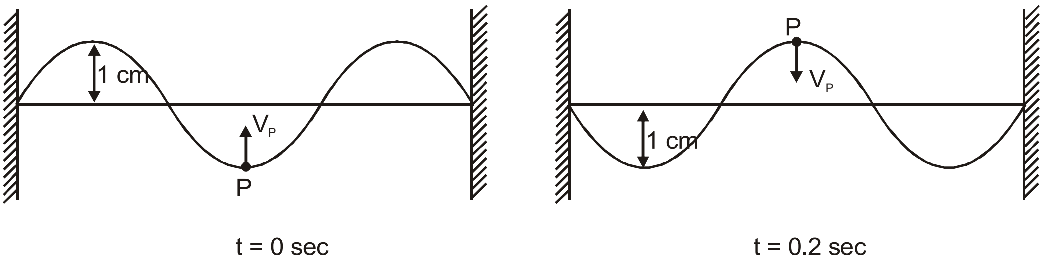
(A) $\frac{v_C}{v}f$ (B) $\frac{2v_C}{v}f$ (C) $\frac{v_C}{2v}f$ (D) $\frac{4v_C}{v}f$

34. Consider the sound wave observed by the driver directly from car has a wavelength λ_1 and the sound wave after reflection from wall-1 observed by the driver has wavelength λ_2 then $\frac{\lambda_1 - \lambda_2}{\lambda_1 + \lambda_2}$ is :

(A) $\frac{v_C}{v}$ (B) $\frac{2v_C}{v}$ (C) $\frac{v_C}{4v}$ (D) $\frac{4v_C}{v}$

COMPREHENSION-2 :

Stationary wave is setup in a uniform string clamped at both the ends. Length of the string is 0.3 m. Snapshot of the string is taken at two instants one at t = 0 sec and another at t = 0.2 sec. These is two snapshots are shown below.

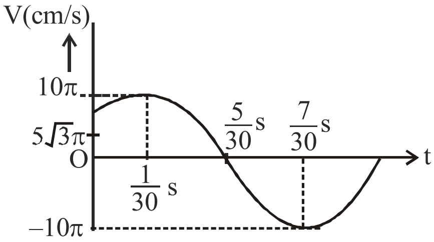


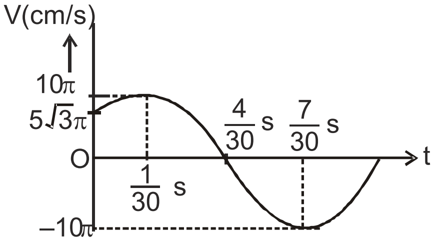
Velocity of point P (which is also the mid point of the string) is in upward direction (take upward direction to be positive) at t = 0 sec. At the instant snapshots are taken particles are at half of their respective maximum displacement from mean position. During this time interval particles have crossed their mean position only once. Answer the following 3 questions for the given situation.

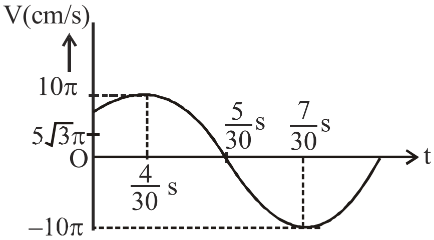
35. Velocity of travelling wave in the string is :

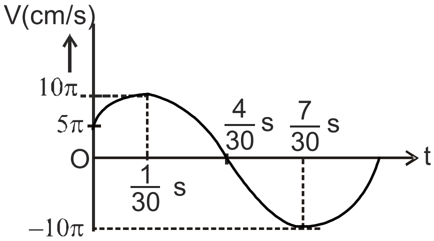
(A) 1 m/s (B) 0.5 m/s (C) 2 m/s (D) 0.25 m/s.

36. Velocity time graph of particle at mid point of the string (i.e., particle P)

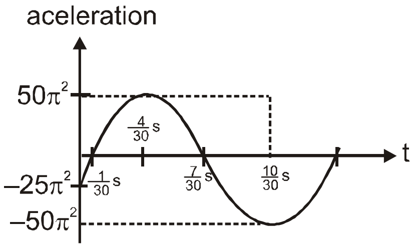
(A) 

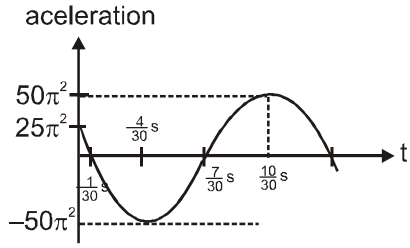
(B) 

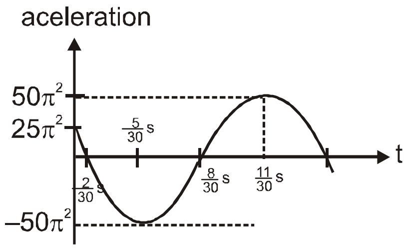
(C) 

(D) 

37. Acceleration time graph of the particle at mid point of the string (i.e., particle P) is

(A) 

(B) 

(C) 

(D) None of these

COMPREHENSION-3

A piano creates sound by gently striking a taut wire with a soft hammer when a key on the piano is pressed. All piano wires in a given piano are approximately the same length. However, each wire is tied down at two points, the bridge and the agraffe. The length of the wire between the bridge and the agraffe is called the speaking length. The speaking length is the part of the wire that resonates. The point of the wire struck by the hammer is displaced perpendicularly to the wire's length . A standing wave is generated by the hammer strike, where v is the velocity of travelling wave, T is the tension in the wire, and μ is the mass per unit length of the wire.

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

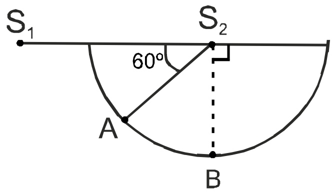
Tuning a piano involves adjustment of the tension in the wires until just the right pitch is achieved. Correct pitch is achieved by listening to the beat frequency between the piano and a precalibrated tuning fork.

38. A piano with which of the following properties would deliver a note with the lowest pitch ?
(A) 100 cm speaking length ; 800 N tension
(B) 120 cm speaking length ; 700 N tension
(C) 100 cm speaking length ; 700 N tension
(D) 120 cm speaking length ; 800 N tension

39. A piano note is compared to a tuning fork vibrating at 440 Hz. Three beats per second are listened by the piano tunner. When the tension in the string is increased slightly, the beat frequency increases. What was the initial frequency of the piano wire ?
(A) 434 Hz (B) 437 Hz (C) 443 Hz (D) 446 Hz

COMPREHENSION-4

Figure shows two line sources of sound, S_1 and S_2 separated by a distance 4 m. The two sources are in same phase at all times. The sources emit same power and their lengths are also same. A detector moves along a circle with center at S_2 and radius 3m. The wavelength of the sound is 1 m. When it is at A the intensity of sound due to source S_2 only is I_0.



40. The intensity of sound at A due to S_1 only is :

(A) $\frac{3I_0}{\sqrt{13}}$ (B) $\frac{\sqrt{13}I_0}{3}$ (C) $\frac{9I_0}{13}$ (D) I_0

41. The intensity of sound at B due to S_1 only is :

(A) $\frac{3I_0}{5}$ (B) $\frac{5I_0}{3}$ (C) $\frac{9I_0}{25}$ (D) I_0

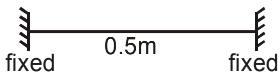
42. The intensity of sound at B due to S_1 and S_2 is :

(A) $\frac{70}{25}I_0$ (B) $I_0\left[\frac{8}{5}+2\sqrt{\frac{3}{5}}\right]$ (C) $\frac{8I_0}{5}$ (D) $I_0\left[\frac{8}{5}+2\sqrt{\frac{9}{25}}\right]$

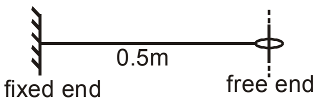
43. In each of the four situations of column -I , a stretched string or an organ pipe is given along with the required data. In case of strings the tension in string is T = 102.4 N and the mass per unit length of string is 1 g/m. Speed of sound in air is 320 m/s. Neglect end corrections. The frequencies of resonance are given in column -II. Match each situation in column-I with the possible resonance frequencies given in Column -II.

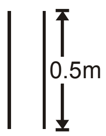
Column-I **Column-II**

(p) String fixed at both ends (1) 320 Hz

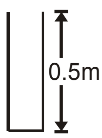


(q) String fixed at one end and free at other end (2) 480 Hz



(r) Open organ pipe 

(3) 640 Hz

(s) Closed organ pipe 

(4) 800 Hz

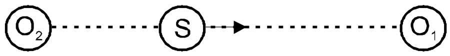
	p	q	r	s
(A)	1	3	2	4
(B)	1	4	3	2
(C)	3	2	4	1
(D)	2	4	1	3

44. A source of sound stationary with respect to medium emits sound of frequency f and wavelength λ. The speed of sound with respect to medium is C, speed of medium is V_m. The observer O_1 receives waves of frequency f_1 and wavelength λ_1. The observer O_2 receives waves of frequency f_2 and wavelength λ_2. Match the column given below if V_s is speed of source with respect to ground.

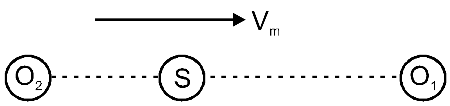
Column–I

(p) Medium at rest, source at rest, O_1 and O_2 moves

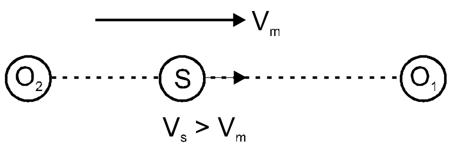
(q) medium at rest, O_1, O_2 at rest, source moves



(r) medium moves, source at rest, O_1,O_2 at rest



(s) medium moves source moves, O_1 , O_2 at rest



Column–II

(1) $\lambda_1 < \lambda < \lambda_2$

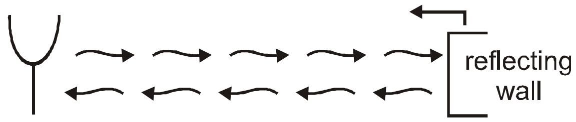
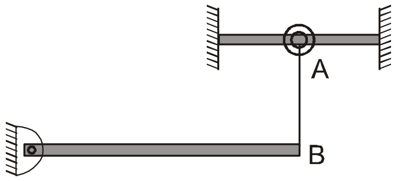
(2) $f_1 > f > f_2$

(3) $\lambda_1 = \lambda_2 = \lambda$

(4) $\lambda_1 > \lambda > \lambda_2$

	p	q	r	s
(A)	3	4	1	2
(B)	4	1	2	3
(C)	4	3	2	1
(D)	3	2	4	1

45. **Match the column:**

Column–I	**Column–II**
(p)  Sinusoidal sound waves are continuously sent from one end by a tuning fork and they are reflected from a moving wall. Due to the superposition of the incident waves and the reflected waves.	(1) Travelling wave is formed
(q)  A rod of mass 20 kg is hinged at one end and is suspeneded by a light wire AB at the other end. The entire system is in vertical plane. The wire AB has length = 1m and mass = 0.01 kg. Now the wire AB is vibrated with a 75 Hz tuning fork, then in wire AB :	(2) Standing wave is formed
(r) Equation of vibrating particles is $y = A\sin^2(\omega t - kx) + B\cos^2(kx - \omega t) + C\cos(kx + \omega t)\sin(\omega t + kx)$ (where A,B,C are constants and can have any value) it is possible that	(3) Beats are formed
(s)  A metal rod is fixed at one end and free at the other end. The free end is hit once by a hammer as shown. Then :	(4) Particles perform simple harmonic motion

	p	q	r	s
(A)	3	2	4	1
(B)	4	2	3	1
(C)	4	3	2	1
(D)	3	2	1	4

ANSWER KEY OF DPP NO. # 08

1.	(C)	**2.**	(B)	**3.**	(B)	**4.**	(B)	**5.**	(D)	**6.**	(B)	**7.**	(D)
8.	(D)	**9.**	(C)	**10.**	(D)	**11.**	(B)	**12.**	(C)	**13.**	(A)	**14.**	(A)
15.	(A)	**16.**	(C)	**17.**	(A) (C)	**18.**	(A) (B) (C) (D)	**19.**	(B) (C) (D)			**20.**	(A) (C)
21.	(A) (D)	**22.**	(A) (B)(C)	**23.**	(A) (B) (C)	**24.**	(A) (B) (C)					**25.**	4
26.	1	**27.**	9	**28.**	4	**29.**	5	**30.**	2	**31.**	8	**32.**	6
33.	3	**34.**	5	**35.**	7	**36.**	12	**37.**	(A)	**38.**	(C)	**39.**	(B)
40.	(C)	**41.**	(A)	**42.**	(B)	**43.**	(C)						

PHYSICS

1. $v_y = \sqrt{\frac{T_y}{\mu_y}}$

$T_y = \left\{\int_0^y \mu_0 e^y dy\right\} g$

$T_y = \mu_0(e^y - 1).g$

$v_y = \sqrt{g - \frac{g}{e^y}}$

$v_y^2 = g(1 - e^{-y})$.

2. Path difference = Path B – Path A

= 7d – 3d = 4d

[Note that there is no phase change in reflections from mirror in case of sound]

For being out of phase :

$\Delta x = 4d = \frac{\lambda}{2}$; $\frac{3\lambda}{2}$;................

For minimum d, $4d = \frac{\lambda}{2}$

$\Rightarrow$ $d = \frac{\lambda}{8}$ **Ans.**

3. For interference at A : S_2 is behind of S_1 by a distance of $100\lambda + \frac{\lambda}{4}$.(equal to phase difference $\frac{\pi}{2}$). Further S_2 lags S_1 by $\frac{\pi}{2}$. Hence the waves from S_1 and S_2 interfere at A with a phase difference of $200.5\,\pi + 0.5\pi = 201\pi = \pi$

Hence the net amplitude at A is 2a – a = a

For interference at B : S_2 is ahead of S_1 by a distance of $100\lambda + \frac{\lambda}{4}$.(equal to phase difference $\frac{\pi}{2}$). Further S_2 lags S_1 by $\frac{\pi}{2}$.

Hence waves from S_1 and S_2 interfere at B with a phase difference of $200.5\,\pi - 0.5\pi = 200\pi = 0\pi$.

Hence the net amplitude at A is 2a + a = 3a

Hence $\left(\frac{I_A}{I_B}\right) = \left(\frac{a}{3a}\right)^2 = \frac{1}{9}$

4. $\dfrac{V}{4(\ell_1+e)} = f, \quad \dfrac{3V}{4(\ell_2+e)} = f$

$\dfrac{V}{4f} = \ell_1 + e$

$\dfrac{3V}{4f} = \ell_2 + e$

$\dfrac{2V}{4f} = \ell_2 - \ell_1 = V = 2f\ (\ell_2 - \ell_1)$

$e = \dfrac{2f(\ell_2-\ell_1)}{4f} - \ell_1 = \dfrac{2\ell_2-2\ell_1-4\ell_1}{4} = \dfrac{2(\ell_2-3\ell_1)}{4}$

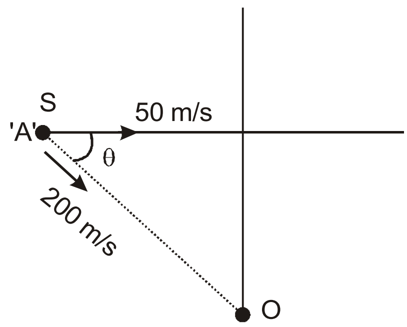
5. $f = f_0\left(1+\dfrac{V_{ob}}{V_{sound}}\right)$

$\Rightarrow \dfrac{f}{f_0} = 1+\dfrac{V_{ob}}{V_{sound}}$ (straight line) ; when $\dfrac{V_{ob}}{V_{sound}} = 0$; $\dfrac{f}{f_0} = 1.$

and as $\dfrac{V_{ob}}{V_{sound}} \to 1 \quad \Rightarrow \quad \dfrac{f}{f_0} \to 2$

6. Sound emitted by source at S which is observed by observer when source crosses origin.

Then $\cos\theta = \dfrac{50t}{200t} = \dfrac{1}{4}$



$96 = f\left(\dfrac{200-0}{200-50\cos\theta}\right)$

f = 90 Hz

7. When we move along +x direction (top to bottom) x increases but T decreases

$v_{wave} = \sqrt{\dfrac{T}{\mu}}$

when T decreases μ must decrease

$\Rightarrow \quad x \to$ increases $\qquad \mu \to$ decreases $\Rightarrow \quad \dfrac{d\mu}{dx} < 0$

8. $f = \frac{v}{2(\ell + 2e)}$ where e = end correction = 0.6 r

$\therefore \quad f = \frac{v}{2(\ell + 2 \times 0.6r)} = \frac{v}{2(\ell + 1.2r)}$

$\therefore \quad \frac{\Delta f}{f} = \frac{\Delta v}{v} - \frac{\Delta(\ell + 1.2r)}{\ell + 1.2r} = \frac{\Delta v}{v} - \frac{\Delta\ell + 1.2\Delta r}{\ell + 1.2r}$

here $\frac{\Delta v}{v} = 0$ (given) $\frac{\Delta f}{f} \times 100 = -\frac{\Delta\ell + 1.2\Delta r}{\ell + 1.2r} \times 100$

for maximum % error : $\Delta\ell = 0.1$, $\Delta r = 0.05$

$\left(\frac{\Delta f}{f} \times 100\right)_{max} = \frac{0.1 + 1.2 \times 0.05}{94 + 1.2 \times 5} \times 100 =$ **0.16% ...Ans.**

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

If radius is doubled and length is doubled, mass per unit length will become four times. Hence

$f' = \frac{1}{2 \times 2\ell}\sqrt{\frac{2T}{4\mu}} = \frac{f}{2\sqrt{2}}$

10. $L = \frac{m\lambda_1}{2}$ and $L\ (m + 1)\ \frac{\lambda_2}{2}$

Where m is no. of harmonic

m.36 = (m + 1) 32 $\quad \Rightarrow m = 8$

L = 8 × 18 = 144 cm

11. (C) $P = \frac{1}{2}\mu\omega^2A^2V$

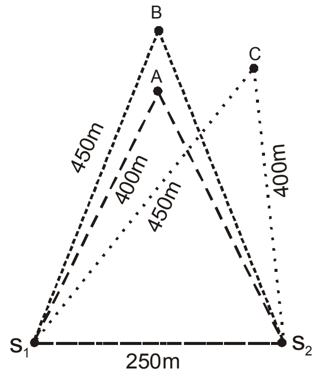
using $V = \sqrt{\frac{T}{\mu}}$

$P = \frac{1}{2}\omega^2 A^2 \sqrt{T\mu}$

$\omega = \sqrt{\frac{2P}{A^2\sqrt{T\mu}}} \quad f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{2P}{A^2\sqrt{T\mu}}}$

using data f = 30 Hz.

12.



At points A and B, path difference between the waves coming from two radio stations is zero. Hence there will be constructive interference at A and B,

For point C, path difference between the waves is 50 metre i.e. $\frac{\lambda}{2}$ so destructive interference takes places at point C.

13. $P_0 = BKS_0$; $k = \frac{2\pi}{\lambda}$; $\lambda = \frac{v}{f}$; $v = \sqrt{\frac{B}{\rho}}$

Using above, we get

$$S_0 = \frac{P_0}{2\rho v\pi f} = \frac{5}{2\times1\times330\times3.14\times1875}$$

$\simeq$ 1 μ meter.

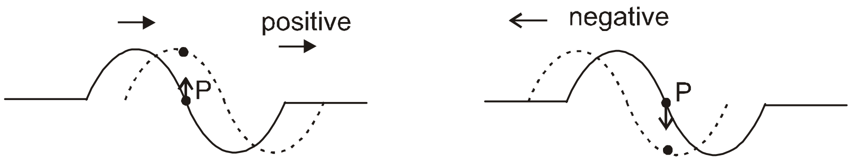
14. Wavelength remains same during approach and recede.

15. The period of beats is the time between maximum intensities. The square of the pressure is proportional to the intensity.

Beat frequency = $\frac{1}{\text{Beat period}} = \frac{1}{0.1}$ = 10 Hz.

16. $V = \sqrt{\frac{T}{\lambda}} = \frac{\omega}{k} \Rightarrow T = \frac{\omega^2\lambda}{k^2} = \left(\frac{420}{21}\right)^2 \times 0.2 = 80$ N.

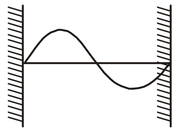
17.



18. Speed of wave in wire $V = \sqrt{\frac{T}{\rho A}} = \sqrt{\frac{Y\Delta\ell}{\ell}A \times \frac{1}{\rho A}} = \sqrt{\frac{Y\Delta\ell}{\ell\rho}}$

Maximum time period means minimum frequency ; that means fundamental mode.

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



$\therefore \quad T = \frac{2\ell}{V} = 2\ell \sqrt{\frac{\ell\rho}{Y\Delta\ell}} = \frac{1}{35}$ second **Ans.**

$\therefore$ (f = 35 Hz)

and; frequency of first overtone = $\frac{V}{\ell}$ = 70 Hz.

19. $\frac{\lambda}{4} = 0.1 \quad \Rightarrow \lambda = 0.4$ m

from graph $\Rightarrow$ T = 0.2 sec. and amplitude of standing wave is 2A = 4 cm.

Equation of the standing wave

$$y(x, t) = -2A\cos\left(\frac{2\pi}{0.4}x\right).\sin\left(\frac{2\pi}{0.2}t\right) \text{ cm}$$

$y(x = 0.05, \ t = 0.05) = -2\sqrt{2}$ cm

$y(x = 0.04, t = 0.025) = -2\sqrt{2}\cos 36°$

speed = $\frac{\lambda}{T}$ = 2 m/sec.

$$V_y = \frac{dy}{dt} = -2A \times \frac{2\pi}{0.2}\cos\left(\frac{2\pi x}{0.4}\right).\cos\left(\frac{2\pi t}{0.2}\right)$$

$V_y = (x = \frac{1}{15}\text{ m}, t = 0.1) = 20\pi$ cm/sec.

20. Frequency of horn directly heard by observer $\frac{v + v_0}{v + v_c}f$

Frequency of echo = $\frac{v}{v + v_c}f$

Frequency of echo of horn as heard by observer.

$$\frac{v}{v - v_c}f.\left(\frac{v + v_0}{v}\right)$$

Frquency of Beats :

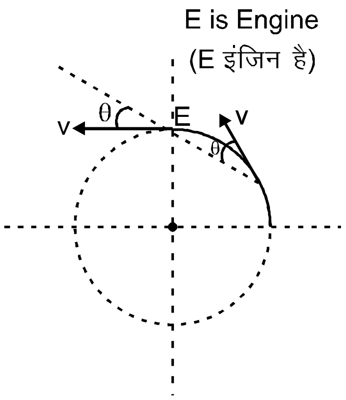
$$= (v + v_0)f\left\{\frac{1}{v - v_c} - \frac{1}{v + v_c}\right\} = \frac{2v_c(v + v_0)}{(v^2 - v_c^2)}f$$

21. $f = 5.\frac{v}{4\ell}$

$\Rightarrow \quad \ell = \frac{5v}{4f} = \frac{15}{16}\,m$

The open end is position of node of pressure. There is no pressure variation.

22.



$$f_{obs} = \frac{f\,[v_s + v\cos\theta]}{[v_s + v\cos\theta]} = f$$

$$\lambda_{obs} = \frac{v_s + v\cos\theta}{f}$$

For any observer in train frequency observed is equal to original frequency but observed wavelength is more.

23. $C = 325\ \frac{m}{sec}$

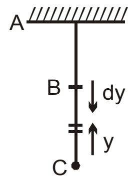
$f = 600$ Hz

$$f_A = \left(\frac{C - V_A}{C + V_S}\right) f = \frac{3600}{7}\ \text{Hz}$$

$$f_B = \left(\frac{C + V_B}{C + V_S}\right) f = 600\ \text{Hz}$$

$$f_C = \left(\frac{C + V_c}{C - V_S}\right) f = 700\ \text{Hz}$$

24. For part BC



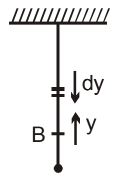
$$v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{m/\ell . y.g}{m/\ell}} = \sqrt{y.g}$$

$$\Rightarrow \quad \frac{dy}{dt} = \sqrt{y.g} \quad \Rightarrow \quad \int_0^{\ell} \frac{dy}{\sqrt{y}} = \int_0^{t_1} \sqrt{g}\, dt$$

$$\Rightarrow \quad 2\sqrt{\ell} = \sqrt{g}.t_1$$

$\Rightarrow$ t_1 = time to go from C to B $= 2\sqrt{\frac{\ell}{g}}$

For part BA



$$v = \sqrt{\frac{2mg + \frac{m}{\ell}.y.g}{m/\ell}} = \sqrt{(2\ell + y)g}$$

$$\frac{dy}{dt} = \sqrt{(2\ell + y)g} \quad \Rightarrow \quad \int_0^{\ell} \frac{dy}{\sqrt{2\ell + y}} = \int_0^{t_2} \sqrt{g}\, dt$$

$$\Rightarrow \quad 2(\sqrt{3} - \sqrt{2}).\sqrt{\ell} = \sqrt{g}.t_2$$

$\Rightarrow$ t_2 = time to go from B to A $= 2(\sqrt{3} - \sqrt{2}).\sqrt{\frac{\ell}{g}}$

$\therefore$ total time $= t_1 + t_2 = 2\sqrt{\frac{\ell}{g}} + 2(\sqrt{3} - \sqrt{2}).\sqrt{\frac{\ell}{g}}$

25. Total energy $E = \int_0^{\ell} \frac{1}{2} dmv^2$

$$= \int_0^{\ell} \frac{1}{2} dmA_x{}^2\omega^2 = \int_0^{\ell} \frac{1}{2}\left(\frac{m}{\ell}\right)dx.A^2 \sin^2 kx.\omega^2 = \frac{1}{4} mA^2\omega^2$$

$$\omega = 2\pi f = 2\pi.\frac{3v}{2\ell}\sqrt{\frac{T}{\mu}} = \frac{3\pi}{\ell}\sqrt{\frac{T\ell}{m}}$$

$\therefore$ Energy $= \frac{1}{4} ma^2.\frac{9\pi^2}{\ell^2}.\frac{T\ell}{m}$

Energy $= \frac{9}{4}\frac{a^2\pi^2 T}{\ell}$

So, energy between two consecutive nodes $= \frac{3}{4}\frac{a^2\pi^2 T}{\ell}$.

26. $y = 0.10 \sin\left(\frac{\pi x}{3}\right) \sin(12\,\pi t)$

$k = \frac{\pi}{3} \quad \Rightarrow \quad \lambda = 6m$

Length of the rope = λ = 6m

$$y = 4 \sin\left(\frac{\pi x}{15}\right) \cos(96\,\pi t) = 2 \sin\left(\frac{\pi x}{15} + 96\pi t\right) + 2 \sin\left(\frac{\pi x}{15} - 96\pi t\right)$$

27. Sound level in dB is

$B = 10 \log_{10}\left(\frac{I}{I_0}\right)$

If B_1 and B_2 are the sound levels and I_1 and I_2 are the intenaities in the two cases

$B_2 - B_1 = 10 \log_{10}\left(\frac{I_2}{I_1}\right)$

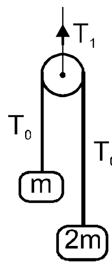
$\frac{I_2}{I_1} = 100 \qquad$ So $\qquad \frac{S_{02}}{S_{01}} = \sqrt{\frac{I_2}{I_1}} = 10$

$S_{02} = 10\, S_{o1}$

and $\quad S_{01} = \frac{P_0}{BK} = \frac{3}{2} \times \frac{10^{-3}}{1.5 \times 10^5} \times \frac{20\pi \times 10^{-2}}{2\pi} = 10Å$

So $\quad S_{o2} = 100Å$

28. $T_1 = 2T_0 = 2\left[\frac{2m(2m)}{m + 2m}\right]g$



$T_1 = \frac{8m}{3}g = \frac{80m}{3}$ ....(i)

In resonance,

$f_{wire} = f_{tube}$

$\frac{(1)V_1}{2\ell_1} = \frac{(1)V_2}{4\ell_2}$

$\frac{\left(\sqrt{\frac{T_1}{\mu}}\right)}{2(x)} = \frac{(400)}{4\left(\frac{x}{2}\right)}$

$\Rightarrow \quad T_1 = \mu(16 \times 10^4)$

From (i), $\quad \frac{80}{3} m = 10^{-4}\,(16 \times 10^4)$

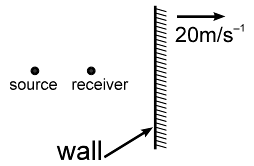
m = 0.6 kg.

29. As ; $f_1 = f$ (For direct sound)

Now ; for reflected sound $f_2 = \left(\frac{V-20}{V+20}\right)f$

If b is the beat frequency ;

$\therefore\ b = f_1 - f_2$



$\therefore\ f - \left(\frac{V-20}{V+20}\right)f \quad = \frac{f.40}{v+20}$

$= \frac{300.40}{350} = \frac{240}{7}$ Hz

30. $v = \sqrt{\frac{\gamma RT}{M}}$

$M = \frac{4\times 2+2\times 2}{4} = 3g$

$\gamma = 1+\frac{2}{f} = 1+\frac{2\times(2+2)}{2\times 3+2\times 5} = \frac{3}{2}$

$\therefore \quad v = \sqrt{\frac{3}{2}\times\frac{25}{3}\times\frac{1000}{3}\times\frac{972}{5}} = 900$ m/s

Ans. 90

31. Imagine a cylinder of radius 7m and length 10m. Intensity of sound at the surface of cylinder is same everywhere.

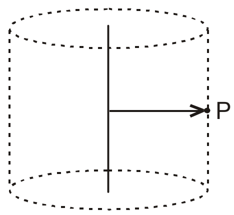
Therefore $I = \frac{P}{2\pi rL} \quad = \frac{2.2\times 10^4}{2\pi\times 10\times 7}$

(As sound is propagating radially out only, sound energy does not flow out through the ends)

$\therefore \quad I = 50\ W/m^2$

Energy intercepted by the detector

$= I \times A \quad = 12$ mW



32. $\lambda = 2\ell = 3m$

Equation of standing wave

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

$y = A$ as amplitude is 2A.

$A = 2A \sin kx$

$\frac{2\pi}{\lambda}x = \frac{\pi}{6} \quad \Rightarrow \quad x_1 = \frac{1}{4}$ m

and $\frac{2\pi}{\lambda}.x = \frac{5\pi}{6} \quad \Rightarrow \quad x_2 = 1.25\ m \Rightarrow x_2 - x_1 = 1m$

33 to 34

(33) $f_{1i} = f_{1r} = \frac{v}{v - v_c} f$, $f_{2i} = f_{2r} = \frac{v}{v + v_c} f$

Now, for driver $f_{dr1} = \frac{v + v_c}{v} f_{1r}$

and $f_{dr2} = \frac{v - v_c}{v} f_{2r}$

So, beat frequency= $| f_{dr1} - f_{dr2} |$

$= \left| \frac{v + v_c}{v} f_{1r} - \frac{v - v_c}{v} f_{2r} \right| = \left\{ \frac{(v + v_c)^2 - (v - v_c)^2}{(v + v_c)(v - v_c)} \right\} f$

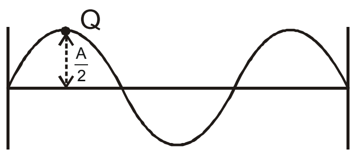
$= \left(\frac{4vv_c}{v^2} \right) f = \left(\frac{4v_c}{v} \right) f$.

(34) $\lambda_1 = \frac{v + v_c}{f}$ $\lambda_2 = \frac{v - v_c}{f}$

$\lambda_1 - \lambda_2 = \frac{2v_c}{f}$, $\lambda_1 + \lambda_2 = \frac{2v}{f}$

$\frac{\lambda_1 - \lambda_2}{\lambda_1 + \lambda_2} = \frac{v_c}{v}$.

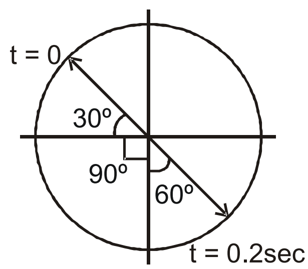
35 to 37 t = 0



Displacement equations of point Q = $A \sin \left(\omega t + \frac{5\pi}{6} \right)$

Equation of standing wave $y(x) = A(x) \sin \left(\omega t + \frac{5\pi}{6} \right) = A \sin kx. \sin (\omega t + \frac{5\pi}{6})$

According to snapshots



$t = \frac{1}{5} = \frac{\pi}{\omega} \Rightarrow \omega = 5\pi$ rad/s

Time period $T = \frac{2\pi}{5\pi} = \frac{2}{5}$ sec

wavelength $\lambda = 0.2$ m

wave velocity $v = \frac{\lambda}{T} = \frac{2}{10} \cdot \frac{5}{2} = \frac{1}{2}$ m / s

Disp. equation for point P $y = A \sin \left(\omega t + \frac{11\pi}{6} \right)$

velocity equation for point P $V_p = \omega A \cos \left(\omega t + \frac{11\pi}{6} \right)$

Acceleration equation for point P $a_p = -\omega^2 A \sin \left(\omega t + \frac{11\pi}{6} \right)$

here $\omega = 5\pi$rad/s A = 2 cm

38. $f = \frac{n}{2\ell}\sqrt{\frac{T}{\mu}}$

$f \propto \frac{\sqrt{T}}{\ell}$

39. $f \propto \sqrt{T}$

So Δf increases by increasing T.

i.e. $f_2 = f_1 + 3 = 443$ Hz]

40 to 42

Applying cosine rule in the triangle S_1S_2A, $\cos 60^0 = \frac{3^2 + 4^2 - S_1A^2}{2 \times 3 \times 4} \Rightarrow S_1A = \sqrt{13}$ .For line sources intensity is inversely proportional to the distance from the source. At A , let the intensity due to the source S_1 be I, then $I\sqrt{13} = I_0\,3$.

Similarly at B , let the intensity due to the source S_1 be I', then $I'5 = I_0\;3$. Path difference = 2m = 2 λ.

$\therefore$ the interference will be constructive. $\therefore I_{res} = I_0 + I' + 2\sqrt{I_0 I'}$

43. (A) The fundamental frequency in the string,

$$f_0 = \frac{\sqrt{T/\mu}}{2\ell} = \sqrt{\frac{102.4}{1 \times 10^{-3}}} \times \frac{1}{2 \times 0.5} \text{ Hz } = 320 \text{ Hz.}$$

Other possible resonance frequencies are f_A and f_0 = 320 Hz, 640 Hz, 960 Hz.

(B) The fundamental frequency in the string.

$$f_0 = \frac{\sqrt{T/\mu}}{4\ell} = \frac{320}{4 \times 0.5} = 160 \text{ Hz.}$$

Other possible resonance frequencies are

f_B = 160 Hz, 480 Hz, 800 Hz.

(C) The fundamental frequency in both ends open organ pipe is

$$f_0 = \frac{v}{2\ell} = \frac{320}{2 \times 0.5} = 320 \text{ Hz.}$$

Other possible resonance frequencies are

f_c = 320 Hz, 640 Hz, 960 Hz

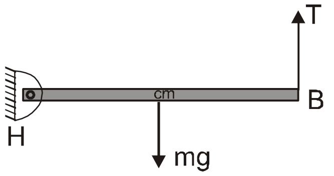
(D) The fundamental frequency in one end open organ pipe is

$$f_0 = \frac{v}{4\ell} = \frac{320}{4 \times 0.5} = 160 \text{ Hz.}$$

Other possible resonance frequencies are

f_D = 160 Hz, 480 Hz, 800 Hz.

45. (A) Due to reflection from a moving wall, frequency of the sound wave will change. So, the superposition of the incident waves and the reflected waves will produce beats.

(B) 

Applying torque balance about the hinge point 'H'

$$(mg)\left(\frac{\ell}{2}\right) = (T)\,(\ell)$$

$$T = \frac{mg}{2} = \frac{20 \times 10}{2} = 100 \text{ m}$$

Natural frequencies of the fixed–free wire are

$$f = \frac{1}{4\ell}\sqrt{\frac{T}{\mu}},\ \frac{3}{4\ell}\sqrt{\frac{T}{\mu}},\ \frac{5}{4\ell}\sqrt{\frac{T}{\mu}},\ ....$$

$$f = \frac{1}{4 \times 1}\sqrt{\frac{100}{0.01}},\ .... \quad \Rightarrow \quad f = 25,\ \underline{\boldsymbol{75}},\ 125,.............$$

f = 75 Hz matches with the frequency of the source, so resonance will occur and standing waves are generated.

(C) $y = A\sin^2(\omega t - kx) + B\cos^2(kx - \omega t) + C\cos(kx + \omega t)\sin(kx + \omega t)$

Solving we can get,

y = (some constant) $\cos 2(\omega t - kx)$ + (some constant) $\sin 2(kx + \omega t)$

which is superposition of waves moving in opposite direction. So, standing waves can be produced.

But if $A = B$ or $C = 0$, then only travelling waves will be formed.

(D) If the hammer is hit once,a pulse will generated and a moving pulse is a travelling wave. The pulse will more rightward, will be reflected from the wall and then move in opposite direction.

As there is no other wave, so standing waves will not form. As this is just a pulse, so particle will not perform SHM.