16

Waves

JEE-Main

Wave Equation

1. A plane progressive wave is given by $y = 2\cos 2\pi(330t - x)$ *m*. The frequency of the wave is : **[08 April, 2024 (Shift-II)]**

(*a*) 165 Hz (*b*) 330 Hz
(*c*) 660 Hz (*d*) 340 Hz

2. The equation of wave is given by $Y = 10^{-2}\sin 2\pi\left(160t - 0.5x + \frac{\pi}{4}\right)$

Where x and Y are in *m* and t in *s*. The speed of the wave is _____ km h^{-1} **[11 April, 2023 (Shift-I)]**

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

4. A longitudinal wave is represented by $x = 10\sin 2\pi\left(nt - \frac{x}{\lambda}\right)$ cm

The maximum particle velocity will be four times the wave velocity if the determined value of wavelength is equal to:
[29 June, 2022 (Shift-I)]

(*a*) 2π (*b*) 5π (*c*) π (*d*) $\frac{5\pi}{2}$

5. Which of the following equations represents a traveling wave?
[24 Feb, 2021 (Shift-II)]

(*a*) $y = A\sin x\cos\omega t$ (*b*) $y = A\sin(15x - 2t)$
(*c*) $y = Ae^{x}\cos(\omega t - \theta)$ (*d*) $y = Ae^{-x^2}(vt + \theta)$

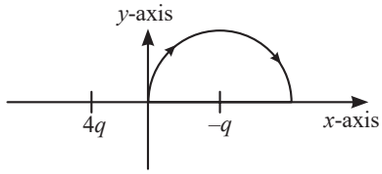
6. Two waves are simultaneously passing through a string and their equations are: $y_1 = A_1\sin k(x - vt)$, $y_2 = A_2\sin k(x - vt + x_0)$. Given amplitudes $A_1 = 12$ mm and $A_2 = 5$ mm, $x_0 = 3.5$ cm and wave number $k = 6.28$ cm^{-1}. The amplitude of resulting wave will be _____ mm.
[26 Aug, 2021 (Shift-II)]

7. For a transverse wave traveling along a straight line, the distance between two peaks (crests) is 5m, while the distance between one crest and one trough is 1.5m. The possible wavelengths (in m) of the waves are: **[4 Sep, 2020 (Shift-I)]**

(*a*) 1, 3, 5, ... (*b*) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \frac{1}{4}\ldots$

(*c*) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, \frac{1}{4}\ldots$ (*d*) 1, 2, 3, ...

8. A two point charges $4q$ and $-q$ are fixed on the x-axis at $x = -d/2$ and $x = d/2$, respectively. If a third point charge 'q' is taken from the origin to $x = d$ along the semicircle as shown in the figure, the energy of the charge will **[4 Sep, 2020 (Shift-I)]**



(*a*) Decrease by $\frac{q^2}{4\pi\varepsilon_0 d}$ (*b*) Decrease by $\frac{4q^2}{3\pi\varepsilon_0 d}$

(*c*) Increase by $\frac{2q^2}{3\pi\varepsilon_0 d}$ (*d*) Increase by $\frac{3q^2}{4\pi\varepsilon_0 d}$

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

(*a*) The wave is propagating along the negative x-axis with speed 25 ms^{-1}.
(*b*) The wave is propagating along the positive x-axis with speed 100 ms^{-1}.
(*c*) The wave is propagating along the positive x-axis with speed 25 ms^{-1}.
(*d*) The wave is propagating along the negative x-axis with speed 100 ms^{-1}.

Velocity of Wave, Energy and Power

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

(*a*) 200 π m/s (*b*) 100 m/s (*c*) 10 m/s (*d*) 50 m/s

11. A travelling wave is described by the equation
$y(x,t) = \left[0.05\sin(8x - 4t)\right]m$
The velocity of the wave is: [all the quantities are in *SI* unit]
[24 Jan, 2023 (Shift-I)]

(*a*) 4 ms^{-1} (*b*) 2 ms^{-1} (*c*) 0.5 ms^{-1} (*d*) 8 ms^{-1}

12. The fundamental frequency of vibration of a string stretched between two rigid support is 50 Hz. The mass of the string is 18 *g* and its linear mass density is 20 g/m. The speed of the transverse waves so produced in the string is _____ms^{-1}. **[15 April 2023 (Shift-I)]**

13. In the wave equation

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

the velocity of the wave will be: **[28 July, 2022 (Shift-I)]**

(*a*) 200 m/s (*b*) $200\sqrt{2}$ m/s

(*c*) 400 m/s (*d*) $400\sqrt{2}$ m/s

14. A transverse wave is represented by $y = 2\sin(\omega t - kx)$cm. The value of wavelength (in cm) for which the wave velocity becomes equal to the maximum particle velocity will be: **[26 July, 2022 (Shift-II)]**

(*a*) 4π (*b*) 2π (*c*) π (*b*) 2

15. The mass per unit length of a uniform wire is 0.135 g/cm. A transverse wave of the form $y = -0.21\sin(x + 30t)$ is produced in it, where *x* is in meter and *t* is in second. Then, the expected value of tension in the wire is $x \times 10^{-2}$ N. Value of *x* is _____. (Round-off to the nearest integer) **[26 Feb, 2021 (Shift-I)]**

16. The amplitude of wave disturbance propagating in the positive *x*-direction is given by $y = \frac{1}{1+(x)^2}$ at $t = 0$ and $y = \frac{1}{1+(x-2)^2}$ at $t = 1$s, where *x* and *y* are in metres. The shape of wave does not change during the propagation. The velocity of the wave will be _____ m /s. **[20 July, 2021 (Shift-I)]**

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

(*a*) 10.2×10^2 N (*b*) 30.5×10^4 N

(*c*) 5.15×10^3 N (*d*) 2.50×10^4 N

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

(*a*) 320 m/s, 120 Hz (*b*) 180 m/s, 80 Hz

(*c*) 180 m/s, 120 Hz (*d*) 320 m/s, 80 Hz

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

(*a*) 12°C (*b*) 11°C (*c*) 15°C (*d*) 4°C

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

(*a*) 10 N (*b*) 7.5 N (*c*) 12.5 N (*d*) 5 N

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

(*a*) 10.0 cm (*b*) 33.3 cm

(*c*) 16.6 cm (*d*) 20.0 cm

22. A light wave is incident normally on a glass slab of refractive index 1.5. If 4% of light gets reflected and the amplitude of the electric field of the incident light is 30 V/m, then the amplitude of the electric field for the wave propagating in the glass medium will be **[12 Jan, 2019 (Shift-I)]**

(*a*) 30 V/m (*b*) 10 V/m (*c*) 24 V/m (*d*) 6 V/m

Interference of Wave

23. Two waves of intensity ratio 1 : 9 cross each other at a point. The resultant intensities at the point, when (*a*) Waves are incoherent is I_1(*b*) Waves are coherent is I_2 and differ in phase by 60°. If $\frac{I_1}{I_2} = \frac{10}{x}$ then x = _____. **[31 Jan, 2024 (Shift-I)]**

24. The equations of two waves are given by:

$y_1 = 5\sin2\pi(x - vt)$ cm

$y_2 = 3\sin2\pi(x - vt + 1.5)$ cm

These waves are simultaneously passing through a string. The amplitude of the resulting wave is: **[24 June, 2022 (Shift-I)]**

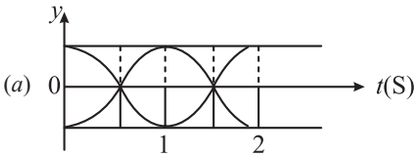
(*a*) 2 cm (*b*) 4 cm (*c*) 5.8cm (*d*) 8 cm

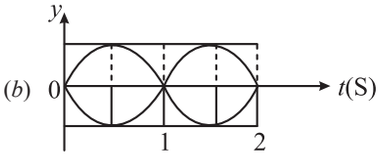
25. Two travelling waves of equal amplitudes and frequencies move in opposite directions along a string. They interfere to produce a stationary wave whose equation is given by $y = \left(10\cos\pi x\sin\frac{2\pi t}{T}\right)$ cm . The amplitude of the particle at $x = \frac{4}{3}$ cm will be _____cm.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

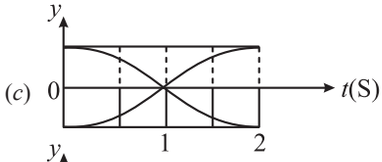
26. Three harmonic waves having equal frequency *v* and same intensity I_0, have phase angles 0, $\frac{\pi}{4}$ and $-\frac{\pi}{4}$ respectively. When they are superimposed the intensity of the resultant wave is close to **[9 Jan, 2020 (Shift-I)]**

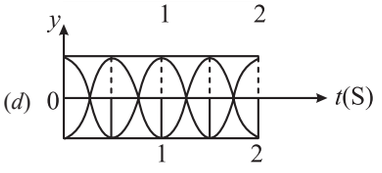
(*a*) $5.8\,I_0$ (*b*) $3\,I_0$ (*c*) I_0 (*d*) $0.2\,I_0$

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

(*a*)


(*b*)


(*c*)


(*d*)


28. Two coherent sources produce waves of different intensities which interfere. After interference, the ratio of the maximum intensity to the minimum intensity is 16. The intensity of the waves are in the ratio **[9 Jan, 2019 (Shift-I)]**

(*a*) 16 : 9 (*b*) 25 : 9 (*c*) 4 : 1 (*d*) 5 : 3

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

(*a*) $\frac{g}{30}$ (*b*) $\frac{g}{5}$ (*c*) $\frac{g}{10}$ (*d*) $\frac{g}{20}$

Reflection of Waves and Standing Waves

30. In a closed organ pipe, the frequency of fundamental note is 30 Hz. A certain amount of water is now poured in the organ pipe so that the fundamental frequency is increased to 110 Hz. If the organ pipe has a cross-sectional area of 2 cm^2, the amount of water poured in the organ tube is _____ *g*. (Take speed of sound in air is 330 m/s) **[30 Jan, 2024 (Shift-I)]**

31. The equation of stationary wave is:

$$y = 2a \sin\left(\frac{2\pi nt}{\lambda}\right)\cos\left(\frac{2\pi x}{\lambda}\right)$$

Which of the following is NOT correct **[04 April, 2024 (Shift-I)]**

(*a*) The dimensions of *nt* is [*L*]
(*b*) The dimensions of *n* is [LT^{-1}]
(*c*) The dimensions of n/λ is [*T*]
(*d*) The dimensions of *x* is [*L*]

32. A sonometer wire of resonating length 90 cm has a fundamental frequency of 400 Hz when kept under some tension. The resonating length of the wire with fundamental frequency of 600 Hz under same tension _____ cm. **[05 April, 2024 (Shift-II)]**

33. A wire of density 8×10^3 kg/m^3 is stretched between two clamps 0.5m apart. The extension developed in the wire is 3.2×10^{-4}. If Y = 8×10^{10} N/m^2, the fundamental frequency of vibration in the wire will be _____ Hz. **[11 April, 2023 (Shift-II)]**

34. A guitar string of length 90 cm vibrates with a fundamental frequency of 120 Hz. The length of the string producing a fundamental frequency of 180 Hz will be _____ cm.

[08 April, 2023 (Shift-II)]

35. In an experiment with sonometer when a mass of 180 g is attached to the string, it vibrates with fundamental frequency of 30 Hz. When a mass *m* is attached, the string vibrates with fundamental frequency of 50 Hz. The value of *m* is _____ g. **[13 April, 2023 (Shift-II)]**

36. A string of length 1 m and mass 2×10^{-5} kg is under tension *T*. When the string vibrates, two successive harmonics are found to occur at frequencies 750 Hz and 1000 Hz. The value of tension *T* is _____Newton. **[JEE Adv, 2023]**

37. A wire of length 30 cm, stretched between rigid supports, has it's n^{th} and $(n+1)^{th}$ harmonics at 400 Hz and 450 Hz, respectively. If tension in the string is 2700 N, it's linear mass density is _____kg/m.

[27 July, 2022 (Shift-II)]

38. The percentage increase in the speed of transverse waves produced in a stretched string if the tension is increased by 4%, will be ……..%.

[25 Feb, 2021 (Shift-II)]

39. A wire having a linear mass density 9.0×10^{-4} kg/m is stretched between two rigid supports with a tension of 900 N. The wire resonates at a frequency of 500 Hz. The next higher frequency at which the same wire resonates is 550 Hz. The length of the wire is _____ m. **[31 Aug, 2021 (Shift-I)]**

40. Two travelling waves produces a standing wave represented by equation, $y = 1.0$ mm cos (1.57 cm^{-1}) x sin (78.5s^{-1})t. The node closest to the origin in the region $x > 0$ will be at $x =$ _____ cm. **[26 Aug, 2021 (Shift-I)]**

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

[03 Sep, 2020 (Shift-I)]

(*a*) 6 (*b*) 12 (*c*) 3 (*d*) 9

42. Two identical strings *X* and *Z* made of same material have tension T_x and T_z in then if their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio T_x/T_z is: **[2 Sep, 2020 (Shift-I)]**

(*a*) 1.25 (*b*) 2.25 (*c*) 1.5 (*d*) 0.44

43. A wire of length *L* and mass per unit length 6.0×10^{-3} kg m^{-1} is put under tension of 540 N. Two consecutive frequencies that it resonates at are 420 Hz and 490 Hz. Then *L* in meters is:

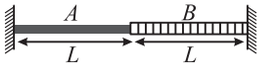
[9 Jan, 2020 (Shift-II)]

(*a*) 1.1 m (*b*) 5.1 m (*c*) 2.1 m (*d*) 8.1 m

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

[2 Sep, 2020 (Shift-II)]

45. A wire of length 2*L*, is made by joining two wires *A* and *B* of same lengths but different radii *r* and 2*r* and made of the same material. It is vibrating at a frequency such that the joint of the two wires forms a node. If the number of anti-nodes in wire *A* is *p* and that in *B* is *q* then the ratio *p* : *q* is: **[8 April, 2019 (Shift-I)]**



(*a*) 4 : 9 (*b*) 3 : 5 (*c*) 1 : 4 (*d*) 1 : 2

46. 50 W/m^2 energy density of sunlight is normally incident on the surface of a solar panel. Some part of incident energy (25%) is reflected from the surface and the rest is absorbed. The force exerted on 1 m^2 surface area will be close to ($c = 3 \times 10^8$ m/s)

[9 April, 2019 (Shift-II)]

(*a*) 15×10^{-8} N (*b*) 35×10^{-8} N (*c*) 10×10^{-8} N (*d*) 20×10^{-8} N

47. A string is clamped at both the ends and it is vibrating in its 4th harmonic. The equation of the stationary wave is $Y = 0.3 \sin(0.157x)\cos(200\pi t)$. The length of the string is: (All quantities are in *SI* units.)

[9 April, 2019 (Shift-I)]

(*a*) 20 m (*b*) 80 m (*c*) 60 m (*d*) 40 m

Velocity of Sound Wave, Energy and Intensity

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

[30 Jan, 2024 (Shift-II)]

49. The speed of sound in oxygen at S.T.P. will be approximately: (Given, R = 8.3 JK^{-1}, $\gamma = 1.4$) **[31 Jan, 2024 (Shift-II)]**

(*a*) 310 m/s (*b*) 333 m/s (*c*) 341 m/s (*d*) 325 m/s

50. Two open organ pipes of length 60 cm and 90 cm resonate at 6th and 5th harmonics respectively. The difference of frequencies for the given modes is _____ Hz.

(Velocity of sound in air = 333 m/s) **[06 April, 2024 (Shift-II)]**

51. The ratio of speed of sound in hydrogen gas to the speed of sound in oxygen gas at the same temperature is:

[06 April, 2023 (Shift-II)]

(*a*) 4 : 1 (*b*) 1 : 2 (*c*) 1 : 4 (*d*) 1 : 1

Vibration in Air Column and Beats

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

[27 Jan, 2024 (Shift-II)]

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

[31 Jan, 2024 (Shift-I)]

(*a*) 60 cm (*b*) 45 cm (*c*) 30 cm (*d*) 15 cm

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

[1 Feb, 2024 (Shift-I)]

55. A closed and an open organ pipe have same lengths. If the ratio of frequencies of their seventh overtones is $\left(\frac{a-1}{a}\right)$ then the value of a is _____. **[08 April, 2024 (Shift-I)]**

56. For a certain organ pipe, the first three resonance frequencies are in the ratio of 1 : 3 : 5 respectively. If the frequency of fifth harmonic is 405 Hz and the speed of sound in air is 324 ms^{-1} the length of the organ pipe is _____ m . **[12 April, 2023 (Shift-I)]**

57. An organ pipe 40 cm long is open at both ends. The speed of sound in air is 360 ms^{-1}. The frequency of the second harmonic is _____ Hz. **[08 April, 2023 (Shift-I)]**

58. In an experiment to determine the velocity of sound in air at room temperature using a resonance tube, the first resonance is observed when the air column has a length of 20.0 cm for a tuning fork of frequency 400 Hz is used. The velocity of the sound at room temperature is 336 ms^{-1}. The third resonance is observed when the air column has a length of _____cm. **[29 June, 2022 (Shift-II)]**

59. The first overtone frequency of an open organ pipe is equal to the fundamental frequency of a closed organ pipe. If the length of the closed organ pipe is 20 cm. The length of the open organ pipe is _____ cm. **[25 June, 2022 (Shift-I)]**

60. A tunning fork of frequency 340 Hz resonates in the fundamental mode with a air column of length 125 cm in a cylindrical tube closed at one end. When water is slowly poured in it, the minimum height of water required for observing resonance once again is _____cm. (Velocity of sound in air is 340 ms^{-1}) **[28 June, 2022 (Shift-II)]**

61. A tuning fork *A* of unknown frequency produces 5 beats/s with a fork of known frequency 340 Hz. When fork *A* is filed, the beat frequency decreases to 2 beats/s. What is the frequency of fork *A*?

[26 Feb, 2021 (Shift-II)]

(*a*) 345 Hz (*b*) 338 Hz (*c*) 342 Hz (*d*) 335 Hz

62. A closed organ pipe of length *L* and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively.
The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with same frequency. The length of the open pipe is $\frac{x}{3}L\sqrt{\frac{\rho_1}{\rho_2}}$ where *x* is (Round off to the Nearest Integer) **[16 March, 2021 (Shift-II)]**

63. A tuning fork is vibrating at 250 Hz. The length of the shortest closed organ pipe that will resonate with the tuning fork will be _____ cm. (Take speed of sound in air as 340 ms^{-1}) **[27 Aug, 2021 (Shift-II)]**

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

[05 Sep, 2020 (Shift-I)]

(*a*) 2200 Hz (*b*) 3300 Hz (*c*) 1100 Hz (*d*) 550 Hz

65. A one metre long (both ends open) organ pipe is kept in a gas that has double the density of air at STP. Assuming the speed of sound in air STP is 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is _____Hz.

[8 Jan, 2020 (Shift-I)]

66. A stationary tuning fork is in resonance with an air column in a pipe. If the tuning fork is moved with a speed of 2 ms^{-1} in front of the open end of the pipe and parallel to it, the length of the pipe should be changed for the resonance to occur with the moving tuning fork. If the speed of sound in air is 320 ms^{-1}, the smallest value of the percentage change required in the length of the pipe is_____. **[JEE Adv, 2020]**

67. A tuning fork of frequency 480 Hz is used in an experiment for measuring speed of sound (*V*) in air by resonance tube method. Resonance is observed to occur at two successive lengths of the air column, $\ell_1 = 30$ cm and $\ell_2 = 70$ cm . Then *V* is equal to:

[12 April, 2019 (Shift-II)]

(*a*) 332 ms^{-1} (*b*) 338 ms^{-1} (*c*) 384 ms^{-1} (*d*) 397 ms^{-1}

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

[10 Jan, 2019 (Shift-II)]

(*a*) 6 (*b*) 4 (*c*) 7 (*d*) 5

JEE-Advanced

Wave Equation

Multiple Correct

1. $Y(x,t)=\dfrac{0.8}{\left[(4x+5t)^2+5\right]}$ represents a moving pulse where x and y are in meter and t is in second. Then, **(IIT-JEE 1999)**

(a) Pulse is moving in positive x-direction

(b) In 2s it will travel a distance of 2.5 m

(c) Its maximum displacement is 0.16 m

(d) It is a symmetric pulse

2. In a wave motion $y = a\sin(kx - \omega t)$, y can represent **(IIT-JEE 1999)**

(a) Electric field (b) Magnetic field

(c) Displacement (d) Pressure

3. As a wave propagates **(IIT-JEE 1999)**

(a) The wave intensity remains constant for a plane wave

(b) The wave intensity decreases as the inverse of the distance from the source for a spherical wave

(c) The wave intensity decreases as the inverse square of the distance from the source for a spherical wave

(d) Total intensity of the spherical wave over the spherical surface centered at the source remains constant at all times

Numerical Types/Integer Types

4. When two progressive waves $y_1 = 4\sin(2x - 6t)$ and $y_2 = 3\sin(2x - 6t - \pi/2)$ are superimposed, the amplitude of the resultant wave is **(IIT-JEE 2010)**

Fill in the Blanks

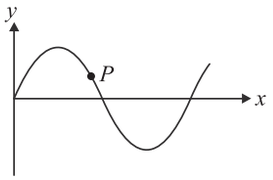
5. A plane progressive wave of frequency 25 Hz, amplitude 2.5×10^{-5} m and initial phase zero propagates along the negative x - direction with a velocity of 300 m/s. At any instant, the phase difference between the oscillations at two points 6 m apart along the line of propagation is ____ and the corresponding amplitude difference is ____ m. **(IIT-JEE 1997)**

6. A travelling wave has the frequency v and the particle displacement amplitude A. For the wave the particle velocity amplitude is _____ and the particle acceleration amplitude is _____ . **(IIT-JEE 1983)**

Velocity of Wave, Energy and Power

Single Correct

7. A transverse sinusoidal wave moves along a string in the positive x-direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap-shot of the wave is shown in figure. The velocity of point P when its displacement is 5 cm is **(IIT-JEE 2008)**



(a) $\dfrac{\sqrt{3}\pi}{50}\hat{j}$ m/s (b) $-\dfrac{\sqrt{3}\pi}{50}\hat{j}$ m/s

(c) $\dfrac{\sqrt{3}\pi}{50}\hat{i}$ m/s (d) $-\dfrac{\sqrt{3}\pi}{50}\hat{i}$ m/s

8. The ends of a stretched wire of length L are fixed at $x = 0$ and $x = L$. In one experiment the displacement of the wire is $y_1 = A\sin\left(\dfrac{\pi x}{L}\right)\sin\omega t$ and energy is E_1 and in other experiment its displacement is $y_2 = A\sin\left(\dfrac{2\pi x}{L}\right)\sin 2\omega t$ and energy is E_2. Then **(IIT-JEE 2001)**

(a) $E_2 = E_1$ (b) $E_2 = 2E_1$ (c) $E_2 = 4E_1$ (d) $E_2 = 16E_1$

9. A traveling wave in a stretched string is described by the equation $y = A\sin(kx - \omega t)$
The maximum particle velocity is **(IIT-JEE 1997)**

(a) $A\omega$ (b) ω / k (c) $d\omega / dk$ (d) x / ω

10. The extension in a string, obeying Hooke's law, is x. The speed of transverse wave in the stretched string is v. If the extension in the string is increased to $1.5x$, the speed of transverse wave will be **(IIT-JEE 1996)**

(a) 1.22 v (b) 0.61 v (c) 1.50 v (d) 0.75 v

11. A transverse wave is described by the equation $y = y_0 sin2\pi\left(ft - \dfrac{x}{\lambda}\right)$
The maximum particle velocity is equal to four times the wave velocity if **(IIT-JEE 1984)**

(a) $\lambda = \pi y_0/4$ (b) $\lambda = \pi y_0/2$ (c) $\lambda = \pi y_0$ (d) $\lambda = 2\pi y_0$

Multiple Correct

12. A transverse sinusoidal wave of amplitude a, wavelength λ and frequency f is traveling on a stretched string. The maximum speed of any point on the string is $v/10$, where v is the speed of propagation of the wave. If $a = 10^{-3}$ m and $v = 10$ m/s, then λ and f are given by **(IIT-JEE 1998)**

(a) $\lambda = 2\pi\times10^{-2}$ m (b) $\lambda = 10^{-3}$ m

(c) $f = \dfrac{10^3}{2\pi}$ Hz (d) $f = 10^4$ Hz

13. A wave is represented by the equation;
$y = A\sin(10\pi x + 15\pi t + \pi/3)$
where, x is in metre and t is in second. The expression represents **(IIT-JEE 1990)**

(a) a wave travelling in the positive x-direction with a velocity 1.5 m/s

(b) a wave travelling in the negative x-direction with a velocity 1.5 m/s

(c) a wave travelling in the negative x-direction with a wavelength 0.2 m

(d) a wave travelling in the positive x-direction with a wavelength 0.2 m

14. A wave equation which gives the displacement along the y-direction is given by: $y = 10^{-4} \sin(60t + 2x)$ where, x and y are in meter and t is time in second. This represents a wave **(IIT-JEE 1981)**

(*a*) Travelling with a velocity of 30 m/s in the negative x - direction

(*b*) Of wavelength (π) m

(*c*) Of frequency $\left(\frac{30}{\pi}\right)$ Hz

(*d*) Of amplitude 10^{-4} m

Numerical Types/Integer Types

15. Four harmonic waves of equal frequencies and equal intensities I_0 have phase angles $0, \frac{\pi}{3}, \frac{2\pi}{3}$ and π. When they are superposed, the intensity of the resulting wave is nI_0. The value of n is **(JEE Adv. 2015)**

16. The amplitude of a wave disturbance travelling in the positive x-direction is given by $y = \frac{1}{(1+x)^2}$ at time $t = 0$ and by $y = \frac{1}{\left[1+(x-1)^2\right]}$ at $t = 2$s, where x and y are in metre.

The shape of the wave disturbance does not change during the propagation. The velocity of the wave is m/s. **(IIT-JEE 1990)**

17. A uniform rope of length 12 m and mass 6 kg hangs vertically from a rigid support. A block of mass 2 kg is attached to the free end of the rope. A transverse pulse of wavelength 0.06 m is produced at the lower end of the rope. What is the wavelength of the pulse when it reaches the top of the rope? **(IIT-JEE 1984)**

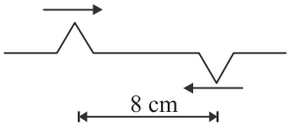
Subjective

18. A harmonically moving transverse wave on a string has a maximum particle velocity and acceleration of 3 m/s and 90 m/s^2 respectively. Velocity of the wave is 20 m/s. Find the waveform. **(IIT-JEE 2005)**

Interference of Wave

Single Correct

19. Two pulses in a stretched string, whose centers are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s the total energy of the pulses will be **(IIT-JEE 2001)**



(*a*) Zero

(*b*) Purely kinetic

(*c*) Purely potential

(*d*) Partly kinetic and partly potential

20. A string of length 0.4 m and mass 10^{-2} kg is tightly clamped at its ends. The tension in the string is 1.6 N. Identical wave pulses are produced at one end at equal intervals of time Δt. The minimum value of Δt, which allows constructive interference between successive pulses, is **(IIT-JEE 1998)**

(*a*) 0.05 s (*b*) 0.10 s (*c*) 0.20 s (*d*) 0.40 s

21. The displacement y of a particle executing periodic motion is given by $y = 4\cos^2\left(\frac{1}{2}t\right)\sin(1000t)$

This expression may be considered to be a result of the superposition of _____ independent harmonic motions. **(IIT-JEE 1992)**

(*a*) Two (*b*) Three (*c*) Four (*d*) Five

Subjective

22. Two radio stations broadcast their programmes at the same amplitude A and at slightly different frequencies ω_1 and ω_2 respectively, where $\omega_1 - \omega_2 = 10^3$ Hz. A detector receives the signals from the two stations simultaneously. It can only detect signals of intensity $\geq 2A^2$. **(IIT-JEE 1993)**

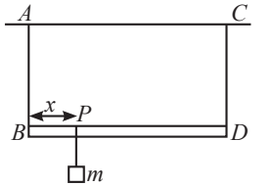
(*a*) Find the time interval between successive maxima of the intensity of the signal received by the detector.

(*b*) Find the time for which the detector remains idle in each cycle of the intensity of the signal.

Reflection of Waves and Standing Waves

Single Correct

23. A massless rod BD is suspended by two identical massless strings AB and CD of equal lengths. A block of mass m is suspended from point P such that BP is equal to x. If the fundamental frequency of the left wire is twice the fundamental frequency of right wire, then the value of x is **(IIT-JEE 2006)**



(*a*) $l/5$ (*b*) $l/4$ (*c*) $4l/5$ (*d*) $3l/4$

24. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9 kg is suspended from the wire. When this mass is replaced by mass M, the wire resonates with the same tuning fork forming three antinodes for the same positions of the bridges. The value of M is **(IIT-JEE 2002)**

(*a*) 25 kg (*b*) 5 kg (*c*) 12.5 kg (*d*) 1/25 kg

25. An object of specific gravity ρ is hung from a thin steel wire. The fundamental frequency for transverse standing waves in the wire is 300 Hz. The object is immersed in water, so that one half of its volume is submerged. The new fundamental frequency (in Hz) is **(IIT-JEE 1995)**

(*a*) $300\left(\frac{2\rho-1}{2\rho}\right)^{1/2}$ (*b*) $300\left(\frac{2\rho}{2\rho-1}\right)^{1/2}$

(*c*) $300\left(\frac{2\rho}{2\rho-1}\right)$ (*d*) $300\left(\frac{2\rho-1}{2\rho}\right)$

26. A wave represented by the equation $y = a\cos(kx - \omega t)$ is superimposed with another wave to form a stationary wave such that point $x = 0$ is a node. The equation for the other wave is **(IIT-JEE 1988)**

(a) $a \sin(kx + \omega t)$ (b) $-a\cos(kx - \omega t)$

(c) $-a\cos(kx + \omega t)$ (d) $-a\sin(kx - \omega t)$

Multiple Correct

27. One end of a taut string of length 3 m along the X – axis is fixed at $x = 0$. The speed of the waves in the string is 100 ms^{-1}. The other end of the string is vibrating in the y – direction so that stationary waves are set up in the string. The possible waveform(s) of these stationary wave is (are) **C-7.4 W-81.63 UA-10.97 (JEE Adv. 2014)**

(a) $y(t) = A\sin\frac{\pi x}{6}\cos\frac{50\pi t}{3}3$ (b) $y(t) = A\sin\frac{\pi x}{3}\cos\frac{100\pi t}{3}$

(c) $y(t) = A\sin\frac{5\pi x}{6}\cos\frac{250\pi t}{3}$ (d) $y(t) = A\sin\frac{5\pi x}{2}\cos 250\pi t$

28. Standing waves can be produced **(IIT-JEE 1999)**

(a) On a string clamped at both ends

(b) On a string clamped at one end and free at the other

(c) When incident wave gets reflected from a wall

(d) When two identical waves with a phase difference of π are moving in the same direction

29. The (x, y) coordinates of the corners of a square plate are (0, 0), (L, 0,), (L, L), and (0, L). The edges of the plate are clamped and transverse standing waves are set-up in it. If $u(x, y)$ denotes the displacement of the plate at the point (x, y) at some instant of time, the possible expression (s) for u is (are) (a = positive constant) **(IIT-JEE 1998)**

(a) $a\cos(\pi x/2L)\cos(\pi y/2L)$ (b) $a\sin(\pi x/L)\sin(\pi y/L)$

(c) $a\sin(\pi x/L)\sin(2\pi y/L)$ (d) $a\cos(2\pi x/L)\sin(\pi y/L)$

Numerical Types/Integer Types

30. A string of length 1 m and mass 2×10^{-5} kg is under tension T. When the string vibrates, two successive harmonics are found to occur at frequencies 750 Hz and 1000 Hz. The value of tension T is _____Newton. **C-22.64 W-54.39 UA-22.97 (JEE Adv. 2023)**

31. A steel wire of length 1 m, mass 0.1 kg and uniform cross-sectional area 10^{-6} m^2 is rigidly fixed at both ends. The temperature of the wire is lowered by 20°C. If transverse waves are set-up by plucking the string in the middle, calculate the frequency of the fundamental mode of vibration. **(IIT-JEE 1984)**

Given : $Y_{steel} = 2 \times 10^{11}$ N/m^2, $\alpha_{steel} = 1.21 \times 10^{-5}$/°$C$.

Fill in the Blanks

32. Sound waves of frequency 660 Hz fall normally on a perfectly reflecting wall. The shortest distance from the wall at which the air particles have maximum amplitude of vibration is ____ m. (Speed of sound = 330 m/s). **(IIT-JEE 1984)**

Subjective

33. A string of mass per unit length μ is clamped at both ends such that one end of the string is at $x = 0$ and the other is at $x = l$. When string vibrates in fundamental mode amplitude of the midpoint O of the string is a, and tension in the string is T. Find the total oscillation energy stored in the string. **(IIT-JEE 2003)**

34. A long wire PQR is made by joining two wires PQ and QR of equal radii. PQ has length 4.8 m and mass 0.06 kg. QR has length 2.56 m and mass 0.2 kg. The wire PQR is under a tension of 80 N. A sinusoidal wave pulse of amplitude 3.5 cm is sent along the wire PQ from the end P. No power is dissipated during the propagation of the wave pulse. Calculate: **(IIT-JEE 1999)**

(a) the time taken by the wave pulse to reach the other end R and

(b) the amplitude of the reflected and transmitted wave pulse after the incident wave pulse crosses the joint Q.

35. The displacement of the medium in a sound wave is given by the equation $y_1 = A\cos(ax + bt)$ where A, a and b are positive constants. The wave is reflected by an obstacle situated $ax = 0$. The intensity of the reflected wave is 0.64 times that of the incident wave. **(IIT-JEE 1991)**

(a) What are the wavelength and frequency of incident wave ?

(b) Write the equation for the reflected wave.

(c) In the resultant wave formed after reflection, find the maximum and minimum values of the particle speeds in the medium.

(d) Express the resultant wave as a superposition of a standing wave and a travelling wave. What are the positions of the antinodes of the standing wave? What is the direction of propagation of travelling wave ?

36. The following equations represent transverse waves;

$z_1 = A\cos(kx - \omega t)$; $z_2 = A\cos(kx + \omega t)$;

$z_3 = A\cos(ky - \omega t)$

Identify the combination (s) of the waves which will produce **(IIT-JEE 1987)**

(a) Standing wave

(b) A wave travelling in the direction making an angle of 45 degrees with the positive X and positive Y-axes. In each case, find the position at which the resultant intensity is always zero.

Velocity of Sound Wave, Energy and Intensity

Single Correct

37. Two plane harmonic sound waves are expressed by the equations.

$y_1(x, t) = A\cos(0.5\pi x - 100\pi t)$

$y_2(x, t) = A\cos(0.46\pi x - 92\pi t)$

(All parameters are in MKS)

What is the speed of the sound? **(IIT-JEE 2006)**

(a) 200 m/s (b) 180 m/s

(c) 192 m/s (d) 96 m/s

38. Two monoatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas 1 to the gas 2 is given by **(IIT-JEE 2000)**

(a) $\sqrt{\frac{m_1}{m_2}}$ (b) $\sqrt{\frac{m_2}{m_1}}$ (c) $\frac{m_1}{m_2}$ (d) $\frac{m_2}{m_1}$

39. The ratio of the speed of sound in nitrogen gas to that in helium gas, at 300 K is **(IIT-JEE 1999)**

(a) $\sqrt{(2/7)}$ (b) $\sqrt{(1/7)}$ (c) $(\sqrt{3})/5$ (d) $(\sqrt{6})/5$

Multiple Correct

40. In an experiment to measure the speed of sound by a resonating air column, a tuning fork of frequency 500 Hz is used. The length of the air column is varied by changing the level of water in the resonance tube. Two successive resonances are heard at air columns of length 50.7 cm and 83.9 cm. Which of the following statements is (are) true? **C-20.66 W-21.12 UA-43.88 PC-14.35 (JEE Adv. 2018)**

(*a*) The speed of sound determined from this experiment is 332 ms^{-1}

(*b*) The end correction in this experiment is 0.9 cm

(*c*) The wavelength of the sound wave is 66.4 cm

(*d*) The resonance at 50.7 cm corresponds to the fundamental harmonic

Fill in the Blanks

41. A point source emits sound equally in all directions in a non-absorbing medium. Two points *P* and *Q* are at a distance 9 m and 25 m respectively from the source. The ratio of amplitudes of the waves at P and *Q* is …… **(IIT-JEE 1989)**

True/False

42. The ratio of the velocity of sound in hydrogen gas $\left(\gamma = \frac{7}{5}\right)$ to that in helium gas $\left(\gamma = \frac{5}{3}\right)$ at the same temperature is $\sqrt{21/5}$.

(IIT-JEE 1983)

Interference and Reflection of Sound Wave

Match the Column

Direction: *Q.43 and Q.44 by appropriately matching the lists based on the information given in the paragraph.*

A musical instrument is made using four different metal strings, 1, 2, 3 and 4 with mass per unit length μ, 2μ, 3μ and 4μ respectively. The instrument is played by vibrating the strings by varying. The free length in between the range L_0 and $2L_0$. It is found that in siring-1 (μ) at free length L_0 and tension T_0 the fundamental mode frequency is f_0.

List-I gives the above four strings while List-II lists the magnitude of some quantity.

List-I	List-II
(I) String-1 (μ)	(P) 1
(II) String-2 (2μ)	(Q) $\frac{1}{2}$
(III) String-3 (3μ)	(R) $\frac{1}{\sqrt{2}}$
(IV) String-4 (4μ)	(S) $\frac{1}{\sqrt{3}}$
	(T) $\frac{3}{16}$
	(U) $\frac{1}{16}$

43. If the tension in each string is T_0, the correct match for the highest fundamental frequency in f_0 units will be.

C-37.82 W-22.48 UA-39.7 (JEE Adv. 2019)

(*a*) I→P, II→Q, III→T, IV→S (*b*) I→P, II→R, III→S, IV→Q

(*c*) I→Q, II→S, III→R, IV→P (*d*) I→Q, II→P, III→R, IV→T

44. The length of the strings 1, 2, 3 and 4 are kept fixed at L_0, $\frac{3L_0}{2}$, $\frac{5L_0}{4}$ and $\frac{7L_0}{4}$ respectively.

Strings 1, 2, 3 and 4 are vibrated at their 1st, 3rd, 5th and 14th harmonies, respectively such that all the strings have same frequency. The correct match for the tension in the four strings in the units of T_0 will be.

C-40.14 W-20.2 UA-39.66 (JEE Adv. 2019)

(*a*) I→P, II→R, III→T, IV→U

(*b*) I→P, II→Q, III→T, IV→U

(*c*) I→P, II→Q, III→R, IV→T

(*d*) I→T, II→Q, III→R, IV→U

True/False

45. A plane wave of sound traveling in air is incident upon a plane's water surface. The angle of incidence is 60°. Assuming Snell's law to be valid for sound waves, it follows that the sound wave will be refracted into water away from the normal. **(JEE Adv. 2020)**

Vibration in Air Column, Organ Pipe and Beats

Single Correct

46. A student is performing an experiment using a resonance column and a tuning fork of frequency 244 s^{-1}. He is told that the air in the tube has been replaced by another gas (assume that the column remains filled with the gas). If the minimum height at which resonance occurs is (0.350 ± 0.005) m, the gas in the tube is

C-4.73 W-76.06 UA-19.21 (JEE Adv. 2014)

(Useful information : $\sqrt{167RT} = 640J^{1/2}$ mole $^{-1/2}$; $\sqrt{140RT} = 590J^{1/2}\,mole^{-1/2}$. The molar masses M in grams are given in the options. Take the value of $\sqrt{10/M}$ for each gas as given there.)

(*a*) Neon $\left(M = 20; \sqrt{10/20} = 7/10\right)$

(*b*) Nitrogen $\left(M = 28; \sqrt{10/28} = 3/5\right)$

(*c*) Oxygen $\left(M = 32; \sqrt{10/32} = 9/16\right)$

(*d*) Argon $\left(M = 36; \sqrt{10/36} = 17/32\right)$

47. A student is performing an experiment on the resonance column. The diameter of the column tube is 4 cm. The frequency of the tuning fork is 512 Hz. The air temperature is 38°C in which the speed of sound is 336 m/s. The zero of the meter scale coincides with the top end of the resonance column tube. When the first resonance occurs, the reading of the water level in the column is

C-11.89 W-28.55 UA-59.55 (JEE Adv. 2012)

(*a*) 14.0 cm (*b*) 15.2 cm (*c*) 16.4 cm (*d*) 17.6 cm

48. A hollow pipe of length 0.8 m is closed at one end. At its open end a 0.5 m a long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of the pipe. If the tension in the wire is 50 N and the speed of sound is 320 ms^{-1}, the mass of the string is **(IIT-JEE 2010)**

(*a*) 5 g (*b*) 10 g (*c*) 20 g (*d*) 40 g

49. A vibrating string of certain length *l* under a tension *T* resonates with a mode corresponding to the first overtone (third harmonic) of an air column of length 75 cm inside a tube closed at one end. The string also generates 4 beats/s when excited along with a tuning fork of frequency *n*. Now when the tension of the string is slightly increased the number of beats reduces to 2 per second. Assuming the velocity of sound in air to be 340 m/s, the frequency n of the tuning fork in Hz is **(IIT-JEE 2008)**

(*a*) 344 (*b*) 336 (*c*) 117.3 (*d*) 109.3

50. Two plane harmonic sound waves are expressed by the equations.

$y_1(x, t) = A\cos(0.5\pi x - 100\pi t)$

$y_2(x, t) = A\cos(0.46\pi x - 92\pi t)$

(All parameters are in MKS)

How many times does an observer hear maximum intensity in one second ? **(IIT-JEE 2006)**

(*a*) 4 (*b*) 10 (*c*) 6 (*d*) 8

51. A tuning fork of 512 Hz is used to produce resonance in a resonance tube experiment. The level of water at first resonance is 30.7 cm and at second resonance is 63.2 cm. The error in calculating velocity of sound is **(IIT-JEE 2005)**

(*a*) 204.1 cm/s (*b*) 110 cm/s

(*c*) 58 cm/s (*d*) 280 cm/s

52. An open pipe is in resonance in 2nd harmonic with frequency f_1. Now one end of the tube is closed and frequency is increased to f_2 such that the resonance again occurs in nth harmonic. Choose the correct option. **(IIT-JEE 2005)**

(*a*) $n = 3, f_2 = (3/4)f_1$ (*b*) $n = 3, f_2 = (5/4)f_1$

(*c*) $n = 5, f_2 = (5/4)f_1$ (*d*) $n = 5, f_2 = (3/4)f_1$

53. A closed organ pipe of length *L* and an open organ pipe contain gases of densities ρ_1 and ρ_2 respectively. The compressibility of gases are equal in both the pipes. Both the pipes are vibrating in their first overtone with the same frequency. The length of the open organ pipe is **(IIT-JEE 2004)**

(*a*) $\frac{L}{3}$ (*b*) $\frac{4L}{3}$ (*c*) $\frac{4L}{3}\sqrt{\frac{\rho_1}{\rho_2}}$ (*d*) $\frac{4L}{3}\sqrt{\frac{\rho_2}{\rho_1}}$

54. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. Calculate the end correction. **(IIT-JEE 2003)**

(*a*) 0.012 m (*b*) 0.025 m (*c*) 0.05 m (*d*) 0.024 m

55. Two vibrating strings of the same material but of lengths *L* and 2*L* have radii 2*r* and *r* respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes. The one of length *L* with frequency v_1 and the other with frequency v_2. The ratio v_1/v_2 is given by **(IIT-JEE 2000)**

(*a*) 2 (*b*) 4 (*c*) 8 (*d*) 1

56. An open pipe is suddenly closed at one end with the result that the frequency of third harmonic of the closed pipe is found to be higher by 100 Hz then the fundamental frequency of the open pipe. The fundamental frequency of the open pipe is **(IIT-JEE 1996)**

(*a*) 200 Hz (*b*) 300 Hz (*c*) 240 Hz (*d*) 480 Hz

57. An organ pipe P_1 closed at one end vibrating in its first harmonic and another pipe P_2 open at both ends vibrating in its third harmonic are in resonance with a given tuning fork. The ratio of the length of P_1 and P_2 is **(IIT-JEE 1988)**

(*a*) 8/3 (*b*) 3/8 (*c*) 1/6 (*d*) 1/3

58. A tube, closed at one end and containing air, produces, when excited, the fundamental note of frequency 512 Hz. If the tube is opened at both ends the fundamental frequency that can be excited is (in Hz) **(IIT-JEE 1986)**

(*a*) 1024 (*b*) 512 (*c*) 256 (*d*) 1/3

59. A cylindrical tube, open at both ends, has a fundamental frequency f in air. The tube is dipped vertically in water so that half of its length is in water. The fundamental frequency of the air column is now **(IIT-JEE 1981)**

(*a*) *f*/2 (*b*) 3*f*/4 (*c*) *f* (*d*) 2*f*

Multiple Correct

60. A student performed an experiment to measure the speed of sound in air using the resonance air-column method. Two resonances in the air-column were obtained by lowering the water level. The resonance with the shorter air-column is the first resonance and that with the longer air column is the second resonance. Then, **(IIT-JEE 2009)**

(*a*) The intensity of the sound heard at the first resonance was more than that at the second resonance

(*b*) The prongs of the tuning fork were kept in a horizontal plane above the resonance tube

(*c*) The amplitude of vibration of the ends of the prongs is typically around 1 cm

(*d*) The length of the air-column at the first resonance was somewhat shorter than $1/4^{th}$ of the wavelength of the sound in air

61. A wave disturbance in a medium is described by $y(x, t) = 0.02 \cos\left(50\pi t + \frac{\pi}{2}\right)\cos(10\pi x)$, where *x* and *y* are in meter and t is in second. **(IIT-JEE 1995)**

(*a*) A node occurs at $x = 0.15$ m

(*b*) An antinode occurs at $x = 0.3$ m

(*c*) The speed of wave is 5 ms^{-1}

(*d*) The wavelength of wave is 0.2 m

62. Velocity of sound in air is 320 m/s. A pipe closed at one end has a length of 1 m. Neglecting end corrections, the air column in the pipe can resonate for sound of frequency. **(IIT-JEE 1989)**

(*a*) 80 Hz (*b*) 240 Hz

(*c*) 320 Hz (*d*) 400 Hz

63. An air column in a pipe, which is closed at one end, will be in resonance with a vibrating tuning fork of frequency 264 Hz, if the length of the column in cm is (Speed of sound in air=330 m/s) **(IIT-JEE 1985)**

(*a*) 31.25 cm (*b*) 62.50 cm

(*c*) 93.75 cm (*d*) 400 cm

64. Two identical straight wires are stretched so as to produce 6 beats/s when vibrating simultaneously. On changing the tension slightly in one of them, the beat frequency remains unchanged. Denoting by T_1, T_2 the higher and the lower initial tension in the strings, then it could be said that while making the above changes in tension

(IIT-JEE 1991)

(*a*) T_2 was decreased (*b*) T_2 was increased

(*c*) T_1 was decreased (*d*) T_1 was increased

65. A person blows into open-end of a long pipe. As a result, a high-pressure pulse of air travels down the pipe. When this pulse reaches the other end of the pipe,

C-38.01 W-55.05 UA-6.94 (IIT-JEE 2012)

(*a*) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.

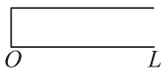
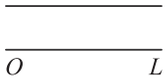
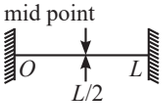
(*b*) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is open.

(*c*) a low-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed.

(*d*) a high-pressure pulse starts travelling up the pipe, if the other end of the pipe is closed.

Match the Column

66. Column-I shows four systems, each of the same length *L*, for producing standing waves. The lowest possible natural frequency of a system is called its fundamental frequency, whose wavelength is denoted as λ_f. Match each system with statements given in Column-II describing the nature and wavelength of the standing waves. **(IIT-JEE 2011)**

Column-I	Column-II
(*a*) Pipe closed at one end 	(p) Longitudinal waves
(*b*) Pipe open at both ends 	(q) Transverse waves
(*c*) Stretched wires clamped at both ends 	(r) $\lambda_f = L$
(*d*) Stretched wire clamped at both ends and at mid point 	(s) $\lambda_f = 2L$ (t) $\lambda_f = 4L$

Numerical Types/Integer Types

67. A stationary tuning fork is in resonance with an air column in a pipe. If the tuning fork is moved with a speed of 2 ms^{-1} in front of the open end of the pipe and parallel to it, the length of the pipe should be changed for the resonance to occur with the moving tuning fork. If the speed of sound in air is 320 ms^{-1}, the smallest value of the percentage change required in the length of the pipe is_____.

C-13.45, W-59.23, UA-27.32 (JEE Adv. 2020)

68. A 20 cm long string, having a mass of 1.0 g, is fixed at both the ends. The tension in the string is 0.5 N. The string is set into vibration using an external vibrator of frequency 100 Hz. Find the separation (in cm) between the successive nodes on the string.

(IIT-JEE 2009)

69. A 3.6 m long pipe resonates with a source of frequency 212.5 Hz when water level is at certain heights in the pipe. Find the heights of water level (from the bottom of the pipe) at which resonances occur. Neglect end correction. Now the pipe is filled to a height *H*(=3.6 m). A small hole is drilled very close to its bottom and water is allowed to leak. Obtain an expression for the rate of fall of water level in the pipe as a function of H. If the radii of the pipe and the hole are 2×10^{-2} m and 1×10^{-3} m respectively. Calculate the time interval between the occurrence of first two resonances. Speed of sound in air is 340 m/s and $g = 10$ m/s^2 **(IIT-JEE 2000)**

70. A string 25 cm long and having a mass of 2.5 g is under tension. A pipe closed at one end is 40 cm long. When the string is set vibrating in its first overtone and the air in the pipe in its fundamental frequency, 8 beats/s are heard. It is observed that decreasing the tension in the string decreases the beat frequency. If the speed of sound in air is 320 m/s find the tension in the string.

(IIT-JEE 1982)

71. In a resonance tube experiment to determine the speed of sound in air, a pipe of diameter 5 cm is used. The air column in pipe resonates with a tuning fork of frequency 480 Hz when the minimum length of the air column is 16 cm. Find the speed of sound in air at room temperature.

Fill in the Blanks

72. A cylinder resonance tube open at both ends has fundamental frequency f in air. Half of the length of the tube is dipped vertically in water. The fundamental frequency of the air column now is ……

(IIT-JEE 1992)

73. In a sonometer wire, the tension is maintained by suspending a 50.7 kg mass from the free end of the wire. The suspended mass has a volume of 0.0075 m^3. The fundamental frequency of vibration of the wire is 260 Hz. If the suspended mass is completely submerged in water, the fundamental frequency will become _____ Hz.

(IIT-JEE 1987)

Subjective

74. The air column in a pipe closed at one end is made to vibrate in its second overtone by tuning fork of frequency 440 Hz. The speed of sound 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. **(IIT-JEE 1998)**

(*a*) Find the length *L* of the air column.

(*b*) What is the amplitude of pressure variation at the middle of the column?

(*c*) What are the maximum and minimum pressures at the open end of the pipe?

(*d*) What are the maximum and minimum pressures at the closed end of the pipe?

75. A metallic rod of length 1 m is rigidly clamped at its mid-point. Longitudinal stationary waves are set-up in the rod in such a way that there are two nodes on either side of the midpoint. The amplitude of an antinode is 2×10^{-6} m. Write the equation of motion at a point 2 cm from the mid-point and those of the constituent waves in the rod. (Young's modulus of the material of the rod = 2×10^{11} Nm^{-2}; density = 8000 kg m^{-3}) **(IIT-JEE 1994)**

76. The vibrations of a string of length 60 cm fixed at both ends are represented by the equation

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

where, x and y are in cm and t is in second. **(IIT-JEE 1985)**

(a) What is the maximum displacement of a point at $x = 5$ cm?

(b) Where are the nodes located along the string?

(c) What is the velocity of the particle at $x = 7.5$ cm at $t = 0.25$ s?

(d) Write down the equations of the component waves whose superposition gives the above wave.

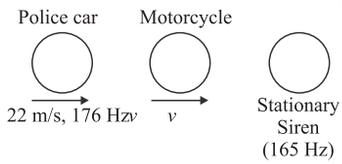
Doppler's Effect

Single Correct

77. A police car with a siren of frequency 8kHz is moving with uniform velocity 36 km/h towards a tall building which reflects the sound waves. The speed of sound in air is 320 m/s. The frequency of the siren heard by the car driver is **(JEE Adv. 2011)**

(a) 8.50kHz (b) 8.25kHz (c) 7.75kHz (d) 7.50kHz

78. A police car moving at 22 m/s chases a motorcyclist. The policeman sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle, if it is given that the motorcyclist does not observe any beats (speed of sound =330 m/s). **(IIT-JEE 2003)**



(a) 33 m/s (b) 22 m/s (c) Zero (d) 11 m/s

79. A siren placed at a railway platform is emitting sound of frequency 5kHz. A passenger sitting in a moving train A records a frequency of 5.5kHz, while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that of train A is **(IIT-JEE 2002)**

(a) 242/252 (b) 2 (c) 5/6 (d) 11/6

80. A whistle giving out 450 Hz approaches a stationary observer at a speed of 33 m/s. The frequency heard by the observer (in Hz) is (Speed of sound = 330 m/s) **(IIT-JEE 1997)**

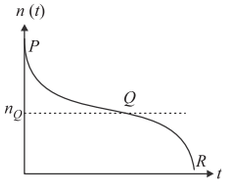
(a) 409 (b) 429 (c) 517 (d) 500

Multiple Correct

81. Two loudspeakers M and N are located 20 m apart and emit sound at frequencies 118 Hz and 121 Hz, respectively. A car in initially at a point P, 1800 m away from the midpoint Q of the line MN and moves towards Q constantly at 60 km/h along the perpendicular bisector of MN. It crosses Q and eventually reaches a point R,1800 m away from Q. Let $v(t)$ represent the beat frequency measured by a person sitting in the car at time t. Let v_P, v_Q and v_R be the beat frequencies measured at locations P, Q and R respectively. The speed of sound in air is 330 ms^{-1}. Which of the following statement(s) is (are) true regarding the sound heard by the person?

C-7.09 W-12.77 UA-56.65 PC-23.49 (JEE Adv. 2016)

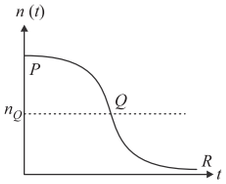
(a) The plot below represents schematically the variation of beat frequency with time



(b) The rate of change in beat frequency is maximum when the car passes through Q

(c) $v_P + v_R = 2v_Q$

(d) The plot below represents schematically the variations of beat frequency with time



82. A sound wave of frequency f travels horizontally to the right. It is reflected from a large vertical plane surface moving to left with a speed v. The speed of sound in medium is c **(IIT-JEE 1995)**

(a) The number of waves striking the surface per second is $f\dfrac{(c+v)}{c}$

(b) The wavelength of reflected wave is $\dfrac{c(c-v)}{f(c+v)}$

(c) The frequency of the reflected wave is $f\dfrac{(c+v)}{(c-v)}$

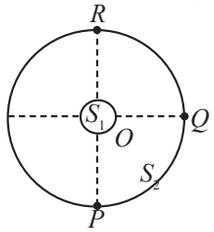
(d) The number of beats heard by a stationary listener to the left of the reflecting surface is $\dfrac{vf}{c-v}$

Comprehension Based/Passage Based

Comprehension-(83 to 84)

S_1 and S_1 are two identical sound sources of frequency 656 Hz. The source S_1 is located at O and S_2 moves anti-clockwise with a uniform speed $4\sqrt{2}$ ms^{-1} on a circular path around O, as shown in the figure. There are three points P, Q and R on this path such that P and R are diametrically opposite while Q is equidistant from them. A sound detector is placed at point P. The source S_1 can move along direction OP. **(JEE Adv. 2023)**

[Given: The speed of sound in air is 324 ms^{-1}]



83. When only S_2 is emitting sound and it is Q, the frequency of sound measured by the detector in Hz is _____.

C-11.95 W-56.87 UA-31.18

84. Consider both sources emitting sound. When S_2 is at R and S_1 approaches the detector with a speed 4ms^{-1}, the beat frequency measured by the detector is _____Hz.

C-14.41 W-53.97 UA-31.63

85. A source, approaching with speed u towards the open end of a stationary pipe of length L, is emitting a sound of frequency f_s. The farther end of the pipe is closed. The speed of sound in air is v and f_0 is the fundamental frequency of the pipe. For which of the following combination(s) of u and f_s, will the sound reaching the pipe lead to a resonance?

C-10.92 W-23.99 UA-54.96 PC-10.13 (JEE Adv. 2021)

(*a*) $u = 0.8v$ and $f_s = f_0$

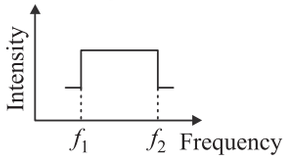
(*b*) $u = 0.8v$ and $f_s = 2f_0$

(*c*) $u = 0.8v$ and $f_s = 0.5f_0$

(*d*) $u = 0.5v$ and $f_s = 1.5f_0$

Comprehension-(86 to 87)

Two trains A and B are moving with speeds 20 m/s and 30 m/s respectively in the same direction on the same straight track, with B ahead of A. The engines are at the front ends. The engine of train A blows a long whistle.



Assume that the sound of the whistle is composed of components varying in frequency from $f_1 = 800$ Hz to $f_2 = 1120$ Hz, as shown in the figure. The spread in the frequency (highest frequency-lowest frequency) is thus 320 Hz. The speed of sound in air is 340 m/s.

86. The speed of sound of the whistle is **(IIT-JEE 2007)**

(*a*) 340 m/s for passengers in A and 310 m/s for passengers in B

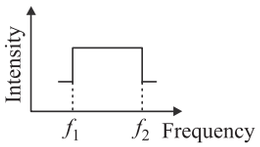
(*b*) 360 m/s for passengers in A and 310 m/s for passengers in B

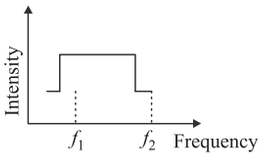
(*c*) 310 m/s for passengers in A and 360 m/s for passengers in B

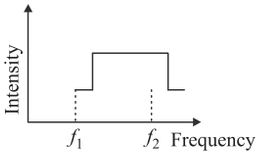
(*d*) 340 m/s for passengers in both the trains

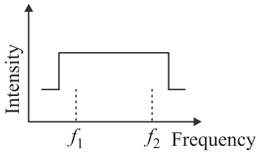
87. The distribution of the sound intensity of the whistle as observed by the passengers in train A is best represented by

(IIT-JEE 2007)

(*a*)


(*b*)


(*c*)


(*d*)


Numerical Types/Integer Types

88. A train S_1, moving with a uniform velocity of 108 km/h, approaches another train S_2 standing on a platform. An observer O moves with a uniform velocity of 36 km/h towards S_2, as shown in figure. Both the trains are blowing whistles of same frequency 120 Hz. When O is 600 m away from S_2 and distance between S_1 and S_2 is 800 m, the number of beats heard by O is ____. [Speed of the sound = 330 m/s]

C-15, W-62, UA-23 (JEE Adv. 2019)

89. Two men are walking along a horizontal straight line in the same direction. The man in front walks at a speed 1.0 ms^{-1} and the man behind walks at a speed 2.0 ms^{-1}. A third man is standing at a height 12 m above the same horizontal line such that all three men are in a vertical plane. The two walking men are blowing identical whistles which emit a sound of frequency 1430 Hz. The speed of sound in air 330 ms^{-1}. At the instant, when the moving men are 10 m apart, the stationary man is equidistant from them. The frequency of beats in Hz, heard by the stationary man at this instant, is

C-9.57 W-67.14 UA-23.29 (JEE Adv. 2018)

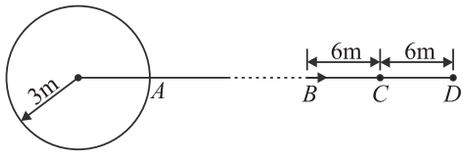
90. A stationary source emits sound of frequency $f_0 = 492$ Hz. The sound is reflected by a large car approaching the source with a speed of 2 ms^{-1}. The reflected signal is received by the source and superposed with the original. What will be the beat frequency of the resulting signal in Hz? (Given that the speed of sound in air is 330 ms^{-1} and the car reflects the sound at the frequency it has received).

C-23.37 W-71.07 UA-5.56 (JEE Adv. 2017)

91. An observer standing on a railway crossing receives frequency of 2.2kHz and 1.8kHz when the train approaches and recedes from the observer. Find the velocity of the train. (The speed of the sound in air is 300 m/s.) **(IIT-JEE 2005)**

92. A whistle emitting a sound of frequency 440 Hz is tied to a string of 1.5 m length and rotated with an angular velocity of 20 rad/s in the horizontal plane. Calculate the range of frequencies heard by an observer stationed at a large distance from the whistle. (Speed of sound =330 m/s). **(IIT-JEE 1996)**

93. A source of sound is moving along a circular path of radius 3 m with an angular velocity of 10 rad/s. A sound detector located far away from the source is executing linear simple harmonic motion along the line BD (see figure) with an amplitude $BC = CD = 6$ m. The frequency of oscillation of the detector is $5/\pi$ per second. The source is at the point A when the detector is at the point B. If the source emits a continuous sound wave of frequency 340 Hz, find the maximum and the minimum frequencies recorded by the detector. (Speed of sound = 340 m/s) **(IIT-JEE 1990)**



94. Two tuning forks with natural frequencies of 340 Hz each move relative to a stationary observer. One fork moves away from the observer, while the other moves towards him at the same speed. The observer hears beats of frequency 3 Hz. Find the speed of the tuning fork. Speed of sound =340 m/s. **(IIT-JEE 1986)**

95. A sonometer wire under tension of 64 N vibrating in its fundamental mode is in resonance with a vibrating tuning fork. The vibrating portion of the sonometer wire has a length of 10 cm and mass of 1 g. The vibrating tuning fork is now moved away from the vibrating wire with a constant speed and an observer standing near the sonometer hears one beat per second. Calculate the speed with which the tuning fork is moved, if the speed of sound in air is 300 m/s.

(IIT-JEE 1983)

96. A source of sound of frequency 256 Hz is moving rapidly towards a wall with a velocity of 5 m/s. How many beats per second will be heard by the observer on the source itself if sound travels at a speed of 330 m/s? **(IIT-JEE 1981)**

Fill in the Blanks

97. A bus is moving towards a huge wall with a velocity of 5 ms^{-1}. The driver sounds a horn of frequency 200 Hz. The frequency of the beats heard by a passenger of the bus will be ____ Hz. (Speed of sound in air = 342 ms^{-1}) **(IIT-JEE 1992)**

True/False

98. A source of sound with frequency 256 Hz is moving with a velocity 5m/s towards a wall and an observer is stationary between the source and the wall. When the observer is between the source and the wall he will hear beats.(The speed of sound is 330 m/s.)**(IIT-JEE 1985)**

Subjective

99. Two narrow cylindrical pipes *A* and *B* have the same length. Pipe *A* is open at both ends and is filled with a mono atomic gas of molar mass M_A. Pipe *B* is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass M_B. Both gases are at the same temperature.

(*a*) If the frequency to the second harmonic of pipe *A* is equal to the frequency of the third harmonic of the fundamental mode in pipe *B*, determine the value of M_A/M_B.

(*b*) Now the open end of the pipe *B* is closed (so that the pipe is closed at both ends). Find the ratio of the fundamental frequency in pipe *A* to that in pipe *B*. **(IIT-JEE 2002)**

100. A boat is travelling in a river with a speed 10 m/s along the stream flowing with a speed 2 m/s. From this boat a sound transmitter is lowered into the river through a rigid support. The wavelength of the sound emitted from the transmitter inside the water is 14.45 mm. Assume that attenuation of sound in water and air is negligible. **(IIT-JEE 2001)**

(*a*) What will be the frequency detected by a receiver kept inside the river downstream?

(*b*) The transmitter and the receiver are now pulled up into air. The air is blowing with a speed 5 m/s in the direction opposite to the river stream. Determine the frequency of the sound detected by the receiver.

(Temperature of the air and water = 20°C; Density of river water = 10^3 kg/m^3;

Bulk modulus of the water = 2.088×10^9 *Pa*;

Gas constant *R* = 8.31 J/mol – *K*;

Mean molecular mass of air = 28.8×10^{-3} kg/mol;

C_p / C_V for air = 1.4)

101. A band playing music at a 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. Obtain an expression for the beat frequency heard by the motorist. **(IIT-JEE 1997)**

102. A train approaching a hill at a speed of 40 km/h sounds a whistle of frequency 580 Hz when it is at a distance of 1 km from a hill. A wind with a speed of 40 km/h is blowing in the direction of motion of the train. Find **(IIT-JEE 1988)**

(*a*) The frequency of the whistle as heard by an observer on the hill,

(*b*) The distance from the hill at which the echo from the hill is heard by the driver and its frequency.

(Velocity of sound in air =1200 km / h)

ANSWER KEY

JEE-Main

1. (*b*)	**2.** [1152]	**3.** [20]	**4.** (*b*)	**5.** (*b*)	**6.** [7]	**7.** (*b*)	**8.** (*b*)	**9.** (*a*)	**10.** (*b*)
11. (*c*)	**12.** [90]	**13.** (*c*)	**14.** (*a*)	**15.** [1215]	**16.** [1]	**17.** (*c*)	**18.** (*d*)	**19.** (*d*)	**20.** (*c*)
21. (*d*)	**22.** (*c*)	**23.** [13]	**24.** (*a*)	**25.** [5]	**26.** (*a*)	**27.** (*d*)	**28.** (*b*)	**29.** (*b*)	**30.** [400]
31. (*c*)	**32.** [60]	**33.** [80]	**34.** [60]	**35.** [500]	**36.** [5]	**37.** [3]	**38.** [2]	**39.** [10]	**40.** [1]
41. (*b*)	**42.** (*b*)	**43.** (*c*)	**44.** [35]	**45.** (*d*)	**46.** (*d*)	**47.** (*b*)	**48.** (Bonus)	**49.** (*a*)	**50.** [740]
51. (*a*)	**52.** [294.00]	**53.** (*d*)	**54.** [6]	**55.** [16]	**56.** [1]	**57.** [900]	**58.** [104]	**59.** [80]	**60.** [50]
61. (*d*)	**62.** [4]	**63.** [34]	**64.** (*a*)	**65.** [106]	**66.** [0.62 to 0.63]		**67.** (*c*)	**68.** (*c*)	

JEE-Advanced

1. (*b*, *c*, *d*)	**2.** (*a*, *b*, *c*, *d*)	**3.** (*a*, *c*, *d*)	**4.** [5]	**7.** (*a*)	**8.** (*c*)	**9.** (*a*)	**10.** (*a*)	**11.** (*b*)	**12.** (*a*, *c*)
13. (*b*, *c*)	**14.** (*a*, *b*, *c*, *d*)	**15.** [3]	**16.** [0.5]	**17.** [0.12]	**19.** (*b*)	**20.** (*b*)	**21.** (*b*)	**23.** (*a*)	**24.** (*a*)
25. (*a*)	**26.** (*c*)	**27.** (*a*, *c*, *d*)	**28.** (*a*, *b*, *c*)	**29.** (*b*, *c*)	**30.** [5]	**31.** [11]	**37.** (*a*)	**38.** (*b*)	**39.** (*c*)
40. (*a*, *b*, *c*)	**42.** [False]	**43.** (*b*)	**44.** (*b*)	**45.** [True]	**46.** (*d*)	**47.** (*b*)	**48.** (*b*)	**49.** (*a*)	**50.** (*a*)
51. (*d*)	**52.** (*b*)	**53.** (*c*)	**54.** (*b*)	**55.** (*d*)	**56.** (*a*)	**57.** (*c*)	**58.** (*a*)	**59.** (*c*)	**60.** (*a*, *d*)
61. (*a*,*b*,*c*,*d*)	**62.** (*a*,*b*,*d*)	**63.** (*a*, *c*)	**64.** (*b*, *c*)	**65.** (*b*, *d*)	**66.** (*A - p, t; B - p, s; C - q, s; D - q, r*)			**67.** [0.62 to 0.63]	
68. [5]	**69.** [43]	**70.** [27.04]	**71.** [336]	**77.** (*a*)	**78.** (*b*)	**79.** (*b*)	**80.** (*d*)	**81.** (*b*, *c*, *d*)	**82.** (*a, b, c*)
83. [648]	**84.** [8.2]	**85.** (*a*, *d*)	**86.** (*b*)	**87.** (*a*)	**88.** [8]	**89.** [5]	**90.** [6]	**91.** [30]	
92. [403, 484]		**93.** [257 Hz, 438 Hz]		**94.** [1.5]	**95.** [0.75]	**96.** [7.88]	**98.** [True]		