Waves

1. Three sound waves of equal amplitudes have frequencies $(\nu - 1)$, ν, $(\nu + 1)$. They superpose to give beats. The number of beats produced per second will be **[AIEEE-2009]**

   (1) 3 (2) 2

   (3) 1 (4) 4

2 A motor cycle starts from rest and accelerates along a straight path at 2 m/s^2. At the starting point of the motor cycle there is a stationary electric siren. How far has the motor cycle gone when the driver hears the frequency of the siren at 94% of its value when the motor cycle was at rest? (Speed of sound = 330 ms^{-1}) **[AIEEE-2009]**

   (1) 98 m (2) 147 m

   (3) 196 m (4) 49 m

3. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right].$$

   The tension in the string is **[AIEEE-2010]**

   (1) 6.25 N (2) 4.0 N

   (3) 12.5 N (4) 0.5 N

4. A travelling wave represented by $y = A\sin(\omega t - kx)$ is superimposed on another wave represented by $y = A\sin(\omega t + kx)$. The resultant is **[AIEEE-2011]**

   (1) A standing wave having nodes at

$$x = \frac{n\lambda}{2};\ n = 0, 1, 2 \ldots\ldots$$

   (2) A standing wave having nodes at

$$x = \left(n + \frac{1}{2}\right)\frac{\lambda}{2};\ n = 0, 1, 2 \ldots\ldots$$

   (3) A wave travelling along $+x$ direction

   (4) A wave travelling along $-x$ direction

5. Statement-1 : Two longitudinal waves given by equations : $y_1(x, t) = 2a\sin(\omega t - kx)$ and $y_2(x, t) = a\sin(2\omega t - 2kx)$ will have equal intensity.

   Statement-2 : Intensity of waves of given frequency in same medium is proportional to square of amplitude only. **[AIEEE-2011]**

   (1) Statement-1 is true, statement-2 is true; statement-2 is not correct explanation of statement-1

   (2) Statement-1 is false, statement-2 is true

   (3) Statement-1 is true, statement-2 is false

   (4) Statement-1 is true, statement-2 is true; statement-2 is the correct explanation of statement-1

6. 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 it is in water. The fundamental frequency of the air-column is now **[AIEEE-2012]**

   (1) $\frac{f}{2}$ (2) $\frac{3f}{4}$

   (3) $2f$ (4) f

7. A sonometer wire of length 1.5 m is made of steel. The tension in it produces an elastic strain of 1%. What is the fundamental frequency of steel if density and elasticity of steel are 7.7×10^3 kg/m^3 and 2.2×10^{11} N/m^2 respectively? **[JEE (Main)-2013]**

   (1) 188.5 Hz (2) 178.2 Hz

   (3) 200.5 Hz (4) 770 Hz

8. A pipe of length 85 cm is closed from one end. Find the number of possible natural oscillations of air column in the pipe whose frequencies lie below 1250 Hz. The velocity of sound in air is 340 m/s. **[JEE (Main)-2014]**

   (1) 12 (2) 8

   (3) 6 (4) 4

9. A train is moving on a straight track with speed 20 ms^{-1}. It is blowing its whistle at the frequency of 1000 Hz. The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound = 320 ms^{-1}) close to **[JEE (Main)-2015]**

   (1) 6% (2) 12%

   (3) 18% (4) 24%

10. A uniform string of length 20 m is suspended from a rigid support. A short wave pulse is introduced at its lowest end. It starts moving up the string. The time taken to reach the support is

(take g = 10 ms^{-2}) **[JEE (Main)-2016]**

(1) 2 s (2) $2\sqrt{2}$ s

(3) $\sqrt{2}$ s (4) $2\pi\sqrt{2}$ s

11. A pipe open at both ends has a fundamental frequency f in air. The pipe is dipped vertically in water so that half of it is in water. The fundamental frequency of the air column is now **[JEE (Main)-2016]**

(1) $\frac{3f}{4}$ (2) $2f$

(3) f (4) $\frac{f}{2}$

12. A granite rod of 60 cm length is clamped at its middle point and is set into longitudinal vibrations. The density of granite is 2.7 × 10^3 kg/m^3 and its Young's modulus is 9.27 × 10^{10} Pa. What will be the fundamental frequency of the longitudinal vibrations? **[JEE (Main)-2018]**

(1) 5 kHz (2) 2.5 kHz

(3) 10 kHz (4) 7.5 kHz

13. A heavy ball of mass M is suspended from the ceiling of a 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 **[JEE (Main)-2019]**

(1) $\frac{g}{30}$ (2) $\frac{g}{5}$

(3) $\frac{g}{20}$ (4) $\frac{g}{10}$

14. A musician using an open flute of length 50 cm produces second harmonic sound waves. A person runs towards the musician from another end of a hall at a speed of 10 km/h. If the wave speed is 330 m/s, the frequency heard by the running person shall be close to **[JEE (Main)-2019]**

(1) 500 Hz (2) 753 Hz

(3) 333 Hz (4) 666 Hz

15. A train moves towards a stationary observer with speed 34 m/s. The train sounds a whistle and its frequency registered by the observer is f_1. If the speed of the train is reduced to 17 m/s, the frequency registered is f_2. If speed of sound is 340 m/s, then the ratio $\frac{f_1}{f_2}$ is **[JEE (Main)-2019]**

(1) $\frac{21}{20}$ (2) $\frac{20}{19}$

(3) $\frac{18}{17}$ (4) $\frac{19}{18}$

16. 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 100 Hz. The separation between successive nodes on the string is close to **[JEE (Main)-2019]**

(1) 33.3 cm (2) 10.0 cm

(3) 16.6 cm (4) 20.0 cm

17. 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) **[JEE (Main)-2019]**

(1) 7 (2) 4

(3) 6 (4)

18. 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 **[JEE (Main)-2019]**

(1) 10 N (2) 7.5 N

(3) 5 N (4) 12.5 N

19. 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? **[JEE (Main)-2019]**

(1) The wave is propagating along the negative x-axis with speed 25 ms^{-1}.

(2) The wave is propagating along the positive x-axis with speed 100 ms^{-1}.

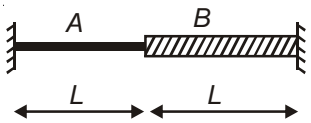
(3) The wave is propagating along the negative x-axis with speed 100 ms^{-1}.

(4) The wave is propagating along the positive x-axis with speed 25 ms^{-1}.

20. A resonance tube is old and has jagged end. It is still used in the laboratory to determine velocity of sound in air. A tuning fork of frequency 512 Hz produces first resonance when the tube is filled with water to a mark 11 cm below a reference mark, near the open end of the tube. The experiment is repeated with another fork of frequency 256 Hz which produces first resonance when water reaches a mark 27 cm below the reference mark. The velocity of sound in air, obtained in the experiment, is close to **[JEE (Main)-2019]**

(1) 322 ms^{-1} (2) 341 ms^{-1}

(3) 328 ms^{-1} (4) 335 ms^{-1}

21. 

A wire of length 2*L*, is made by joining two wires *A* and *B* of same length 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 antinodes in wire *A* is *p* and that in *B* is *q* then the ratio $p : q$ is **[JEE (Main)-2019]**

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

(3) 3 : 5 (4) 1 : 4

22. 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 **[JEE (Main)-2019]**

(1) 4°C (2) 12°C

(3) 15°C (4) 11°C

23. A string is clamped at both the ends and it is vibrating in its 4^{th} 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) **[JEE (Main)-2019]**

(1) 60 m (2) 20 m

(3) 40 m (4) 80 m

24. Two cars *A* and *B* are moving away from each other in opposite directions. Both the cars are moving with a speed of 20 ms^{-1} with respect to the ground. If an observer in car *A* detects a frequency 2000 Hz of the sound coming from car *B*, what is the natural frequency of the sound source in car *B*?

(speed of sound in air = 340 ms^{-1})

[JEE (Main)-2019]

(1) 2150 Hz (2) 2300 Hz

(3) 2060 Hz (4) 2250 Hz

25. A string 2.0 m long and fixed at its ends 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 **[JEE (Main)-2019]**

(1) 320 m/s, 120 Hz (2) 320 m/s, 80 Hz

(3) 180 m/s, 80 Hz (4) 180 m/s, 120 Hz

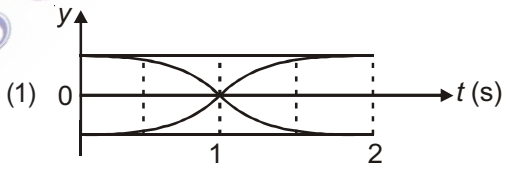
26. A stationary source emits sound waves of frequency 500 Hz. Two observers moving along a line passing through the source detect sound to be of frequencies 480 Hz and 530 Hz. Their respective speeds are, in ms^{-1}, **[JEE (Main)-2019]**

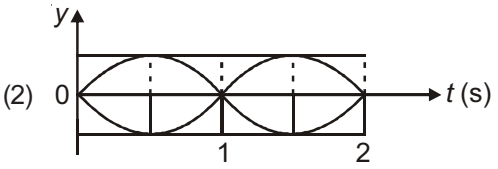
(Given speed of sound = 300 m/s)

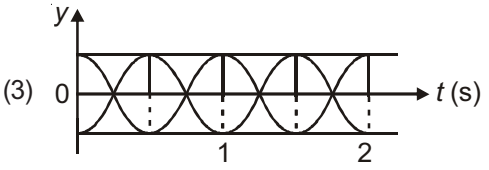
(1) 12, 16 (2) 16, 14

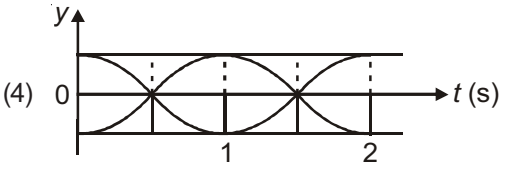
(3) 8, 18 (4) 12, 18

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

(1) 

(2) 

(3) 

(4) 

28. A source of sound S is moving with a velocity of 50 m/s towards a stationary observer. The observer measures the frequency of the source as 1000 Hz. What will be the apparent frequency of the source when it is moving away from the observer after crosssing him? (Take velocity of sound in air is 350 m/s) **[JEE (Main)-2019]**

(1) 857 Hz (2) 1143 Hz

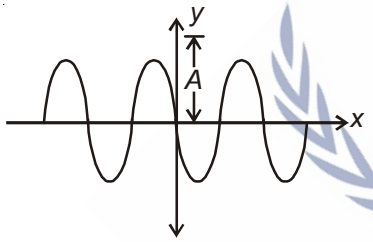
(3) 807 Hz (4) 750 Hz

29. A submarine (A) travelling at 18 km/hr is being chased along the line of its velocity by another submarine (B) travelling at 27 km/hr. B sends a sonar signal of 500 Hz to detect A and receives a reflected sound of frequency ν. The value of ν is close to : (Speed of sound in water = 1500 ms^{-1}) **[JEE (Main)-2019]**

(1) 499 Hz (2) 504 Hz

(3) 507 Hz (4) 502 Hz

30. A progressive wave travelling along the positive x-direction is represented by $y(x, t) = A\sin(kx - \omega t + \phi)$. Its snapshot at $t = 0$ is given in the figure. **[JEE (Main)-2019]**



For this wave, the phase ϕ is :

(1) π (2) $-\frac{\pi}{2}$

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

31. A small speaker delivers 2 W of audio output. At what distance from the speaker will one detect 120 dB intensity sound? **[JEE (Main)-2019]**

[Given reference intensity of sound as 10^{-12} W/m^2]

(1) 30 cm (2) 40 cm

(3) 10 cm (4) 20 cm

32. Two sources of sound S_1 and S_2 produce sound waves of same frequency 660 Hz. A listener is moving from source S_1 towards S_2 with a constant speed u m/s and he hears 10 beats/s. The velocity of sound is 330 m/s. Then, u equals: **[JEE (Main)-2019]**

(1) 10.0 m/s (2) 5.5 m/s

(3) 2.5 m/s (4) 15.0 m/s

33. 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, l_1 = 30 cm and l_2 = 70 cm. Then, v is equal to **[JEE (Main)-2019]**

(1) 332 ms^{-1} (2) 384 ms^{-1}

(3) 379 ms^{-1} (4) 338 ms^{-1}

34. Speed of transverse wave on a straight wire (mass 6.0 g, length 60 cm and area of cross-section 1.0 mm^2) is 90 ms^{-1}. If the Young's modulus of wire is 16×10^{11} Nm^{-2}, the extension of wire over its natural length is **[JEE (Main)-2020]**

(1) 0.01 mm (2) 0.02 mm

(3) 0.04 mm (4) 0.03 mm

35. A stationary observer receives sound from two identical tuning forks, one of which approaches and the other one recedes with the same speed (much less than the speed of sound). The observer hears 2 beats/sec. The oscillation frequency of each tuning fork is ν_0 = 1400 Hz and the velocity of sound in air 350 m/s. The speed of each tuning fork is close to **[JEE (Main)-2020]**

(1) $\frac{1}{4}$ m/s (2) $\frac{1}{2}$ m/s

(3) 1 m/s (4) $\frac{1}{8}$ m/s

36. 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 **[JEE (Main)-2020]**

(1) 30.5×10^4 N (2) 2.50×10^4 N

(3) 5.15×10^3 N (4) 10.2×10^2 N

37. Three harmonic waves having equal frequency ν 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 **[JEE (Main)-2020]**

(1) $3I_0$ (2) $5.8I_0$

(3) $0.2I_0$ (4) I_0

38. 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

[JEE (Main)-2020]

(1) 1.1 m (2) 5.1 m

(3) 8.1 m (4) 2.1 m

39. Two identical strings X and Z made of same material have tension T_X and T_Z in them. If their fundamental frequencies are 450 Hz and 300 Hz, respectively, then the ratio T_X/T_Z is

[JEE (Main)-2020]

(1) 1.5 (2) 2.25

(3) 0.44 (4) 1.25

40. 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 wavetrain of wavelength 6 cm is produced at the lower end of the rope. What is the wavelength of the wavetrain (in cm) when it reaches the top of the rope?

[JEE (Main)-2020]

(1) 6 (2) 3

(3) 12 (4) 9

41. For a transverse wave travelling along a straight line, the distance between two peaks (crests) is 5 m, while the distance between one crest and one trough is 1.5 m. The possible wavelengths (in m) of the waves are **[JEE (Main)-2020]**

(1) 1, 2, 3, ... (2) 1, 3, 5, ...

(3) $\frac{1}{1}, \frac{1}{3}, \frac{1}{5}, \ldots.$ (4) $\frac{1}{2}, \frac{1}{4}, \frac{1}{6}, \ldots.$

42. The driver of a bus approaching a big wall notices that the frequency of his bus's horn changes from 420 Hz to 490 Hz when he hears it after it gets reflected from the wall. Find the speed of the bus if speed of the sound is 330 ms^{-1}

[JEE (Main)-2020]

(1) 61 kmh^{-1} (2) 91 kmh^{-1}

(3) 81 kmh^{-1} (4) 71 kmh^{-1}

43. Assume that the displacement (s) of air is proportional to the pressure difference (Δp) created by a sound wave. Displacement (s) further depends on the speed of sound (v), density of air (ρ) and the frequency (f). If $\Delta p \sim 10$ Pa, $v \sim 300$ m/s, $\rho \sim 1$ kg/m^3 and $f \sim 1000$ Hz, then s will be of the order of (take the multiplicative constant to be 1)

[JEE (Main)-2020]

(1) $\frac{3}{100}$ mm (2) 10 mm

(3) 1 mm (4) $\frac{1}{10}$ mm

44. 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 **[JEE (Main)-2020]**

(1) 2200 Hz (2) 3300 Hz

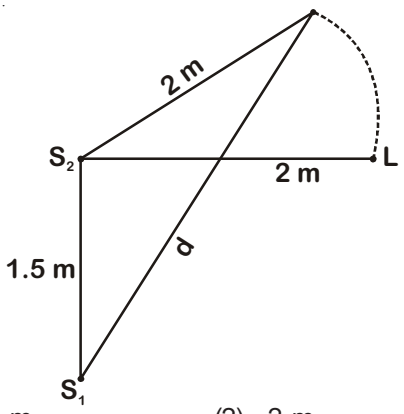
(3) 1100 Hz (4) 550 Hz

45. A driver in a car, approaching a vertical wall notices that the frequency of his car horn, has changed from 440 Hz to 480 Hz, when it gets reflected from the wall. If the speed of sound in air is 345 m/s, then the speed of the car is **[JEE (Main)-2020]**

(1) 36 km/hr (2) 54 km/hr

(3) 24 km/hr (4) 18 km/hr

46. Two coherent sources of sound, S_1 and S_2, produce sound waves of the same wavelength, $\lambda = 1$ m, in phase. S_1 and S_2 are placed 1.5 m apart (see fig). A listener, located at L, directly in front of S_2 finds that the intensity is at a minimum when he is 2 m away from S_2. The listener moves away from S_1, keeping his distance from S_2 fixed. The adjacent maximum of intensity is observed when the listener is at a distance d from S_1. Then, d is **[JEE (Main)-2020]**



(1) 5 m (2) 2 m

(3) 12 m (4) 3 m

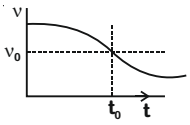
47. An object of mass m is suspended at the end of a massless wire of length L and area of cross-section, A. Young modulus of the material of the wire is Y. If the mass is pulled down slightly its frequency of oscillation along the vertical direction is **[JEE (Main)-2020]**

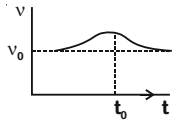
(1) $f = \frac{1}{2\pi}\sqrt{\frac{mL}{YA}}$ (2) $f = \frac{1}{2\pi}\sqrt{\frac{YA}{mL}}$

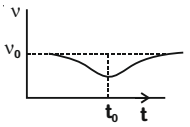
(3) $f = \frac{1}{2\pi}\sqrt{\frac{YL}{mA}}$ (4) $f = \frac{1}{2\pi}\sqrt{\frac{mA}{YL}}$

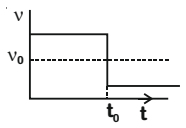
48. A sound source S is moving along a straight track with speed v, and is emitting sound of frequency ν_0 (see figure). An observer is standing at a finite distance, at the point O, from the track. The time variation of frequency heard by the observer is best represented by **[JEE (Main)-2020]**

(t_0 represents the instant when the distance between the source and observer is minimum)

(1) 

(2) 

(3) 

(4) 

49. 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 at STP in 300 m/s, the frequency difference between the fundamental and second harmonic of this pipe is _____ Hz. **[JEE (Main)-2020]**

50. 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 is (Young's modulus of wire $Y = 9 \times 10^{10}$ Nm^{-2}), (to the nearest integer), _____. **[JEE (Main)-2020]**

❑ ❑ ❑