PHYSICS

NCERT - FULL MARKS PHYSICS(TAMIL)

WAVES

Example

1. Given below are some examples of wave motion. State in each case if the wave motion is transverse , longitudinal or a combination of

both:

(a) Motion of a kink in a longitudinal spring produced by displacing one end of the spring sideways.

(b) Waves produced in a cylinder containing a liquid by moving its piston back and forth.

(c) Waves produced by a motorboat sailing in water.

(d) Ultrasonoic waves in air produced by a vibrating quartz crystal.

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2. A wave travelling along a string is discribed by.

$y(x, t) = 0.005 \sin(80.0x - 3.0t).$

in which the numerical constants are in SI units

$(0.005m, 80.0radm^{-1}, \text{ and } 3.0rads^{-1}).$

Calculate (a) the amplitude, (b) the wavelength, and (c) the period and frequency of the wave. Also, calculate the displacement y of the wave at a distance x = 30.0 cm and t = 20 s ?

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3. A steel wire 0.72 m long has a mass of $5.0 \times 10^{-3} kg$. If the wire is under a tension of 60 N. What is the speed of transverse waves on the wire ?

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4. Estimate the speed of sound in air at standard temperature and pressure. Athe mass of 1 mole of air is $29.0 \times 10^{-3} kg$.

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5. A pipe, 30.0 cm long. Is open at both ends. Which harmonic mode of the pipe resonates a 1.1 kHz source? Will resonance with the same source be observed if one end of the pipe is closed ? Take the speed of sound in air as $330ms^{-1}$.

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6. Two sitar strings A and B playing the note .Dha. are slightly out of tune and produce beats of frequency 5 Hz. The tension of the string B is slightly increased and the beat frequency is found to decrease to 3 Hz. What is the original frequency of B if the frequency of A is 427 Hz ?

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7. A rocket is moving at a speed of $200ms^{-1}$ towards a stationary target. While moving, it emits a wave of frequency 1000 Hz. Some of the sound reaching the target gets reflected back to the rocket as an echo. Calculate (1) the frequency of the sound as detected by the target and (2) the frequency of the echo as detected by the rocket.

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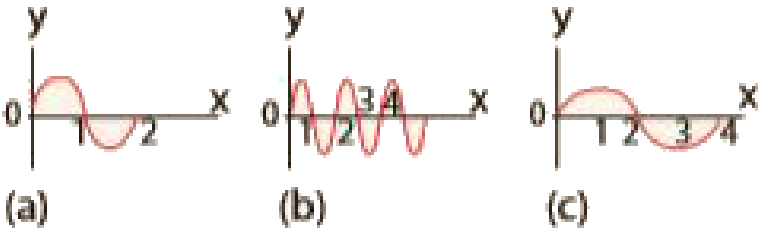
8. Which of the following has longer wavelength?



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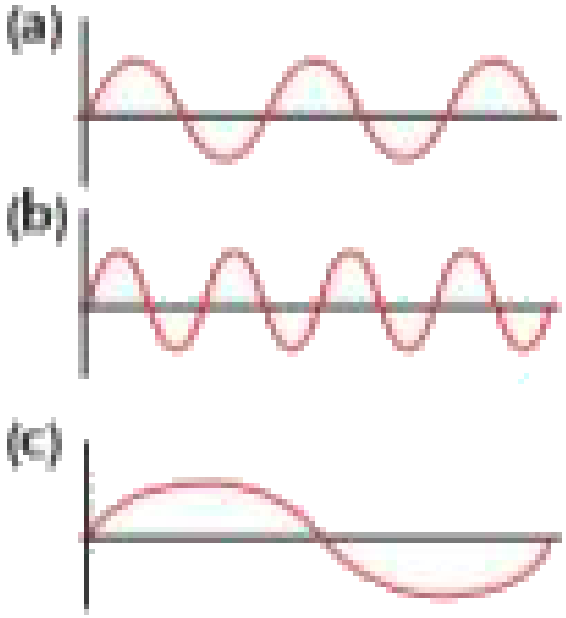
9. Three waves are shown in the figure below



Write down the frequency in ascending order

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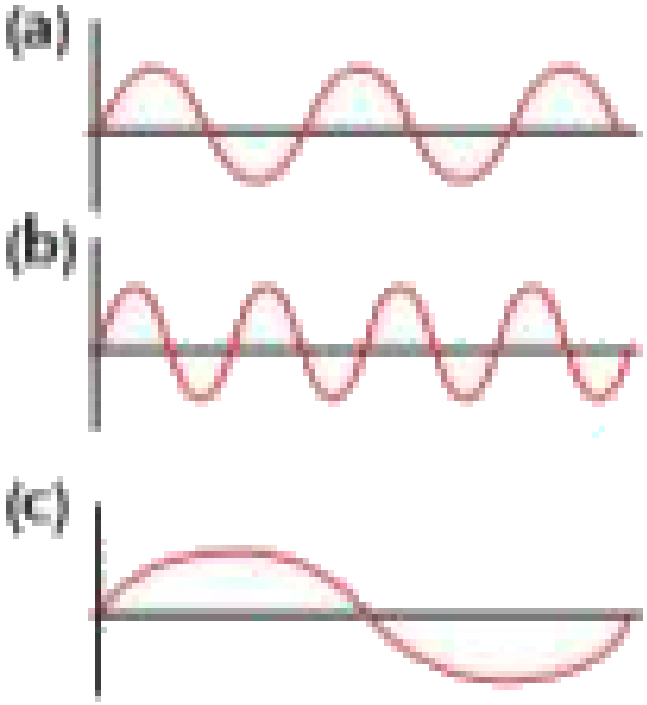
10. Three waves are shown in the figure below



Write down the wavelength in ascending order

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11. The average range of frequencies at which human beings can hear sound waves varies from 20 Hz to 20 kHz. Calculate the wavelength of the sound wave in these limits. (Assume the speed of sound to be 340 ms^{-1}.

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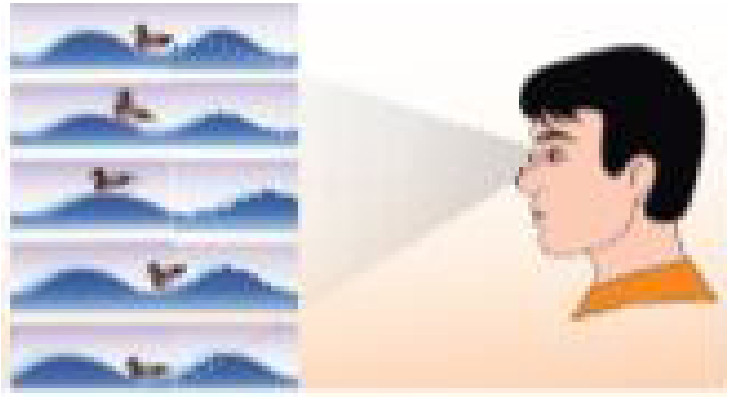
12. A man saw a toy duck on a wave in an ocean. He noticed that the duck moved up and down 15 times per minute. He roughly measured the wavelength of the ocean wave

as 1.2 m. Calculate the time taken by the toy duck for going one time up and down and also the velocity of the ocean wave.



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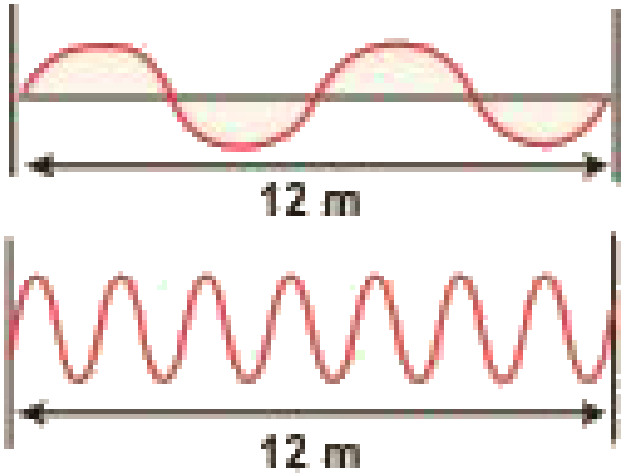
13. Consider a string whose one end is attached to a wall. Then compute the following in both situations given in figure

(assume waves crosses the distance in one second)



(a) Wavelength, (b) Frequency and (c) Velocity

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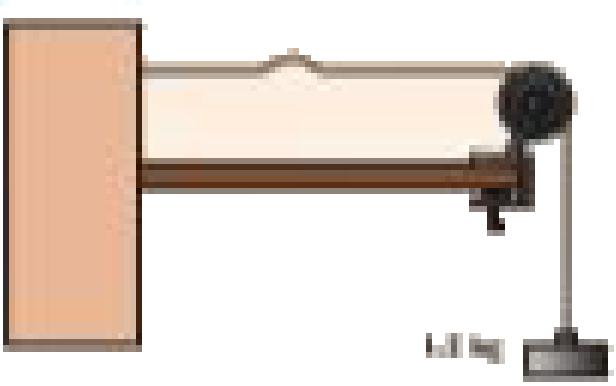
14. Calculate the velocity of the travelling pulse as shown in the figure below. The linear

mass density of pulse is 0.25 kg m^{-1}. Further, compute the time taken by the travelling pulse to cover a distance of 30 cm on the string.



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15. Calculate the speed of sound in a steel rod whose Young's modulus $Y = 2 \times 10^{11} Nm^{-2}$ and $\rho = 7800 kgm^{-3}$

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16. An increase in pressure of 100 kPa causes a certain volume of water to decrease by 0.005% of its original volume.

Calculate the bulk modulus of water?

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17. An increase in pressure of 100 kPa causes a certain volume of water to decrease by 0.005%

of its original volume.

Compute the speed of sound (compressional waves) in water?

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18. The ratio of the densities of oxygen and nitrogen is 16:14. Calculate the temperature when the speed of sound in nitrogen gas at $17^{\circ}C$ is equal to the speed of sound in oxygen gas.

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19. Suppose a man stands at a distance from a cliff and claps his hands. He receives an echo from the cliff after 4 second. Calculate the distance between the man and the cliff. Assume the speed of sound to be 343 m s^{-1}

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20. Sketch y = x -a for different values of a.

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21. How does the wave y=sin(x-a) for a = 0 , $a = \frac{\pi}{4}, a = \frac{\pi}{2}, a = \frac{3\pi}{2}$ and $a = \pi$ look like? Sketch this wave.

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22. Check the dimensional of the wave y = sin(x-vt). If it is dimensionally wrong, write the above equation in the correct form.

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23. The wavelength of two sine waves are λ_1 = 1m and λ_2 = 6m . Calculate the corresponding wave numbers.

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24. A mobile phone tower transmits a wave signal of frequency 900MHz. Calculate the length of the waves transmitted from the mobile phone tower.

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25. Consider two sources A and B as shown in the figure below. Let the two sources emit simple harmonic waves of same frequency but of different amplitudes, and both are in phase (same phase). Let O be any point equidistant from A and B as shown in the figure. Calculate the intensity at points O, Y and X. (X and Y are not equidistant from A & B)

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26. Two speakers C and E are placed 5 m apart and are driven by the same source. Let a man stand at A which is 10 m away from the mid point O of C and E. The man walks towards the point O which is at 1 m (parallel to OC) as shown in the figure. He receives the first minimum in sound intensity at B. Then calculate the frequency of the source. (Assume speed of sound = 343 m s^{-1})

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27. Consider two sound waves with wavelengths 5 m and 6 m. If these two waves propagate in a gas with velocity 330 ms^{-1}. Calculate the number of beats per second.

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28. Two vibrating tuning forks produce waves whose equation is given by $y_1 = 5\sin(240\pi t)$

and $y_2 = 4\sin(244\pi t)$. Compute the number of beats per second.

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29. Compute the distance between anti-node and neighbouring node.

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30. Let f be the fundamental frequency of the string. If the string is divided into three

segments l_1, l_2 and l_3 such that the fundamental frequencies of each segments be f_1, f_2 and f_3 respectively. Show that

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

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31. Consider a string in a guitar whose length is 80 cm and a mass of 0.32 g with tension 80 N is plucked. Compute the first four lowest frequencies produced when it is plucked.

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32. A baby cries on seeing a dog and the cry is detected at a distance of 3.0 m such that the intensity of sound at this distance is $10^{-2} Wm^{-2}$. Calculate the intensity of the baby's cry at a distance 6.0 m.

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33. The sound level from a musical instrument playing is 50 dB. If three identical musical instruments are played together then

compute the total intensity. The intensity of the sound from each instrument is $10^{-12} Wm^{-2}$

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34. If a flute sounds a note with 450Hz, what are the frequencies of the second, third, and fourth harmonics of this pitch?. If the clarinet sounds with a same note as 450Hz, then what are the frequencies of the lowest three harmonics produced ?

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35. If the third harmonics of a closed organ pipe is equal to the fundamental frequency of an open organ pipe, compute the length of the open organ pipe if the length of the closed organ pipe is 30 cm.

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36. A frequency generator with fixed frequency of 343 Hz is allowed to vibrate above a 1.0 m

high tube. A pump is switched on to fill the water slowly in the tube. In order to get resonance, what must be the minimum height of the water?. (speed of sound in air is 343 m s^{-1})

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37. A student performed an experiment to determine 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 0.2 m. If the length is varied such that the same tuning fork resonates with the first overtone at 0.7 m. Calculate the end correction.

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38. Consider a tuning fork which is used to produce resonance in an air column. A resonance air column is a glass tube whose length can be adjusted by a variable piston. At room temperature, the two successive

resonances observed are at 20 cm and 85 cm of the column length. If the frequency of the length is 256 Hz, compute the velocity of the sound in air at room temperature.

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39. A sound of frequency 1500 Hz is emitted by a source which moves away from an observer and moves towards a cliff at a speed of 6 ms^{-1}.

Calculate the frequency of the sound which is coming directly from the source.

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40. A sound of frequency 1500 Hz is emitted by a source which moves away from an observer and moves towards a cliff at a speed of 6 ms^{-1}.

Compute the frequency of sound heard by the observer reflected off the cliff. Assume the speed of sound in air is 330 m s^{-1}

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41. An observer observes two moving trains, one reaching the station and other leaving the station with equal speeds of 8 m s^{-1}. If each train sounds its whistles with frequency 240 Hz, then calculate the number of beats heard by the observer.

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Exercises

1. A string of mass 2.50kg is under a tension of 200N. The length of the stretched string is 20.0m. If the transverse jerk is struck at one end of the string, how long does the disturbance take to reach the other end?

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2. A stone dropped from the top of a tower of height 300m splashes into the water of a pond near the base of the tower. When is the

splash heard at the top given that the speed of sound in air is $340ms^{-1}$? $\left(g = 9.8ms^{-2}\right)$

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3. A steel wire has a length of 12.0m and a mass of 2.10kg. What should be the tension in the wire so that speed of a transverse wave on the wire equals the speed of sound in dry air at $20^{\circ}C = 343ms^{-1}$

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4. Use the formula $v = \sqrt{\frac{\gamma p}{\rho}}$ to explain why the speed of sound in air

(a) is independent of pressure.

(b) increases with temperature.

(c) increases with humidity

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5. You have learnt that a travelling wave in one dimension is represented by a function y= f(x, t) where x and t must appear in the combination $x - vt$ or $x + vt$, i.e.,

$y = f(x \pm vt)$. Is the converse true? Examine if the following functions for y can possibly represent a travelling wave:

(a) $(x - vt)^2$

(b) $\log\left[(x + vt)/x_0\right]$

(c) $1/(x + vt)$

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6. A bat emits ultrasonic sound of frequency 1000kHz in air. If the sound meets a water surface. What is the wavelength of (a) the

reflected sound (b) the transmitted sound? Speed of sound in air is $340ms^1$ and in water $1486ms^{-1}$

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7. A hospital uses an ultrasonic scanner to locate tumours in a tissue. What is the wavelength of sound in the tissue in which the speed of sound in $1.7kms^{-1}$? The operating frequency of the scanner is 4.2MHz.

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8. A transverse harmonic wave on a string is described by $y(x,t) = 3.0\sin(36t + 0.018x + \pi/4)$ where x and y are in cm and t in s. The positive direction of x is from left to right

(a) Is this a travelling wave or a stationary wave?

If it is travelling what are the speed and direction of its propagation?

(b) What are its amplitude and frequency?

(c) What is the initial phase at the origin ?

(d) What is the least distance between two successive crests in the wave?

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9. For the wave discribed in Exercise 15.8, plot the displacement (y) versus (t) graphs dor x = 0.2 and 4 cm. What are shapes of these graphs? In which aspects does the oscillatory motion in travelling wave differ from one point to another: amplitude, frequency or phase?

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10. For the travelling harmonic wave

$y(x, t) = 2.0 \cos 2\pi(10t - 0.0080x + 0.35)$

where x and y in cm and t in s. Calculate the phase difference between oscillatory motion of two points seperated by a distance of

(a) 4 m,

(b) 0.5 m,

(c) $\lambda/2$,

(d) $3\lambda/4$

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

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

where x and y are in m and t in s. The length of the string is 1.5 m and its mass is $3.0 \times 10^{-2} kg$.

Answer the following :

(a) Does the function represent a travelling wave or a stationary wave?

(b) Interpret the wave as a superposition of two waves travelling in opposite directions.

What is the wavelength, frequency , and speed of each wave ?

(c) Determine the tension in the string.

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12. (i) For the wave on a string described in $y(x, t) = 0.06 \sin\left(\frac{2\pi}{3}\right) x \cos(120\pi t),$. Do all the points on the string oscillate with the same (a) frequency , (b) phase , (c) amplitude? Explain your answers. (ii) What is the

amplitude of a point 0.375 m away from one end?

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13. Given below are some functions of x and t to represent the displacement (transverse or longitudinal) of an elastic wave. Some which of these represent (i) a travelling wave, (ii) a stationary wave or (iii) none at all:

(a) $y = 2\cos(3x)\sin(10t)$

(b) $y = 2\sqrt{x - vt}$

(c) $y = 3\sin(5x - 0.5t) + 4\cos(5x - 0.5t)$

(d) $y = \cos x \sin t + \cos 2x \sin 2t$

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14. A wave stretched between two rigid supports vibrate in its fundamental mode with a frequency of 45 Hz. The mass of wire is $3.5 \times 10^{-2} kg$ and its linear mass density is $4.0 \times 10^{-2} kgm^{-1}$. What is (a) the speed of transverse wave on the string, and (b) the tension in the string?

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15. A metre - long tube open at one end, with a movalble piston at the other end, shows resonance with a fixed frequency source (a tunning fork of frequency 340 Hz)when the tube length is 25.5 cm or 79.3 cm. Estimate the speed of sound in air at the temperature of the experiment. The edge effects may be neglected.

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16. A steel rod 100 cm lomg is clamped at its middle. The fundamental frequency of longitudinal vibrations of the rod are given to be 2.53 kHz. What is the speed of sound in steel?

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17. A pipe 20 cm long is closed at one end. Which harmonic mode of the pipe is resonantly excited by a 430 Hz source ? Will the same source be in resonane with the pipe

if both end are open ? (speed of sound in air is $340 ms^{-1}$).

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18. Two sitar strings A and B playing the note .Ga. are slightly out of tune and produce beats of frequency 6 Hz. The tension in the string A is slightly reduced and the beat frequency is found to reduce to 3 Hz. If the original frequency of A is 324 Hz. What is the of B ?

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19. Explain why (or how):

(a) in a sound wave a displacement node is a pressure antinode and vice versa.

(b) bats can ascertain distances, directions, nature, and sizes of the obstacles without any ..eyes...

(c) a violin note and sitar note may have the same frequency. yet we can distinguish between the two notes.

(d) solids can support both longitudinal and transverse waves, but only longitudinal waves

can propagate in gases, and

(e) the shape of a pulse gets distorted during propagation in a dispersive medium.

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20. A train standing at the outer signal of a railway station blows a whistle of frequency 400Hz in still air. (i) What is the frequency of the whistle for a platform observer when the train (a) approaches the platform with a speed of $10ms^{-1}$. (b) recedes from the platform with

a speed of $10ms^{-1}$? (ii) What is the speed of sound in each case? The speed of sound in still air can be taken as $340ms^{-1}$.

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21. A train standing in a station-yard, blows a whistle of frequency 400Hz in still air. The wind starts blowing in the direction from the yard to the station with a speed of $10ms^{-1}$. What are the frequency wavelength and speed of sound for an observer standing on the

station.s platform? Is the situation exactly identical the case when the air is still and the observer runs towards the yard at a speed of $10ms^{-1}$? The speed of sound in still air can be taken as $340ms^{-1}$

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22. A travelling harmonic wave on a string is described by

$y(x, t) = 7.5\sin(0.005x + 12t + \pi/4)$ (a) what are the displacement and velocity of

oscillation of a point at x=1 cm, and t=1s? Is this velocity equal to the velocity of wave propagation?

(b) Locate the points of the string which have the same transverse displacements and velocity as the x=1 cm point at t=2s, 5s and 11s

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23. A narrow sound pulse (for example, a short pip by a whistle) is sent across a medium (a) Does the pulse have a definite (i) frequency (ii)

wavelength (iii) speed of propagation? (b) If the pulse rate is 1 after every 20s. (that is the whistle is blown for a split of second after every 20s), is the frequency of the note produced by the whistle equal to 1/20 or 0.05Hz?

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24. One end of a long string of linear mass density $8.0 \times 10^{-3} kgm^{-1}$ is connected to an electrically driven tuning fork of frequency

256Hz. The other end passes over a pulley and is tied to a pan containing a mass of 90kg. The pulley end absorbs all the incoming energy so that reflected waves at this end have negligible amplitude. At t=0, the left end (fork end) of the string x=0 has zero transverse displacement (y=0) and is moving along positive y-direction. The amplitude of the wave is 5.0 cm. Write down the transverse displacement y as function of x and t that describes the wave on the string.

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25. A SONAR system fixed in a submarine operates at a frequency 40.0kHz. An enemy submarine moves towards the SONAR with a speed of $360kmh^{-1}$. What is the frequency of sound reflected by the submarine ? Take the speed of sound in water to be $1450ms^{-1}$.

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26. Earthquakes generate sound waves inside the earth. Unlike a gas, the earth can

experience both transverse (S) and longitudinal (P) sound wave. Typical the speed of S wave is about $4.0kms^{-1}$, and that of P wave is $8.0kms^{-1}$. A seismograph records P and S waves from an earthquake. The first P wave arrives 4min before the first S wave. Assuming the waves travel in straight line, at what distance does the earthquake occur?

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27. A bat is flitting about in a cave, navigating via ultrasonic beeps. Assume that the sound emission frequency of the bat is 40kHz. During one fast swoop directly toward a flat wall surface, the bat is moving at 0.03 times the speed of sound in air. What frequency does the bat hear reflected off the wall?

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Evaluation I Multiple Choice Questions

1. A student tunes his guitar by striking a 120 Hertz with a tuning fork, and simultaneously plays the 4th string on his guitar. By keen observation, he hears the amplitude of the combined sound oscillating thrice per second. Which of the following frequencies is the most likely the frequency of the 4th string on his guitar?.

A. 130

B. 117

C. 110

D. 120

Answer: B

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2. A transverse wave moves from a medium A to a medium B. In medium A, the velocity of the transverse wave is 500 ms^{-1} and the wavelength is 5 m. The frequency and the wavelength of the wave in medium B when its velocity is 600 ms^{-1}, respectively are

A. 120 Hz and 5 m

B. 100 Hz and 5 m

C. 120 Hz and 6 m

D. 100 Hz and 6 m

Answer: D

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3. For a particular tube, among six harmonic frequencies below 1000 Hz, only four harmonic frequencies are given: 300 Hz, 600 Hz, 750 Hz

and 900 Hz. What are the two other frequencies missing from this list?

A. 100 Hz, 150 Hz

B. 150 Hz, 450 Hz

C. 450 Hz, 700 Hz

D. 700 Hz, 800 Hz

Answer: B

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4. Which of the following options is correct?.

A	B
(1) Quality	(A) Intensity
(2) Pitch	(B) Waveform
(3) Loudness	(C) Frequency

Options for (1), (2) and (3), respectively are

A. (B), (C) and (A)

B. (C), (A) and (B)

C. (A), (B) and (C)

D. (B), (A) and (C)

Answer: A

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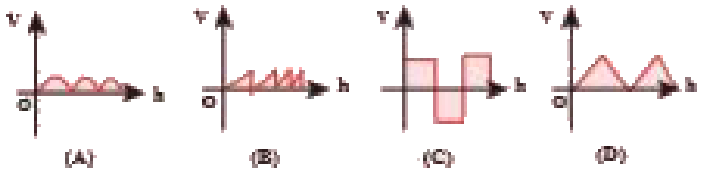
5. Compare the velocities of the wave forms given below, and choose the correct option.



where, v_A, v_B, v_C and v_D are velocities given in (A), (B), (C) and (D), respectively.

A. $v_A > v_B > v_D > v_C$

B. $v_A < v_B < v_D < v_C$

C. $v_A = v_B = v_D = v_C$

D. $v_A > v_B = v_D > v_C$

Answer: C

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6. A sound wave whose frequency is 5000 Hz travels in air and then hits the water surface. The ratio of its wavelengths in water and air is

A. 4.3

B. 0.23

C. 5.3

D. 1.23

Answer: A

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7. A person standing between two parallel hills fires a gun and hears the first echo after t, sec and the second echo after t_1 sec. The distance between the two hills is

A. $\frac{v(t_1 - t_2)}{2}$

B. $\frac{v(t_1 t_2)}{2(t_1 + t_2)}$

C. $v(t_1 + t_2)$

D. $\frac{v(t_1 + t_2)}{2}$

Answer: D

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8. An air column in a pipe which is closed at one end, will be in resonance with the

vibrating body of frequency 83 Hz. Then the length of the air column is

A. 1.5 m

B. 0.5 m

C. 1.0 m

D. 2.0 m

Answer: C

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9. The displacement y of a wave travelling in the x direction is given by $y = \left(2 \times 10^{-3}\right)\sin\left(300t - 2x + \frac{\pi}{4}\right)$, where x and y are measured in metres and tin second. The speed of the wave is

A. 150 m s^{-1}

B. 300 m s^{-1}

C. 450 m s^{-1}

D. 600 m s^{-1}

Answer: A

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10. Consider two uniform wires vibrating simultaneously in their fundamental notes. The tensions, densities, lengths and diameter of the two wires are in the ratio 8:1, 1:2, x:y and 4: 1 respectively. If the note of the higher pitch has a frequency of 360 Hz and the number of beats produced per second is 10, then the value of x : y is

A. $36:35$

B. $35:36$

C. $1:1$

D. $1:2$

Answer: A

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11. Which of the following represents a wave

A. $(x-vt)^3$

B. x(x+vt)

C. $\frac{1}{(x+vt)}$

D. sin(x+vt)

Answer: D

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12. A man sitting on a swing which is moving to an angle of 60° from the vertical is blowing a whistle which has a frequency of 2.0 k Hz. The whistle is 2.0 m from the fixed support point of the swing. A sound detector which

detects the whistle sound is kept in front of the swing. The maximum frequency the sound detector detected is

A. 2.027 kHz

B. 1.974 kHz

C. 9.74 kHz

D. 1.011 kHz

Answer: A

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13. Let $y = \frac{1}{1+x^2}$ at t = 0 s be the amplitude of the wave propagating in the positive x-direction. At t = 2s , the amplitude of the wave propagating becomes $y = \frac{1}{1+(x-2)^2}$. Assume that the shape of the wave does not change during propagation. The velocity of the wave is

A. 0.5m s^{-1}

B. 1.0m s^{-1}

C. 1.5m s^{-1}

D. 2.0m s^{-1}

Answer: B

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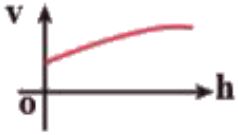
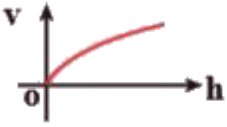
14. A uniform rope having mass m hangs vertically from a rigid support. A transverse wave pulse is produced at the lower end. Which of the following plots shows the correct variation of speed v with height h from the lower end?

A. 

B. 

C. 

D. 

Answer: D

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15. An organ pipe A closed at one end is allowed to vibrate in its first harmonic and another pipe B open at both ends is allowed

to vibrate in its third harmonic. Both A and B are in resonance with a given tuning fork. The ratio of the length of A and B is

A. $\frac{8}{3}$

B. $\frac{3}{8}$

C. $\frac{1}{6}$

D. $\frac{1}{3}$

Answer: C

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Evaluation Iv Numerical Problems

1. The speed of a wave in a certain medium is 900 m/s. If 3000 waves passes over a certain point of the medium in 2 minutes, then compute its wavelength?

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2. Consider a mixture of 2 mol of helium and 4 mol of oxygen. Compute the speed of sound in this gas mixture at 300 K.

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3. A ship in a sea sends SONAR waves straight down into the seawater from the bottom of the ship. The signal reflects from the deep bottom bed rock and returns to the ship after 3.5 s. After the ship moves to 100 km it sends another signal which returns back after 2s. Calculate the depth of the sea in each case and also compute the difference in height between two cases.

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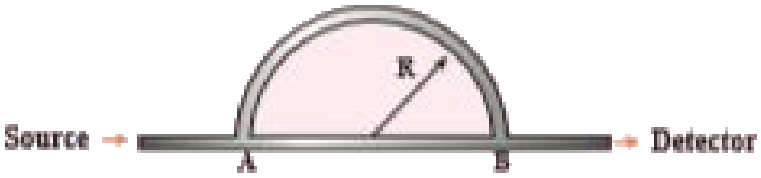
4. A sound wave is transmitted into a tube as shown in figure. The sound wave splits into two waves at the point A which recombine at point B. Let R be the radius of the semi-circle which is varied until the first minimum. Calculate the radius of the semi-circle if the wavelength of the sound is 50.0 m.



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5. Let the source propagate a sound wave whose intensity at a point (initially) be I. Suppose we consider a case when the amplitude of the sound wave is doubled and the frequency is reduced to one-fourth. Calculate now the new intensity of sound at the same point ?.

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6. A police in a siren car moving with a velocity 20 ms^{-1} chases a thief who is moving in a car with a velocity $v_0 ms^{-1}$. The police car sounds at frequency 300Hz, and both of them move towards a stationary siren of frequency 400Hz. Calculate the speed in which thief is moving.

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7. Consider the following function

(a) $y = x^2 + 2\alpha t x$

(b) $y = (x + vt)^2$

which among the above function can be characterized as a wave ?

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