

Chapter	7 Waves and Vibrations	Class	1 st Year	Subject	Physics
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Give Short Answers of the Following Questions

1. Explain "Principle of Superposition".

Ans. If a particle of a medium is simultaneously acted upon by number of waves, then the resultant displacement of the particle is the algebraic sum of their individual displacements. This is called super position principle.

$$Y = y_1 + y_2 + y_3 + \dots + y_n$$

2. What is "Doppler Effect"? Does it hold for both sound and light waves?

Ans. Doppler Effect: The apparent change in the frequency (or pitch) of waves due to the relative motion between the source and observer is called Doppler's Effect.

It applicable to both mechanical (e.g. sound waves) as well as electromagnetic waves (eg radio waves, visible light, microwaves).

3. What is effect on frequency of sound waves, when source and observer are moving towards each other?

Ans. If source is moving towards stationary observer $f^1 = \frac{v}{v - v_s} f$

If observer is moving toward stationary source $f^1 = \frac{v + v_o}{v - v_s} f$

If both of them are moving towards each other $f^1 = \frac{v + v_o}{v - v_s} f$

So the observed frequency will increase.

4. What is the frequency and the wavelength of third harmonic in a closed organ pipe?

Ans. Third mode of vibration contains three nodes and three anti-nodes. If λ_5 is the wavelength, the length of the pipe is.

$$I = \frac{\lambda_5}{4} + \frac{\lambda_5}{2} + \frac{\lambda_5}{2}$$

$$I = \left(\frac{1+2+2}{4} \right) \lambda_5$$

$$I = \frac{5\lambda_5}{4}$$

OR $\lambda_5 = \frac{4I}{5}$

If f_5 is the frequency of sound, then speed becomes,

$$V = f_5 \lambda_5$$

OR $f_5 = \frac{v}{\lambda_5}$

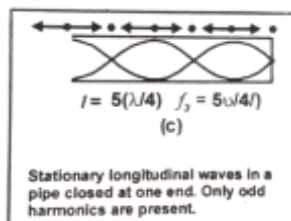
Putting value of λ_5 , we get

$$f_5 = \frac{v}{\frac{4I}{5}} = \frac{5v}{4I} = 5 \left(\frac{v}{4I} \right)$$

So $f_5 = 5f_1$ [since $\frac{v}{4I} = f_1$]

Which is the frequency of third harmonic or second overtone.

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5. What is the frequency and wavelength of 3rd mode of stationary waves in closed organ pipe?

Ans. If air column vibrates in n loops then,

$$F_n = n \left(\frac{v}{4l} \right) = n f_1 \text{ where } n = 1, 3, 5, 7, \dots$$

$$\text{For 3rd mode put } n = 5, \text{ so } f_5 = 5 \left(\frac{v}{4l} \right) = 5 f_1$$

And wavelength is

$$\lambda_n = \frac{4l}{n} \text{ where } n = 1, 3, 5, 7, \dots$$

$$\text{For 3rd mode put } n = 5, \text{ so } \lambda_5 = \frac{4l}{5}$$

6. Define Doppler shift. Write down its formula.

Ans. The change in wavelength observed by the observer due to motion of source is called Doppler's shift.

$$\Delta \lambda = \frac{u_s}{f}$$

7. How can Doppler Effect be used to monitor blood flow through major arteries?

Ans. Velocity of blood flow is detected by using Doppler Effect by noting the Doppler's shift (change in frequency). For this purpose we use the ultrasonic waves of frequency 5MHz to 10 MHz. are directed towards arteries and detected the scattered signal. By observing the apparent frequency, we can find the speed of star.

8. Which measurement of a wave is the most important when determining the wave's intensity?

Ans. The most important measurement of a wave when determining its intensity is its amplitude.

Relationship between Amplitude and Intensity:

The intensity of a wave is proportional to the square of its amplitude ($I \propto A^2$). This means that even small increases in amplitude can result in significant increases in intensity.

9. Can you apply Doppler effect to light waves? Describe briefly.

Ans. Yes, the Doppler effect can be applied to light waves.

Doppler Shift:

When a light source moves relative to an observer:

1. Red shift: If the source moves away from observer, it shows red shift (increased wavelength).

2. Blue shift: If the source moves towards the observer, it shows blue shift (decreased wavelength).

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This effect is commonly observed in astronomy, helping us understand the motion of stars and galaxies.

10. Can you compare the compressions and rarefactions of the longitudinal wave with the peaks and troughs of the transverse wave? Discuss.

Ans. Similarities:

Both longitudinal and transverse waves exhibit oscillations and transfer energy.

Differences:

- In Longitudinal waves, particles move parallel to the wave direction whereas in Transverse waves, particles move perpendicular to the wave direction.
- In Longitudinal waves, compressions (high density) and rarefactions (low density) whereas in Transverse waves, peaks (highest displacement) and troughs (lowest displacement).

Analogy:

- Compressions and rarefactions in longitudinal waves can be thought of as analogous to peaks and troughs in transverse waves:
- Compressions $\approx$ Peaks (high density/displacement)
- Rarefactions $\approx$ Troughs (low density/displacement)
- But a physical mechanism behind longitudinal and transverse waves is different.

11. How should a source of sound move with respect to an observer so that the frequency of its sound does not change? Write two examples.

Ans. If the relative velocity between the source and the observer is zero, there will be no change in frequency of sound.

Examples

- When the observer is at origin and sound source moves along the circumference of the circle then their distance remain the same and the frequency of sound does not change.
- Source and observer are moving in same direction with same speed.

12. Why is it difficult to recognize beats when the frequency difference is greater than 10 Hz? Exemplify.

Ans. Beats are difficult to recognize when the frequency difference is greater than 10 Hz because: The beat frequency becomes too rapid for our brain to process also it our auditory limitation that human hearing can't distinguish beats with frequency differences greater than 10 Hz.

13. What are the conditions for interference to occur?

Ans. Conditions for detectable interference pattern

The following condition must be met, in order to observe the interference phenomenon;

1. The interfering beams must be monochromatic. (single wavelength)

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- The interfering beams of light must be coherent. (same phase or constant phase difference)
- The source should be narrow and very close to each other.
- The intensity of the two sources be comparable.

14. Differentiate between constructive and destructive interference of waves.

Ans.

Constructive Interference	Destructive Interference
1. When two waves meet at a point with same phase then they reinforce each other.	1. When two waves meet at a point out of phase, they cancel the effect of each other.
2. Path difference between two waves is $\Delta S = n\lambda$ where $n = 0, \pm 1, \pm 2, \dots$	2. Path difference between two waves is $\Delta S = (2n + 1)\frac{\lambda}{2}$ where $n = 0, \pm 1, \pm 2, \dots$
3. Phase difference between two wave is $2n\pi$ where $n = 0, 1, 2, 3, \dots$	3. Phase difference between two waves is $(2n + 1)\pi$ where $n = 0, 1, 2, 3, \dots$
4. Amplitude of resultant waves increases.	4. Amplitude of resultant waves decreases.

15. What are coherent waves and coherent sources? Give examples.

Ans. Coherent waves

The waves that have a constant phase difference and the same frequency.

Coherent Sources:

A coherent source is a source that emits coherent waves.

Examples:

- Two slits from the same light source.
- Sound waves emitted by loud speakers caused by same audio source.

16. Distinguish between longitudinal and transverse waves.

Ans.

Longitudinal waves	Transverse waves
1. In longitudinal waves, the particles of the medium vibrate parallel to the direction of wave propagation.	1. In transverse waves, the particles of the medium vibrate at right angles to the directions of wave propagation.
2. Longitudinal waves consists of compressions and rarefactions.	2. Transverse waves consists of crests and troughs.
3. Longitudinal waves cannot be polarized.	3. Transverse waves can be polarized.
4. Sound wave is an example of longitudinal wave.	4. Light wave and waves on string are examples of transverse wave.

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17. Is it possible for two identical waves travelling in the same direction along a string to give rise to a stationary wave? How is it so?

Ans. No, it is not possible.

Reason

Stationary waves are produced only when two identical waves traveling in opposite direction along the same string superpose.

18. How would you apply Doppler effect in studying cardiac problems in humans?

Ans. Doppler echocardiography is applied to study cardiac problems by measuring blood flow velocities. Velocity of blood flow is detected by using Doppler effect by noting the Dopplers shift (change in frequency). The Doppler effect can be used to monitor blood flow through major arteries. Ultrasonic waves of frequencies 5MHz to 10MHz are directed towards the artery and a receiver detects the back scattered frequency.

19. What is meant by diffraction of waves? For what purpose, the ripple tank is used?

Ans. Diffraction of Waves:

Diffraction is the bending of waves around obstacles or the spreading of waves through small openings. The diffraction of wave depends upon the wavelength.

Ripple Tank:

A ripple tank is a shallow container filled with water, used to study wave behavior, including diffraction. The tank consists of a vibrating rod or a stone dropper to create water waves.