CLASS – 11

WORKSHEET- WAVES

A. INTRODUCTION TO WAVE

(1 Mark Questions)

1. With propagation of longitudinal waves through a medium, the quantity transmitted is
   (a) matter (b) energy
   (c) matter and energy (d) energy, matter and momentum

2. Why are the longitudinal waves also called pressure waves?

3. What is the direction of oscillations of the particles of the medium through which (i) a transverse and (ii) a longitudinal wave is propagating?

4. Ocean waves hitting a beach are always found to be nearly normal to the shore. Why?

5. Which of the following wave functions does not represent a travelling wave?
   (a) $y = (x - vt)^2$ (b) $y = \log(x + vt)$ (c) $y = 1/x + vt$ (d) all of these

(2 Marks Questions)

6. Solids can support both longitudinal and transverse waves, but only longitudinal waves can propagate in gases. Give reason.

(3 Marks Questions)

7. You have learnt that travelling wave in one dimension is represented by a fraction $y = f(x, t)$ where x and t must appear in the combination $x - v\,t$ 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) $\log[(x+vt)x_0]$ (c) $\exp[-(x+vt)/x_0]$ (d) $1/(x+vt)$.

B. PLANE PROGRESSIVE WAVE OR HARMONIC WAVE

(1 Mark Questions)

1. Two astronauts on the surface of the moon cannot talk to each other, why?

2. What is the evidence that (i) sound is a wave, (ii) sound is a mechanical wave and (iii) sound waves are longitudinal waves?

3. Do displacement, particle velocity and pressure variation in a longitudinal wave vary with the same phase?

4. A progressive wave is represented by $y = 5\sin(100\pi t - 2\pi x)$ where x and y are in m and t is in s. The maximum particle velocity is
(a) 100 π m/s (b) 200 π m/s (c) 400 π m/s (d) 500 π m/s

5. The propagation constant of a wave is also called its
(a) wavelength (b) frequency (c) wave number
(d) angular wave number

6. A wave of wavelength 2m propagate through a medium. What is the phase difference between two particles on the line of propagation? Given that the distance between the particles is 75m.

7. Newton assumed that sound propagation in a gas takes under
(a) isothermal condition (b) adiabatic condition
(c) isobaric condition (d) isentropic condition

8. For v_{rms} is the rms speed of molecules in a gas and v is the speed of sound waves in the gas, then the ratio v_{rms}/v is
(a) $\sqrt{\frac{3}{\gamma}}$ (b) $\sqrt{\frac{\gamma}{3}}$ (c) $\sqrt{3\gamma}$ (d) $\frac{\sqrt{3}}{\gamma}$

9. What kind of thermodynamical process occur in air, when a sound wave propagates through it?

10. State the factors on which the speed of a wave travelling along a stretched ideal string depends.

11. What is the effect of pressure on the speed of sound in air? Justify your answer.

(2 Marks Questions)

12. If the phase difference between two sound waves of wavelength λ is 60°, what is the corresponding path difference?

13. Define wave number and angular wave number and give their SI units.

14. 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 to the speed of sound in dry air at 20°C = 343m/s.

15. Discuss the effect of the following factors on the speed of sound: (a) pressure (b) density (c) humidity (d) temperature.

16. A String of mass 2.50kg is under a tension of 200N. The length of the stretched string is 20.0m. If a transverse jerk is struck at one end of the string, how long does the disturbance take to reach the other end? [Ans. 0.5s]

(3 Marks Questions)

17. The equations of displacements of two waves are $y_1 = 10\sin\left[3\pi t + \frac{\pi}{3}\right]$ and $y_2 = 5\left[\sin 3\pi t + \sqrt{3}\cos 3\pi t\right]$. Find the ratio of their amplitudes.

18. A mechanical wave travels along a string is described by y(x, t) = 0.005 sin (3.0t – 80x) in which numerical constants are in SI units. Calculate (a) amplitude of displacement (b) amplitude of velocity (c) wavelength (d) amplitude of acceleration (e) the time period (f) frequency of oscillation

19. What is the nature of sound waves in air? How is the speed of sound waves in atmosphere affected by the (i) humidity (ii) temperature?

20. A stone dropped from the top of the tower 300 m high splashes into water of a pond near the base of the tower. When is the splash heard at the top? Speed of sound in air = 340m/s, g = 9.8 m/s^2. [Ans. 8.7s]

21. A steel wire has a length of 12.0 ms and a mass of 2.10kg. What should be the tension in the wire equals the speed of sound in dry air at 20°C is 343 ms^{-1}? [Ans. 2.06×10^4N]

22. Use the formula $v = \sqrt{\lambda P/r}$ to explain why the speed of sound in air (a) is independent of pressure, (b) increases with temperature (c) increases with humidity.

23. A bat emits ultrasound frequency 100 kHz in air. If this sound meets a water surface, what is the wavelength of (i) the reflected sound (ii) the transmitted sound? Speed of sound n air = 340 ms^{-1} and in water = 1486 ms^{-1}. [Ans. 3.4×10^{-3}m, 1.49×10^{-2}m]

24. A hospital uses and ultrasonic scanner to locate tumours in a tissue. What is the wavelength of sound in a tissue in which the speed of sound is 1.7 kms^{-1}? The operating frequency of the scanner is 4.2 MHz. [Ans. 4.047×10^{-4}m]

25. A transverse harmonic wave on a strong is described by:

$$Y(x, t) = 3.0 \sin(36t + 0.081x + \pi/4)$$

Where x, y are in cm and t in s. The positive direction of x is from left to right.

(i) Is this a travelling or a stationary wave? If it is travelling, what are the speed and direction of its propagation

(ii) What are its amplitude and frequency?

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

(iv) Hat is the least distance between two successive crests in the wave?

26. Given below are some functions of x and t to represent the displacement (transverse or longitudinal) of an elastic wave. State 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) $y = \cos x \sin t + 2x \sin 2t$

(5 marks Questions)

27. For the wave described by $y(x, t) = 3.0 \sin(36t + 0.018x + \pi/4)$. Plot the displacement (u) versus (t) graphs for x = 0, 2 and 4cm. What are the shaped of these graphs? In which aspects does the oscillatory motion in travelling wave differ from one point to another: amplitude, frequency or phase?

28. For the travelling harmonic wave $y(x, t) = 2.0 \cos 2\pi(10t - 0.0080x + 0.35s)$, where x and y are in cm and t is in s. Calculate the phase difference between oscillatory motion of two points by a distance of (a) 4m (b) 0.5m (c) $\lambda/2$ (d) $3\lambda/4$.

29. The equation of a plane progressive wave is given by equation: $y = 10 \sin 2\pi(t - 0.005x)$, where x and y are in cm and t in seconds. Calculate (i) amplitude (ii) frequency (iii) wavelength (iv) velocity of wave.

30. A transverse harmonic wave on a string is described by y(x, t) = 3.0sibn (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?

31. A standing wave set up in a medium is given by $y = 4\cos\left(\frac{\pi x}{3}\right)$ where x an y are in cm and t is in seconds. (i) Write the equation of the two component waves and give amplitude and velocity of each wave. (ii) What is the distance between the adjacent modes? (iii)What is the velocity of the particle of the medium at x = 3cm and time t = 1/8s?

32. The transverse displacement of a string (clamped at its two ends) is given by $y(x, t) = 0.06 \sin(2\pi/3) \times \cos 120\pi t$ where x, y are in m and t in s. The length of the string is 1.5m and its mass is 3.0×10^{-2}kg. Answer the following:
(a) Does the function represent a travelling or a stationary wave?
(b) Interpret the wave as a superposition of two waves travelling in opposite directions. What are the wavelength frequency and speed of propagation of each wave?
(c) Determine the tension in the string.

C. REFLECTION AND REFRACTION OF WAVES

(1 Mark Questions)

1. The phenomenon of echo is an example of
(a) reflection (b) refraction (c) beat (d) resonance

2. When you shout in front of a hill, your own shout is repeated. Explain.

(2 Marks Questions)

3. Explain why we cannot hear an echo in a small room?

4. What do you mean by reverberation? What is reverberation time?

D. SUPERPOSITION OF WAVE

E. STANDING WAVES

(1 Mark Questions)

1. Why do stationary waves not transport energy?

2. When you shout in front of an open organ pipe, what happens to the wavelength of the fundamental note?

3. When are stationary waves produced?

(2 Marks Questions)

4. What are the differences between stationary waves and progressive waves?

5. Differentiate between harmonics and overtones.

(3 Marks Questions)

6. Give any three differences between progressive wave and stationary wave. A stationary wave is $y = 12 \sin 300t \cos 2x$. What is the distance between two nearest modes?

7. An open pipe has a fundamental frequency of 240 Hz. The first overtone of a closed organ pipe has the same frequency as the first overtone of the open pipe. How long is each pipe? Velocity of sound at room temperature is 350m/s.

8. The length of a wire between the two ends of a sonometer is 105cm. Where should the two bridges be placed so that the fundamental frequencies of the three segments are in the ratio of 1:5:15?

9. A metre-long tube open at one end, with a movable piston at the other end, shows resonance with a fixed frequency source (a turning 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 effect may be neglected. [Ans. 1/3]

(5 Marks Questions)

10. What are stationary waves? Explain the formation of stationary waves graphically.

F. BEATS

(1 Mark Questions)

1. When two waves of almost equal frequencies v_1 and v_2 reach at a point simultaneously, the time interval between successive maxima is
   (a) $v_1 + v_2$ (b) $v_1 - v_2$ (c) $1/ v_1 + v_2$ (d) $1/ v_1 - v_2$

2. Which of the following phenomenon is used by the musicians to tune their musical instruments?
   (a) interference (b) diffraction (c) beats (d) polarization

3. Why do we not hear beats due to sound waves emitted by the violin section of an orchestra?

4. Two sound source produce 12 beats in 4 seconds. By how much do their frequencies differ?

(2 Marks Questions)

5. If two sound waves of frequencies 480Hz and 536Hz superpose, will they produce beats? Would you hear the beats?

6. Why is the sonometer box hollow and provided with holes?

7. How does the frequency of a tuning fork change, when the temperature is increased?

(3 Marks Questions)

8. Calculate the speed of sound in a gas in which two waves of lengths 100cm and 101cm produce 24 beats in 6 seconds.

9. Two sitar strings A and B playing the note ‘Ga’ are slight out of tune and produce beats of frequency 6Hz. The tension in the string A is slightly reduced and the beat frequency is found to reduce to 3Hz. If the original frequency of A I s324Hz, what is the frequency of B?

10. What is beat phenomenon?

(5 Marks Questions)

11. What are beats? Explain their formation analytically? Prove that the beat frequency is equal to the difference in frequencies of the two superposing waves.

G. INTERFERENCE

(1 Mark Questions)

1. Intensities of two waves, which produce interference are 9:4. The ratio of maximum and minimum intensity is
   (a)9:4 (b) 3:2 (c) 25:1 (d) 5:1

(3 Marks Questions)

2. Two periodic waves of intensities I_1 and I_2 pas through a region at the same time in the same direction. What is the sum of the maximum and minimum intensities?

H. DOPPLER'S EFFECT

(1 Mark Questions)

1. Doppler effect is applicable for
   (a) sound waves only (b) light waves only
   (c) both sound and light waves (d) none of these

2. A train approaching a railway platform with a speed of 20m/s starts blowing the whistle. Speed of sound in air is 340 m/s. If the frequency of the emitted sound from the whistle is 640Hz, the frequency of sound as heard by the person standing on the platform is
   (a) 600 Hz (b) 640 Hz (c) 680Hz (d) 720 Hz

3. What is Doppler effect?

4. An observer moves towards a stationary source of sound with a velocity one-fifth of the velocity of sound. The percentage change in the apparent frequency is
   (a) zero (b) 5% (c) 10% (d) 20%

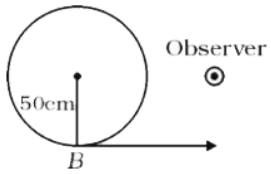
(2 Marks Questions)

5. What is the speed of the observer for whom a note is 10 percent lower than the emitted frequency?

6. A SONAR system fixed in a submarine operates at a frequency 40.0 kHz. An enemy submarine moves towards the Sonar with a speed of 360km/h. What is the frequency of sound reflected by the submarine. Take the speed fo sound in water to be 1450m/s.

(3 Marks Questions)

7. A whistle revolve in a circle with angular velocity ω = 20 rad/s. If the frequency of the sound is 385Hz and speed is 340 m/s, then find the frequency heard by the observer when the whistle is at B.



8. A railway engine and a car are moving parallel but in opposite direction with velocities 144 km/h and 72 km/h respectively. The frequency of engine's whistle is 500Hz and the velocity of sound in 340 m/s. Calculate the frequency of sound heard in the car when (i) the car and engine are approaching each other (ii) both are moving away from each other.

(5 marks Questions)

9. A train standing in a station yard, blows a whistle of frequency 400 Hz in still air. The wind starts blowing in the direction from the yard to the station with a speed of 10m/s. What are frequency, wavelength and speed of sound for an observer standing on the station platform? Is the situation exactly identical to the case when the air is still and the observer runs toward the yard at a speed of 10m/s? The speed of sound in still air can be taken as 340m/s.

10. 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 10m/s. (b) recedes from the platform with a speed of 10m/s.
(ii) What is the speed of sound in each case if the speed of sound in still air is 340 m/s.

11. (a) What is Doppler effect?
(b) Derive an expression for the apparent frequency when a source moves towards a stationary observer.
(c) A policeman on duty detects a drop of 15% in the pitch of the horn of a motor car as it crosses him. Calculate the speed of car, if the velocity of sound is 330 m/s.

12. 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.

13. A train, standing at the outer signal of a railway station blows a whistle of frequency 400 Hz 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 10 ms~1. (b) recedes from the platform with a speed of 10 ms^{-1}(ii) What is the speed of sound in each case? The speed of sound in still air can be taken as 340 ms^{-1} . [Ans. 412 Hz, 389 Hz]

I. CHALLENGING PROBLEMS:

1. One end of a long string of linear mass density 8.0 x 10^{-3} kg m^{-1} is connected to an electrically driven tuning fork of frequency 256 Hz. The other end passes over a pulley and is tied to a pan containing a mass of 90 kg. 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.

2. A SONAR system fixed in a submarine operates at a frequency 40.0 kHz. An enemy submarine moves towards the SONAR with a speed of 360 km h^{-1}. What is the frequency of sound reflected by the submarine? Take the speed of sound in water to be 1450 ms^{-1}.
[Ans. 45.9kHz]

3. Earthquakes generate sound waves inside the earth. Unlike a gas, the earth can experience both transverse (S) and longitudinal (P) sound waves. Typically the speed of S wave is about 4.0 km s^{-1} . A seismograph records P and S waves from an earthquake. The first P wave arrives 4 min before the first S wave. Assuming the waves travel in straight line, at what distance does the earthquake occur? [Ans. 1920 km]

4. A bat is flitting about in a cave, navigating via ultrasonic beeps. Assume that the sound emission frequency of the bat is 40 kHz. 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? [Ans. 42.47 kHz]