Wave Motion

Wave velocity: $v = \lambda f$ $\quad v = \frac{\omega}{K}$ | $k = \frac{2\pi}{\lambda}$ | $\omega = 2\pi f = \frac{2\pi}{T}$

Maximum particle velocity: $(v_p)_{max} = a\omega$

Maximum particle acceleration: $(a_p)_{max} = a\omega^2$

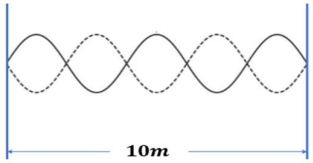
Distance between successive nodes $= \frac{\lambda}{2}$ = Distance between successive antinodes

Distance between successive node and antinode $= \frac{\lambda}{4}$

$Phase\ difference = \frac{2\pi}{\lambda} \times Path\ difference$

$phase\ difference = k \times path\ difference$

1. a. Define progressive wave. [1]
   b. Derive equation of progressive wave. [3]
   c. A wave has the equation: $y = 0.02\sin(30t - 4x)$, y and x in meters and t in seconds. Find (i) frequency (ii) wavelength (iii) speed. [**4.8Hz, 1.6m, 7.5m**] [2]
   d. A radio station broadcasts at 700KHz. If the radio waves travel with a speed of $3 \times 10^8 m/s$, calculate the wavelength of radio waves. [**428.6m**] [2]
2. a. What are stationary waves? Prove that the distance between any two consecutive nodes or consecutive antinodes in a stationary wave is $\lambda/2$. [3]
   b. A stretched string of given length resonates in one second as shown in figure.
      i. What is the type of wave shown in fig? [1]
      ii. Discuss the mechanism of formation of wave shown in fig. [2]
      iii. Determine the frequency, wavelength, propagation constant and speed of the wave. [2]



3. a. A ship's Sonar sends down a signal of 6000Hz through water in which the speed of sound is 1500 m/s. The echo from the sea-bed is received after 2 seconds. What is the depth of the sea bed? [2]
   b. The distance between two consecutive nodes in a stationary wave is 20cm. If the speed of wave at 0^oC be 330m/s, calculate its frequency at 0^oC ? What would be the velocity of sound at 20^oC? [2]
   c. Is polarization possible for longitudinal waves? Why? [2]
4. a. If you are walking on the moon surface, can you hear the cracking sound behind you? Explain. [2]
   b. State principle of superposition of wave. Write an equation of stationary wave. [1]
   c. The distance between two consecutive nodes in a stationary wave is 20cm. If the speed of wave at 0^oC be 330m/s, calculate its frequency at 0^oC ? [2]
   d. For a travelling wave: $y = 2.0\ cos\ (10t - 0.8\ x + 0.35)$, where x & y are in m, t in seconds. What is the difference between oscillatory motions at two points separated by a distance of: (i) 4 m & (ii) $3\lambda/4$?
   [*Ans:* (i) **3.2 radian** (ii) **4.7 radian**] [2]
   e. A wave has frequency of 5KHz and amplitude 2m. Find maximum particle velocity. [2]

Mechanical Waves

Velocity of mechanical wave: $v = \sqrt{\frac{E}{\rho}}$ $\quad E$ = modulus of elasticity of medium

ρ = density of medium

$\left(\frac{E}{\rho}\right)_{solid} > \left(\frac{E}{\rho}\right)_{liquid} > \left(\frac{E}{\rho}\right)_{air}$ Hence, speed of sound is maximum in solid.

Velocity of sound in air: $v = \sqrt{\frac{\gamma P}{\rho}}$ | $v \propto \frac{1}{\sqrt{\rho}}$ | $v = \sqrt{\frac{\gamma RT}{M}}$ | $v \propto \sqrt{T}$

$v = \lambda f$ | $\frac{v_1}{v_2} \propto \sqrt{\frac{\rho_2}{\rho_1}}$ | $\frac{v_1}{v_2} \propto \sqrt{\frac{T_1}{T_2}}$

According to Newton, the propagation of sound wave through air is an isothermal process. This assumption developed incorrect result. Hence, modification is needed.

According to Laplace, the propagation of sound wave through air is an adiabatic process. This modification developed correct result.

1. a. When sound waves travel through a medium, does the temperature at various points remain constant? [1]
   b. Write down relation of Laplace's correction of speed of sound in gaseous medium. [1]
   c. Find the atomicity (γ) of the gas at NTP. Density of air at NTP is 1.293kg/m³. [2]
   d. Calculate the increase in velocity of sound produced by 1°C rise in temperature, if the velocity of sound at 0°C 332m/s. [**Ans 0.61m/s**] [2]
   e. At what temperature will the velocity of sound in air be double than the velocity in air at 22°C? [**1180K**] [2]
   f. Write Newton's formula for the speed of sound in the gas. Why and what correction was applied by Laplace in this formula? [2]
   g. Discuss the effect of temperature and pressure on the velocity of sound in air. [2]
   h. Explain which property of a medium is responsible to form wave patterns from SHM of particles. [2]
2. a. During a lightning, light and sound are produced simultaneously but we see light before we hear the sound. Why? [2]
   b. Using concept in (a), estimate the distance of the lightning strike from the boy. Where, a lightning flash which is followed by a thunder 3 secs later. Given, velocity of sound on that day= $332\ m/s$, velocity of light (c) = 3×10^8 m/s.
   [**Ans: 996 m**] [3]
   c. A source of sound of frequency $512\ Hz$ emits waves of wavelength $670\ mm$ in air at 20^oC. What would be the wavelength of sound from the source at 0^oC? [2]
   d. A man standing at one end of a closed corridor 65 m long blow a short blast on a whistle. He hears the second echo in a total time of 3 sec, temperature being 27^oC. Calculate the velocity of sound at 10^oC. [2]
   e. Hydrogen and oxygen gas are at same temperature. In which medium does the sound travel faster? Explain. [2]