Progressive Wave.

(1) These waves propagate in the forward direction of medium with a finite velocity.

(2) Energy and momentum are transmitted in the direction of propagation of waves without actual transmission of matter.

(3) In progressive waves, equal changes in pressure and density occurs at all points of medium.

(4) Various forms of progressive wave function.

where y = displacement
A = amplitude
ω = angular frequency
n = frequency
k = propagation constant
T = time period
λ= wave length
v = wave velocity
t = instantaneous time
x = position of particle from origin

(i) $y = A \sin(\omega t - kx)$

(ii) $y = A \sin(\omega t - \frac{2\pi}{\lambda}x)$

(iii) $y = A \sin 2\pi\left[\frac{t}{T} - \frac{x}{\lambda}\right]$

(iv) $y = A \sin \frac{2\pi}{\lambda}(vt - x)$

(v) $y = A \sin \omega\left(t - \frac{x}{v}\right)$

Important points

(a) If the sign between t and x terms is negative the wave is propagating along positive X-axis and if the sign is positive then the wave moves in negative X-axis direction.

(b) The coefficient of sin or cos functions i.e. Argument of sin or cos function i.e. (ω t - kx) = Phase.

(c) The coefficient of t gives angular frequency ω = 2 $\pi n = \frac{2\pi}{T}$ = vk.

(d) The coefficient of x gives propagation constant or wave number $k = \frac{2\pi}{\lambda} = \frac{\omega}{v}$.

(e) The ratio of coefficient of t to that of x gives wave or phase velocity. i.e. v = $\frac{\omega}{k}$.

(f) When a given wave passes from one medium to another its frequency does not change.

(g) From v = $n\lambda$ $\therefore$ v $\propto \lambda$ $\because$ n = constant $\therefore$ $\frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$.

(5) Some terms related to progressive waves

(i) Wave number ($\bar{n}$): The number of waves present in unit length is defined as the wave number ($\bar{n}$) = $\frac{1}{\lambda}$.

Unit = meter–1; Dimension = [L–1].

(ii) Propagation constant (k) : k = $\frac{\phi}{x}$ = $\frac{\text{Phase difference between particles}}{\text{Distance between them}}$

$$k = \frac{\omega}{v} = \frac{\text{Angular velocity}}{\text{Wave velocity}}$$ and k = $\frac{2\pi}{\lambda} = 2\pi\bar{\lambda}$

(iii) Wave velocity (v): The velocity with which the crests and troughs or compression and rarefaction travel in a medium, is defined as wave velocity v = $\frac{\omega}{k}$ = n $\lambda = \frac{\omega\lambda}{2\pi} = \frac{\lambda}{T}$.

(iv) Phase and phase difference: Phase of the wave is given by the argument of sine or cosine in the equation of wave. It is represented by $\phi(x,t) = \frac{2\pi}{\lambda}(vt - x)$.

(v) At a given position (for fixed value of x) phase changes with time (t).

$\frac{d\phi}{dt} = \frac{2\pi v}{\lambda} = \frac{2\pi}{T} \Rightarrow d\phi = \frac{2\pi}{T}.dt \Rightarrow$ Phase difference = $\frac{2\pi}{T} \times$ Time difference.

(vi) At a given time (for fixed value of t) phase changes with position (x).

$\frac{d\phi}{dx} = \frac{2\pi}{\lambda} \Rightarrow d\phi = \frac{2\pi}{\lambda} \times dx \Rightarrow$ Phase difference = $\frac{2\pi}{\lambda} \times$ Path difference

· Time difference = $\frac{T}{\lambda} \times$ Path difference