

# Concept

**Matter Waves**  
Waves associated with particles like - electrons, protons, neutrons, atoms, molecules, etc.

**Electromagnetic Waves**  
Do not require any material medium for their propagation e.g., light waves

**Mechanical Waves**  
Require material medium for their propagation

**Essential Properties for propagation**

- Elasticity
- Inertia
- Minimum friction

**Relation b/w wave velocity ( $v$ ), wavelength ( $\lambda$ ) and frequency ( $\nu$ )**  
Wave velocity  $v = \nu\lambda$   
Time period ( $T$ ) =  $\frac{1}{\text{frequency}}$   
Angular frequency ( $\omega$ ) =  $2\pi\nu$   
Wave number ( $\bar{\nu}$ ) =  $\frac{1}{\text{wavelength}}$

**Types of waves**

**Transverse waves**  
Individual particles of the medium oscillate perpendicular to the direction of wave propagation

**Longitudinal waves**  
Individual particles of the medium oscillate along the direction of wave propagation

**WAVES**  
Information and energy propagate in the form of signal or disturbances without actual transfer of matter

**Speed of longitudinal wave**  
Speed of sound,  $V = \sqrt{\frac{E}{\rho}}$   
 $= \sqrt{\frac{Y}{\rho}} = \sqrt{\frac{P}{\rho}} = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$   
for air  $\gamma = 7/5$   
Elasticity of solids maximum and of gases-minimum

**Speed of transverse wave in a stretched string :**  
 $V = \sqrt{\frac{T}{M}}$   $T = \text{tension}$   
and  $M = \text{mass/length}$

**Displacement relation in a plane progressive wave**  
 $y(x, t) = A \sin(\omega t - kx + \phi_0)$   
 $y(x, t) = A \sin 2\pi\left(\frac{t}{T} - \frac{x}{\lambda}\right)$   
velocity amplitude  $v_0 = A\omega$   
Acceleration amplitude  $a_0 = A\omega^2$

• If string is stretched by some weight then speed of transverse wave is given by

**Speed of sound in gases**  
 $V = \sqrt{\frac{\gamma P}{\rho}}$   
 $= \sqrt{\frac{\gamma RT}{M}}$

**Wave equation**  
 $\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2} \frac{\partial^2 y}{\partial t^2}$

**Standing waves**  
When two waves of same frequency and amplitude travel in opposite directions, they interfere to form a standing wave.  
 $y = 2A \sin kx \cos \omega t$

**Standing waves in a pipe**  
In a pipe closed at one end, the length of the pipe is equal to an odd multiple of  $\frac{\lambda}{4}$ .  
 $L = (2n-1) \frac{\lambda}{4}$

**Standing waves in a string**  
In a string fixed at both ends, the length of the string is equal to an integer multiple of  $\frac{\lambda}{2}$ .  
 $L = n \frac{\lambda}{2}$

**Standing waves in a pipe**  
In a pipe open at both ends, the length of the pipe is equal to an integer multiple of  $\frac{\lambda}{2}$ .  
 $L = n \frac{\lambda}{2}$

# Chapter 20 Waves

**Rachel S Tattersall**



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