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Progressive Waves

By A.S. Roy

A progressive wave is a form of disturbance which travels from one part of a medium to the other through the vibratory motion of the particles of the medium about their equilibrium positions.

A number of particles make a continuous elastic medium. If the first particle is set in vibration, the disturbance is handed over from particle to particle. Thus each particle is set in vibration, but a little later than the previous particle. Thus the phase of vibration changes from particle to particle. When the disturbance reaches a particle at the moment when the first particle has completed one vibration, then this particle vibrates in the same phase as the first particle.

Let us consider a series of particles lying along the x-axis. Let the particle situated at the origin O act as the source of disturbance, so that a plane progressive simple harmonic wave originating at O travel in the positive direction of x-axis. As the wave proceeds, each successive particle of the medium is set in S.H. vibration. Fig (1) shows the displacement y of different particles situated at different positions (x) along the x-axis at a particular instant.

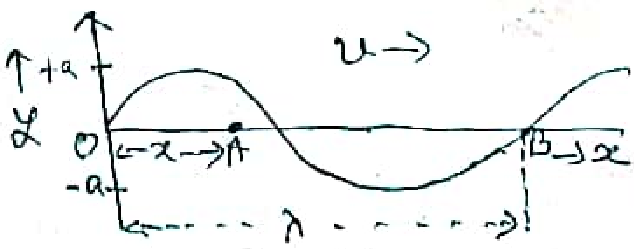

Fig (1)

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Let the time be measured from the instant when the particle at the origin O is passing through its equilibrium position. Then the displacement of the particle at O at any instant t is given by

$$y = a \sin \omega t$$
$$= a \sin \frac{2\pi}{T} t \quad \ldots\ldots (i)$$

where a is the amplitude and T is the period of vibration $(T = \frac{2\pi}{\omega})$

Let A be any arbitrary point at a distance x from O, and the wave be travelling with a velocity v. Then the wave, which starts from O, would reach the point A in x/v sec. Hence the particle at A will start its vibration x/v seconds later than the particle at O, i.e A will lag behind O by x/v sec. Therefore, the displacement at A at the instant t will be the same as was at O at an instant x/v seconds earlier i.e at the instant (t − x/v). Hence, the displacement at A at the instant t can be obtained by substituting (t − x/v) in place of t in equation (i) and is given by

$$y = a \sin \frac{2\pi}{T}(t - x/v)$$
$$= a \sin \frac{2\pi}{Tv}(vt - x)$$
$$= a \sin \frac{2\pi}{\lambda}(vt - x) \quad \ldots (ii) \quad \because vT = \lambda$$

This equation represents the displacement of a particle at a distance x from a fixed point and at a time t i.e the equation of progressive wave