> Date

Giridhar Kumar

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MJC, SEM-II, Physics Notes

12/02/24.

Topic :- Vibration of string :-

A vibration in a string is a wave. Resonance causes a vibrating to produce a sound with constant frequency, i.e constant pitch. If the length or tension of the string is correctly adjusted, the sound produced is a musical tone. Vibrating strings are the basis of string instruments such as guitars, cellos and pianos.

* The velocity of propagation of a wave in a string (v) is proportional to the square root of the force of tension of the string (T) and inversely proportional to the square root of the linear density (μ) of the string.

$$\boxed{v = \sqrt{\frac{T}{\mu}}}$$

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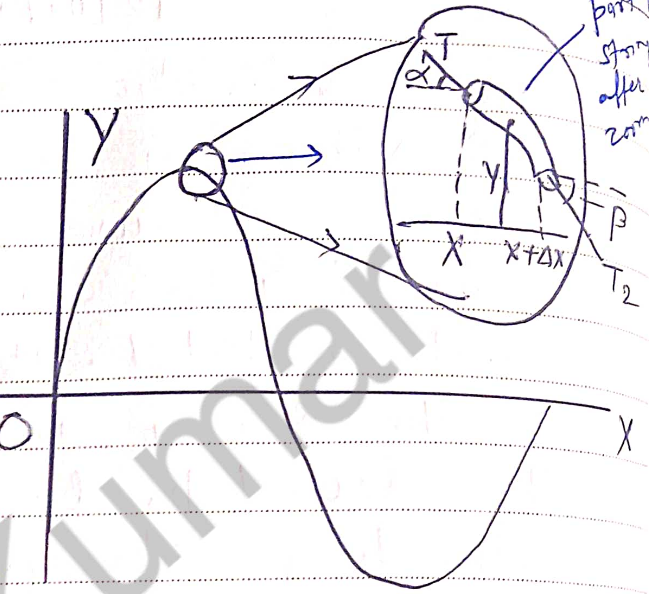
Derivation:-



Let Δx be the length of a piece of string, m its mass and μ is its linear density. If angle α and β are small, then the horizontal components of tension on either side can both be approximated by a constant T, for which the net horizontal force is zero. By using the small angle approximation the horizontal tension acting on both sides of the string segment are given by.

$$T_{1x} = T_1 \cos(\alpha) \simeq T$$

$$T_{2x} = T_2 \cos(\beta) \simeq T$$

From Newton's second law for the vertical component, the mass of the piece

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times its acceleration, a, will be equal to the net force on the piece.

$$\Sigma F_y = T_{1y} - T_{2y} = -T_2 \sin(\beta) + T_1 \sin(\alpha)$$

$$= \Delta m a \approx \mu \Delta x \frac{\partial^2 y}{\partial t^2}$$

Dividing this expression by T and substituting the first and second equation

$$-\frac{\cancel{T_2}\sin(\beta)}{\cancel{T_2}\cos(\beta)} + \frac{\cancel{T_1}\sin(\alpha)}{\cancel{T_1}\cos(\alpha)} = -\tan\beta + \tan\alpha$$

$$= \frac{\mu \Delta x}{T} \cdot \frac{\partial^2 y}{\partial t^2}$$

According to the small-angle approximation,

$$\frac{1}{\Delta x}\left(\frac{\partial y}{\partial x}\Big|^{x+\Delta x} - \frac{\partial y}{\partial x}\Big|^{x}\right) = \frac{\mu}{T} \frac{\partial^2 y}{\partial t^2}$$

In the limit that Δx approaches zero,

$$\therefore \frac{\partial^2 y}{\partial x^2} = \frac{\mu}{T} \cdot \frac{\partial^2 y}{\partial t^2}$$

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$$\Rightarrow \frac{\partial x^2}{\partial t^2} = \frac{T}{\mu} \qquad \left[\because \frac{\partial x^2}{\partial t^2} = v^2\right]$$

$$\Rightarrow v^2 = \frac{T}{\mu}$$

$$\Rightarrow \boxed{v = \sqrt{\frac{T}{\mu}}}$$

Proved.