Physics 101

Lecture 26

Monday March 8, 2004

Topics: Standing Waves

Superposition Principle of Waves

Dynamics of Rigid body motions

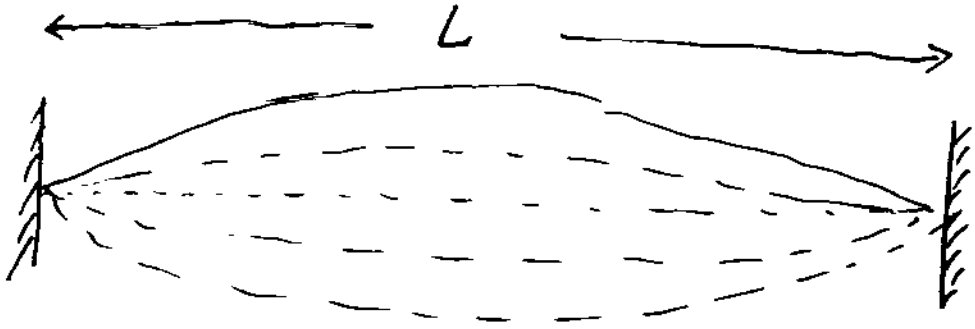
Ref: 14-7, 14-8, ch. 11.

- Standing Waves

  — NOT Travelling

If the two ends of a string are fixed, then there is no motion at the end points. The wave is called a standing wave.

e.g.:

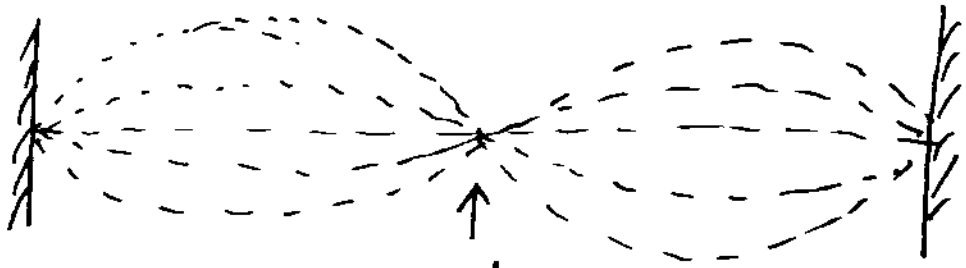


$L = \frac{\lambda}{2}$.

OR.

$L = \lambda$.

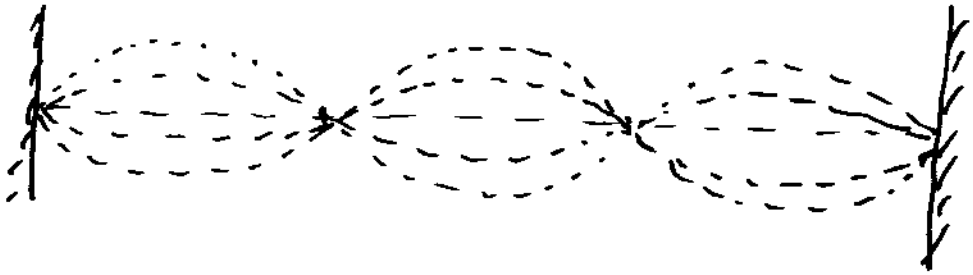
$= \frac{\lambda}{2} \cdot (2)$



Node.

OR

$L = \frac{\lambda}{2}(3)$



....

$f = \frac{v}{\lambda}$

In general: $L = \frac{\lambda}{2}(n)$, $\lambda = \frac{2L}{n}$, $f = \frac{nv}{2L} = n \cdot \frac{v}{2L}$.

$n = 1$. 1st Harmonic (fundamental): $f_1 = \frac{v}{2L}$.

$n = 2$. 2nd Harmonic. $f_2 = \frac{v}{2L}(2)$

....

$n = k$. kth Harmonic. $f_k = \frac{v}{2L}(k)$.

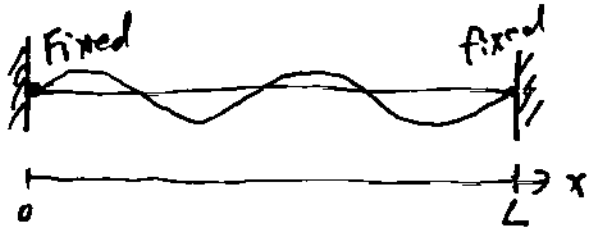
• Math Description of a standing wave

Idea — Superposition of an on-going wave to the right and a reflected wave to the left.

$$y = y_1 + y_2 \quad \text{(superposition principle of waves)}$$

$$= A\cos(kx - \omega t + \varphi) + A\cos(kx + \omega t + \varphi)$$

$$= 2A\cos(\omega t)\cos(kx + \varphi)$$



$$\left[\cos\alpha + \cos\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\cos\left(\frac{\alpha+\beta}{2}\right)\right]$$

when $x = 0$, $y = 0 \Rightarrow \cos\varphi = 0$, $\varphi = \frac{\pi}{2}$.

when $x = L$, $y = 0 \Rightarrow \cos(kL + \varphi) = 0$.

$$\cos\left(kL + \tfrac{\pi}{2}\right) = 0.$$

$$\sin(kL) = 0.$$

$$kL = n\pi \qquad \left(k = \tfrac{2\pi}{\lambda}\right)$$

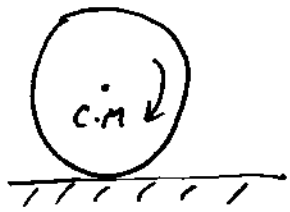
$$\frac{2\pi}{\lambda}L = n\pi.$$

$$L = n\frac{\lambda}{2}, \quad n = 1, 2, 3, \ldots$$

- Dynamics of Rolling objects.

① Linear Motion of C.M.

$$\vec{F} = m\vec{a}$$



② Rotation about C.M.

$$\tau = I\alpha$$ —— True even when C.M. is moving and $\vec{a} \neq 0$

Rolling without slidding —— $a = I\alpha$.

- Mechanical Energy

$$E = U + K$$

$$= U_{cm} + \frac{1}{2} m v_{cm}^2 + \frac{1}{2} I \omega^2$$

I, ω —— about C.M.

- Friction — static ~~(no slidding)~~ (No sliding)

No energy loss.

Mechanical Energy is conserved.