Physics 101

Lecture 23.

Friday, Feb. 28, 2003.

Topics Covered

Waves — Transverse and Longitudinal

Harmonic Wave functions.

standing waves.

Ref: 14-1, 2, 3, 8

- Wave — Propagation of vibration.

  Demo: slinky.

- Transverse wave

$\updownarrow$ $\qquad\longrightarrow$ Direction of propagation

direction of vibration.

- Longitudinal wave.

$\longleftrightarrow$ $\qquad\longrightarrow$ Direction of Propagation

Direction of vibration.

- Difference Between Wave and Wind:

  Wave — propagation of vibration.

  Wind — propagation of mass.

  e.g.: Sound is a wave, but no mass transmition

  ~~When I speak loud~~,

  Loud $\neq$ windy.

- Math description of waves

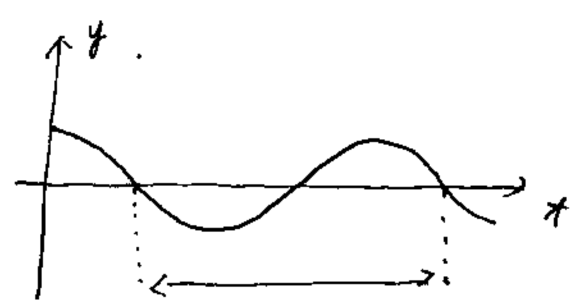
  — wave function $y = y(x, t)$.

  [Take transverse wave as an example].

①. At any given location x, $y = f(t)$ — SHM.

$$y = A \cdot \cos(\omega t + \varphi_1)$$

$$= A \cdot \cos\left(\frac{2\pi}{T} t + \varphi_1\right)$$



T = period.

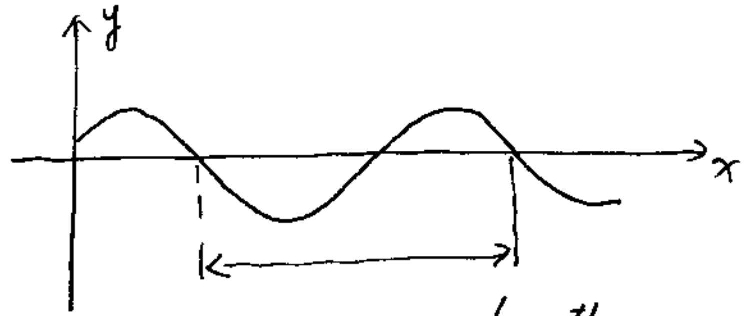
$T = \frac{2\pi}{\omega}$, $\omega = \frac{2\pi}{T}$

ω — How fast the wave varies in time.

T — it takes T seconds to complete a cycle of vibration.
(The wave repeats it self in T seconds).

② . At any given time t, $y = g(x)$. — sine shape.

$$y = A \cdot \cos(kx + \varphi_2)$$
$$= A \cdot \cos\left(\frac{2\pi}{\lambda}x + \varphi_2\right).$$

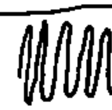


λ = wavelength.

k — wave number
$\left(k = \frac{2\pi}{\lambda}\right)$

How fast the wave varies in space.

(spatial period = λ)

Large k  small λ.

smal k.  large λ

λ — The wave repeats itself in λ meters.

- Speed of wave:

  It takes T seconds for the wave to travel λ meters.

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

- on a string.
$$v = \sqrt{\frac{F}{\mu}}.$$

F — ~~Tension~~ Tension in the string.

μ — mass per unit length.

meaning: The larger the Tension,
The faster the wave travels.

The larger the μ. (denser, or, Heavier).
The slower the wave.

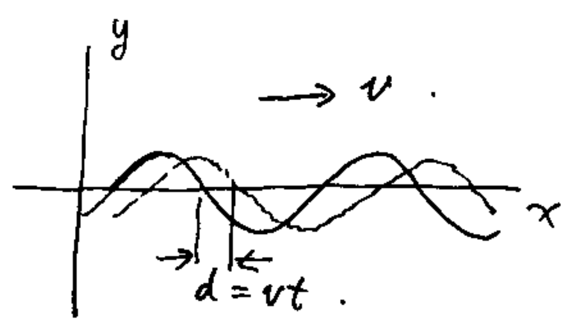
- The Wave function

$$y = y(x, t).$$

for a wave traveling along x-axis at a speed v.

at $t=0$.

$$y = A \cdot \cos(kx + \varphi)$$



at $t \neq 0$, $t = t$.

$$y = A \cdot \cos[k(x-d)+\varphi]$$

$$= A \cdot \cos[k(x-vt)+\varphi]$$

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

The wave has moved to the right by a distance $d = vt$.

$$\omega = kv = \frac{2\pi}{\lambda} v = \frac{2\pi}{T}.$$

If the wave moves to the left:

$$y = A \cdot \cos[k(x+d)+\varphi] = A \cdot \cos[k(x+vt)+\varphi] = A\cos(kx+\omega t+\varphi)$$