Wave function for a Sine wave.

The particle at the very end (left) of medium, what does it do?

Ans: It osillates up and down, in a harmonic motion

Its displacement, y, can be written as:

$$y(t) = \underbrace{A}_{\text{Amplitude}} \cos \underbrace{\omega}_{\text{angular frequency}} t$$

? why there is no x in the above Eq?

Ans. because we are looking at a fixed particle at $x = 0$.

? What about other particles at $x > 0$?

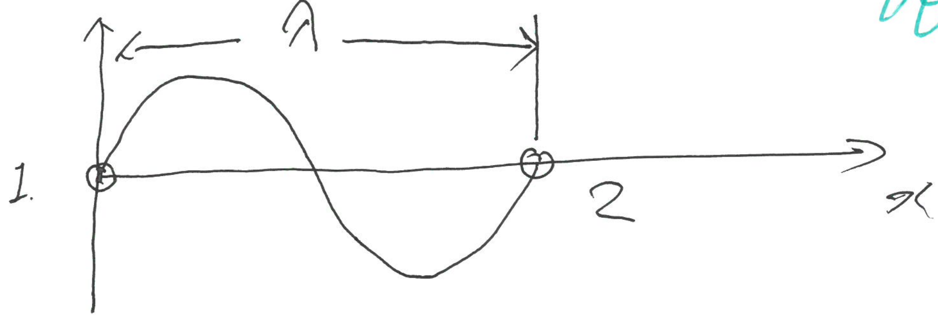
Ans: They all oscillate with the same ω.

$\Rightarrow$ choose an arbitrary particle at x.

$$y(x,t) = A\cos\omega t \quad ?$$

The particle at x performs SHM.
BUT, its motion lags behind from the one at $x=0$.

How far behind ?



If $x = \lambda$. 1 & 2 are in phase

OR. we can say that 2 is behind 1 by $\underline{\underline{2\pi}}$.

For particle 2

$$y = A\cos(\omega t - 2\pi)$$

For any particle with $0 < x < \lambda$, It lags behind 1 by

$$\frac{x}{\lambda} \cdot 2\pi .$$

(The particles farther down the line ~~to~~ fall further behind)

Now.

$$y(x,t) = A\cos\left(\omega t - \frac{x}{\lambda} \cdot 2\pi\right)$$

We call $\left(\frac{2\pi}{\lambda}\right) = k \rightarrow$ the wave number

Thus $y(x,t) = A\cos(\omega t - kx)$

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

because $\cos(-\alpha) = \cos\alpha$

$$y(x,t) = A\cos k\left(x - \frac{\omega}{k}t\right)$$

Recall the general form of a wave function

$$f(x,t)$$

$$\Downarrow$$

$$f(x - vt)$$

comp.

$$f(x - vt)$$

$$A\cos k\left(x - \frac{\omega}{k}t\right)$$

Hence $\frac{\omega}{k} = v$ is the wave speed.

Note. We choose to use

Cos function

Sin fun can be used as well.

$$\frac{\omega}{k} = \frac{2\pi f}{2\pi/\lambda} = f\lambda = v$$