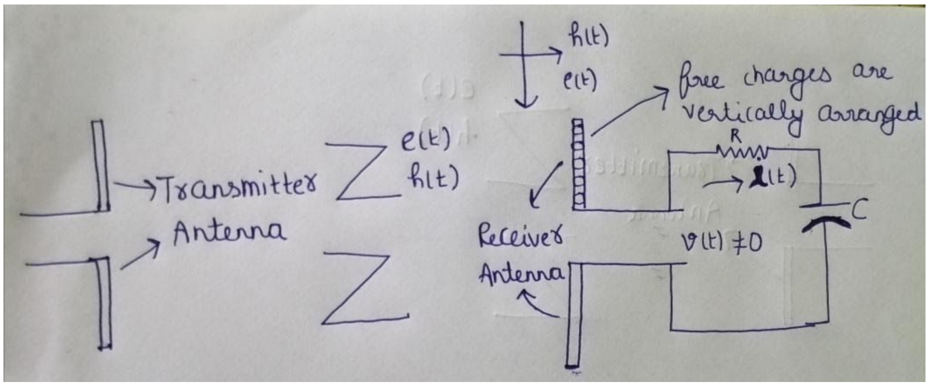
Satellite & Mobile Communication Network

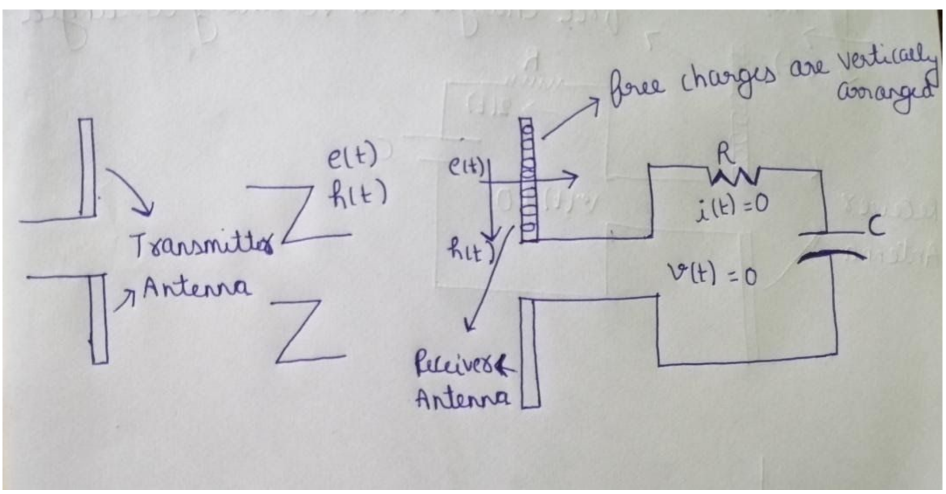
18.08.2020

1. e(t) vertical to the vertical antenna



   a. Free charges are arranged vertically.
   b. e is also arranged vertically.

2. e(t) horizontal to the vertical antenna



   a. Free charges are arranged vertically.
   b. e exerted horizontally.

3. Adjustment of the receiving antenna is required by rotation.
4. Electromagnetic wave equation :

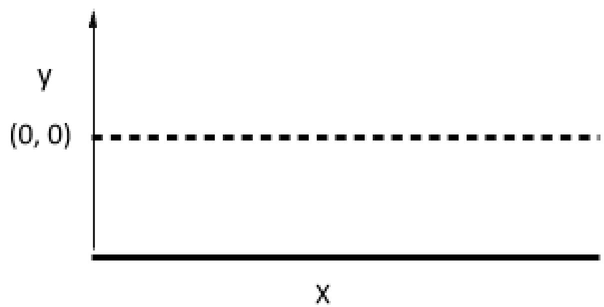
$$\vec{e}(t, x) = Esin(2\pi ft + \frac{2\pi}{\lambda}x)$$

$$\vec{h}(t,\ x)\ = Hsin(2\pi ft\ +\ \frac{2\pi}{\lambda}x)$$

where E = Amplitude of Electrical field
H = Amplitude of Magnetic field
F = Cyclic frequency
λ = Wavelength

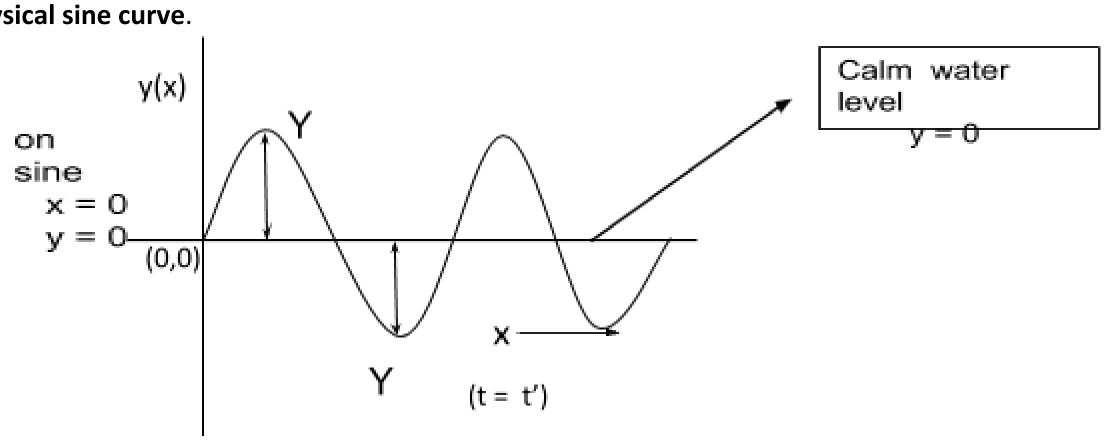
To understand and derive the above equation as a function of t(time) and x(space) , let's take the example of a water wave of a lake.

5. Calm Lake

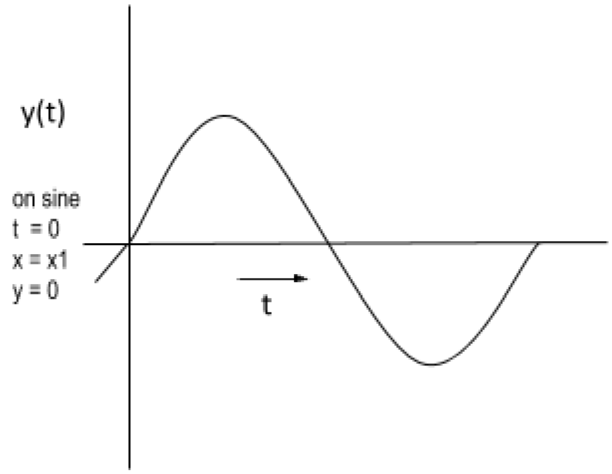


At any x y(x) = 0

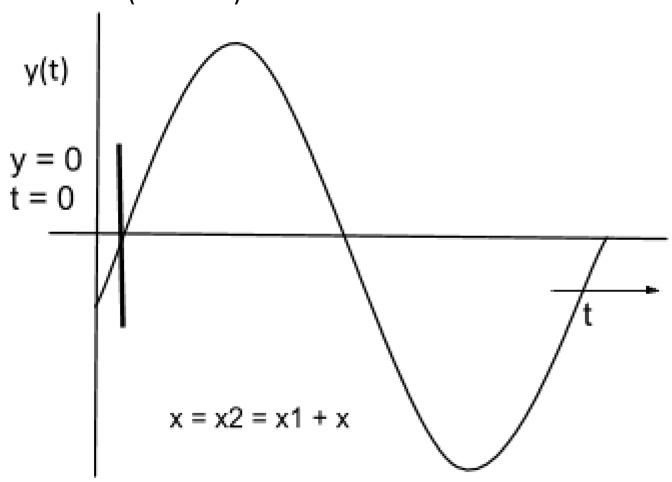
6. When water wave is set up in the lake :
   At time t = t', look at all x points
   Y = Amplitude
   There is a **physical sine curve**.



7. Look at the wave at any point x = x1 where the wave starts.
   Look at the time variation.

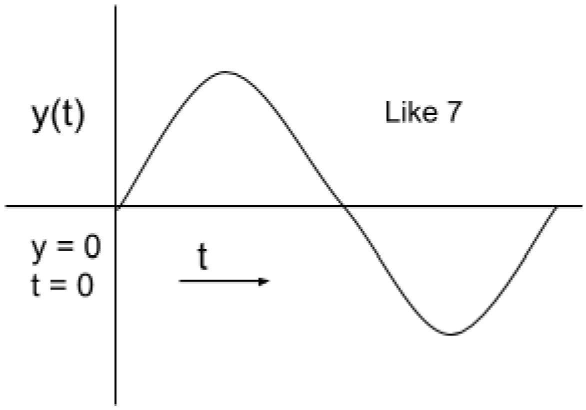


Variation at x = x2 = (x1 + Δx)



Lagging by angle Θ
So here, wave starts at Θ angle
2 π => T
x = x3, x4, x5 where x1<x2<x3…<x5…
The wave starts at a later point of time.

8. We say the wave travels.
9.



At x = x_1

$y(t) = Y sin(2\pi f t)$

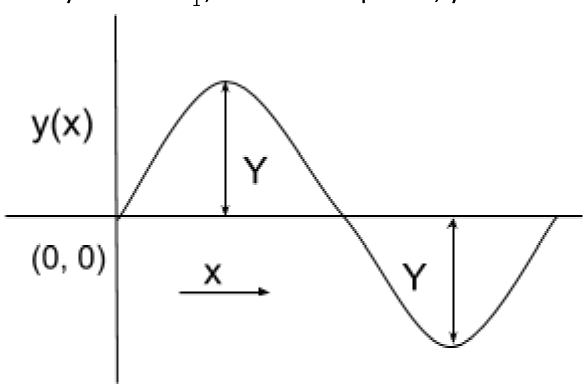
f = cyclic frequency = $\frac{1}{T}$

T = time period

At x = x_2

$y(t) = Y sin(2\pi f t - \theta)$

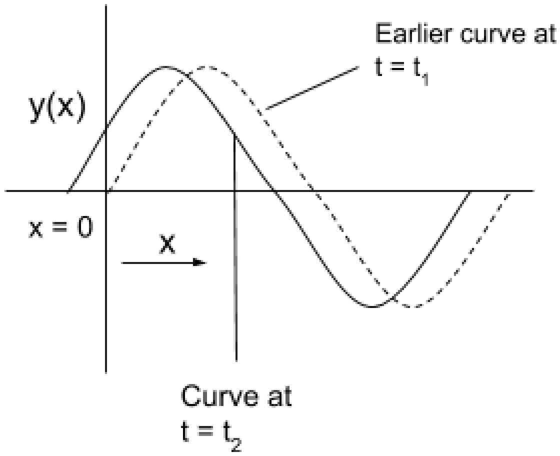
10. Now look at the variation of y w.r.t space.
    At any time t = t_1 , look at all x points, you will see a sine wave.



$y(x) = Y sin(\beta x)$

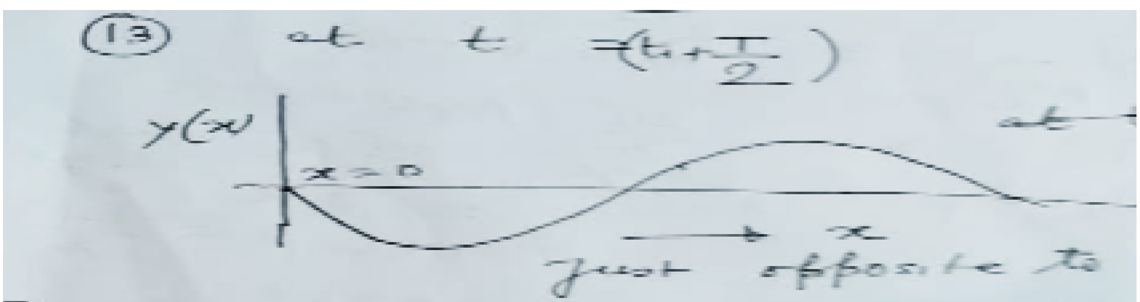
where ⍰ = constant

11. Look at all x points at another time t = t2 = (t1 + Δ t)

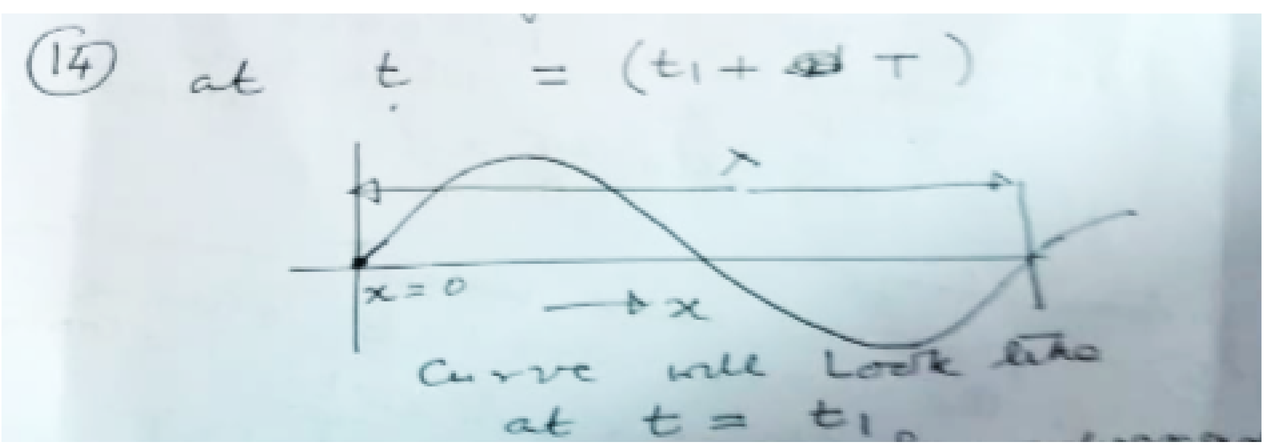


12. At $t = t_1 + \frac{T}{4}$ (time period)

13. At $t = t_1 + \frac{T}{2}$



14. At $t = t_1 + T$



We say the wave has advanced at a length of λ in time T.

path length λ ⟶ T ⟶ 2*π Angle

In time T change

path changes by λ

The Angle changes by 2*π

λ ⟶ 2*π

path change ⟶ Angle change

1 ⟶ 2*π/ λ Angle change

x path change ⟶ 2*π*x/λ Angle change

= β * x

where β = 2*π/ x

15. Therefore the variation of the wave w.r.t. x where t is constant.

$$y(x) = Y \sin\left(\frac{2\pi x}{\lambda}\right)$$

16. We already know variation of the wave w.r.t. t where x = constant

$$y(t) = Y \sin\left(\frac{2\pi t}{T}\right)$$
$$= Y \sin(2\pi f t)$$

Now combining 15 and 16 variation w.r.t **t** (time) and **x** (space)

$$y(t, x) = Y \sin\left(2\pi f t + \frac{2\pi x}{\lambda}\right)$$

where the constant

$\lambda = wavelength = distance\ between\ two\ consecutive\ space\ points\ with\ the\ same\ phase$
$(both\ y = 0\ or\ both\ y = Y)\ at\ a\ particular\ time\ t = t$

17. From 14 we have seen that the wave advances/ travels λ distances in time T

T time $\rightarrow$ λ distance

1 time $\rightarrow$ $\frac{\lambda}{T} = f * distance$

Velocity of wave $v = f\lambda$

18. In a similar manner $if = v(t)$ of transmitter antenna is $V \sin(2\pi f t)$

Then,

$$\vec{e}(t) = E \sin(2\pi f t)$$
$$\vec{h}(t) = H \sin(2\pi f t)$$

where transmitter antenna point $x = 0$.

Therefore, the wave equation a distance x from transmitter antenna:

$$\vec{e}(t, x) = Esin(2\pi ft + \frac{2\pi x}{\lambda})$$

$$\vec{h}(t, x) = Hsin(2\pi ft + \frac{2\pi x}{\lambda})$$

19. Particle mode and wave mode energy transfer:

    a. **Particle Mode:**
    At particle of mass m and velocity v has kinetic energy:

    $$E = \frac{1}{2}mv^2$$

    If you throw this particle to a football on still water, the football starts moving. Here the energy is transformed in particle mode. The particle carrying energy actually moves.

    b. **Wave Mode:**
    You stir water at the edge of the pond → wave set up → in the wave no water particle moves from the mean position → wave reaches the ball and moves it.