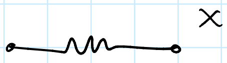
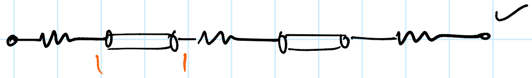
Lec-3

Monday, January 13, 2020 8:45 AM

1) 

not a way to simulate

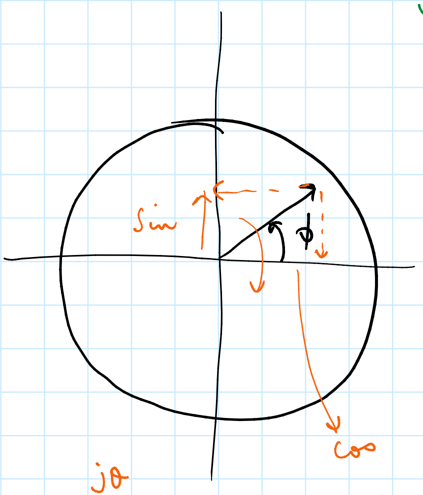
2) 

Slightly better way to simulate

Waves travelling in forward & reverse direction

Forward Travelling wave (Left to right)

$$\underbrace{V^+ e^{-\alpha x}}_{\text{Amplitude}} \; \underbrace{e^{j(\omega t - \beta x)}}_{\text{Phase.}}$$



$e^{j\theta} = \cos\theta + j\sin\theta$

$$\boxed{\phi = \omega t - \beta x}$$

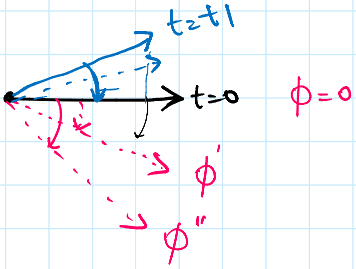
$t=0$

$\phi = \omega \cdot 0 - \beta x$

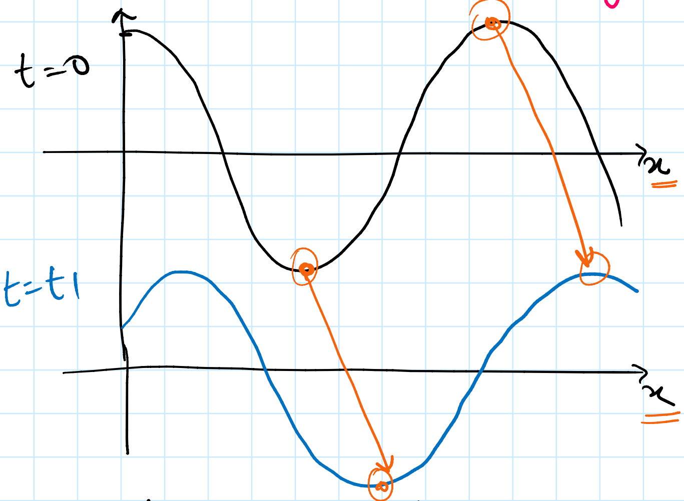
$\boxed{x \uparrow \; \phi \downarrow}$

$t=t_1$

$\phi = \omega \cdot t_1 - \beta x$



Counter clockwise → Phase reducing

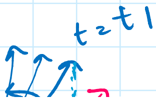


Wave travelling in the reverse direction (Right to left)

$$\underbrace{V^- e^{+\alpha x}}_{\text{Amp.}} \; \underbrace{e^{j(\omega t + \beta x)}}_{\text{Phase}} \leftarrow$$

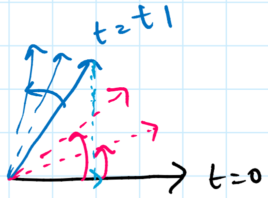
t=0

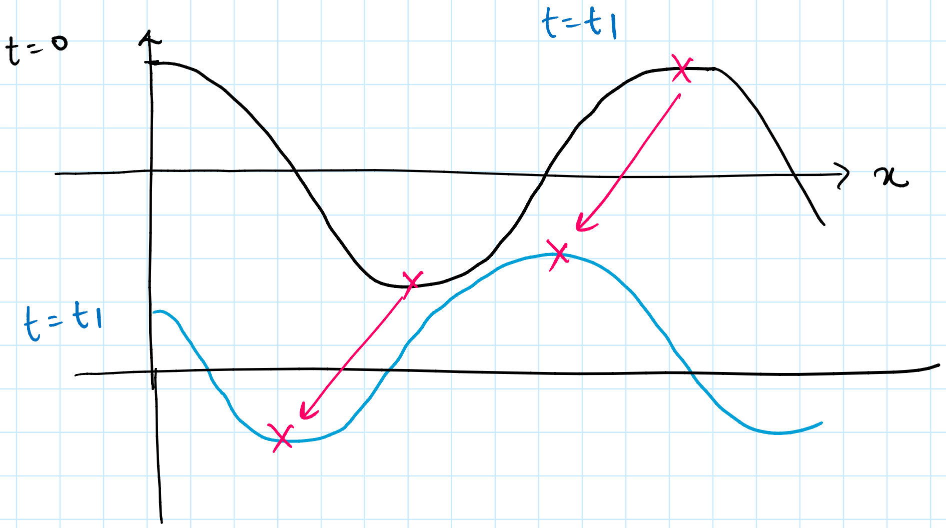
$x \uparrow \; \phi \uparrow$



Amp. Phase

t=0 $x\uparrow \ \phi\uparrow$





Propagation Constant : $\gamma = \sqrt{(R+j\omega L)(G+j\omega C)} = \alpha + j\beta$

Forward travelling waveform

$$: \underbrace{V^+ e^{-\alpha x}}_{\text{magnitude}} \underbrace{e^{-j\beta x}}_{\text{Phase component}}$$

↓ Space phase component

Space phase : $-\beta x$

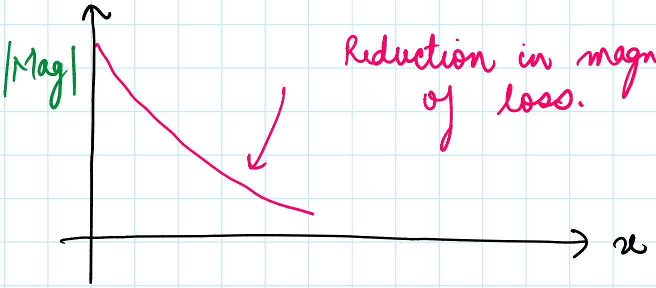
↓ Phase change per unit length. (rad/m)

Phase change in covering a distance 'λ' = 2π

$$\boxed{\beta = \frac{2\pi}{\lambda}}$$

Magnitude of the forward travelling wave.

$$\text{Mag.} = V^+ e^{-\alpha x}$$



Reduction in magnitude is because of loss.

$$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$$

Loss Less Transmission Line

$R=0 \quad G=0 \qquad \gamma = \sqrt{(-1)\,\omega^2 LC} \rightarrow j\omega\sqrt{LC}$

α = Attenuation Constant : Nepers/m

Relationship between dBs & Nepers

$x = 0$	$x = 1\text{m}$
$\lvert V^+ \rvert$	$V^+ e^{-\alpha x}$

Power loss in a waveform after travelling a distance : x

$$\text{Power loss (dB)} = -10\log\left(\frac{(V^+ e^{-\alpha x})^2}{(V^+)^2}\right)$$

$$= -20\log\left(e^{-\alpha x}\right)$$

$x = 1\text{m}$

$$= -20\log\left(e^{-\alpha}\right)$$

$-8.68\,dB = \alpha = 1\ \text{neper}/m$ ↓

$$\boxed{\alpha = 1\,\text{neper}/m = 8.68\,dB \text{ of power loss}}$$

Example:

$R = 0.5\,\Omega/m$
$L = 0.2\,\mu H/m$
$C = 100\,pF/m$
$G = 0.1\,\mho/m$

Calculate γ, α, β

Frequency $= 1\,GHz$.

$\gamma = \sqrt{(R+j\omega L)(G+j\omega C)}$

$$\gamma = \sqrt{(0.5 + j\omega\, 0.2\times10^{-6})(0.1 + j\omega\times100\times10^{-12})} \leftarrow$$

$$(a+ib)^2 = a^2 - b^2 + i\,2ab$$

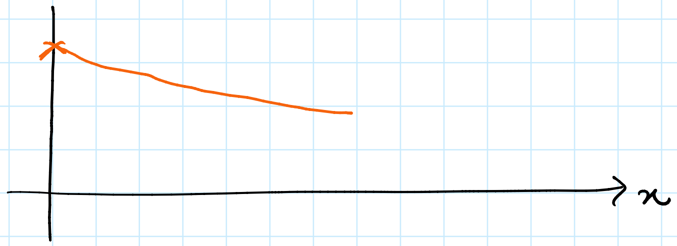
$$\underbrace{a+ib}_{} = \sqrt{\underbrace{a^2-b^2}_{} + i\,\underbrace{2ab}_{}}$$

$$\gamma = 2.23 + j\,28.2$$

$$\alpha = 2.23\ \text{nepers}/m$$

$$\beta = 28.2\ \text{rad}/m.$$

Example:



$t=0$
$x=0$

Amplitude is given
8.66 V

- We want to know the amplitude of the wave at a different time & at a different distance

$t = 100\,ns$
$x = 1\,m$

Step 1:

$x = 1m$

Step 1:

→ Calculate V^+

$$v(t) = \mathrm{Re}\left\{ V^+ e^{-\alpha x} e^{-j\beta x} e^{j\omega t} \right\}$$