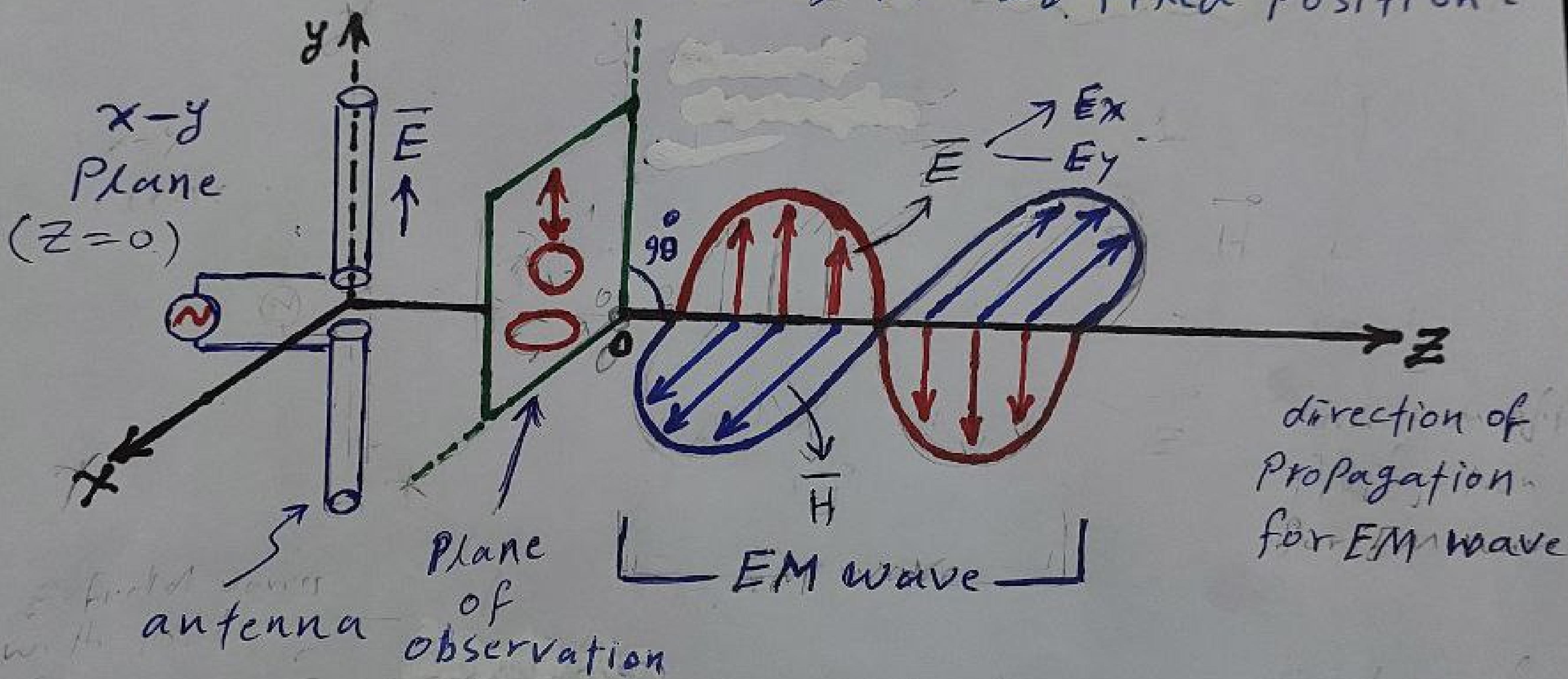
Polarization:

is the orientation of electric field component ($\bar{E}$) of an electromagnetic wave relative to the surface of earth, or

is trace (locus) of tip (↑) of Electric field vector ($\bar{E}$), as a function of time at fixed position.



(i.e wave is Propagated)

$$E(z,t) = E_o \sin(wt - Kz)\,\bar{x} + E_o \sin(wt - KZ + \delta)\,\bar{y}$$

E-field varies with Position & time

direction of E-field (unit vector)

Where, K : propagation constant $= w\sqrt{\mu \epsilon}$

notes

- Polarization is important to get the maximum Performance from the antenna.
- The Polarization of an electromagnetic wave radiated by the antenna is the Polarization of an antenna.
- In reality, the Polarization of an antenna varies with direction from the center of the antenna so, differen Parts of the antenna Pattern are going to have different Polarizations (as mentioned before in stage-4 in antenna impedance). therefore,
- when refering to antenna Polarization, it is mean just the Polarization in the direction at maximum gain of antenna.
- Polarization can changes as the signal travels away from the source due to the magnetic field of earth or due to reflection.
- There are three types of Polarization depending on the mannar of E-fied orientation:

① Linear Polarization
② Circular Polarization
③ Elliptical Polarization

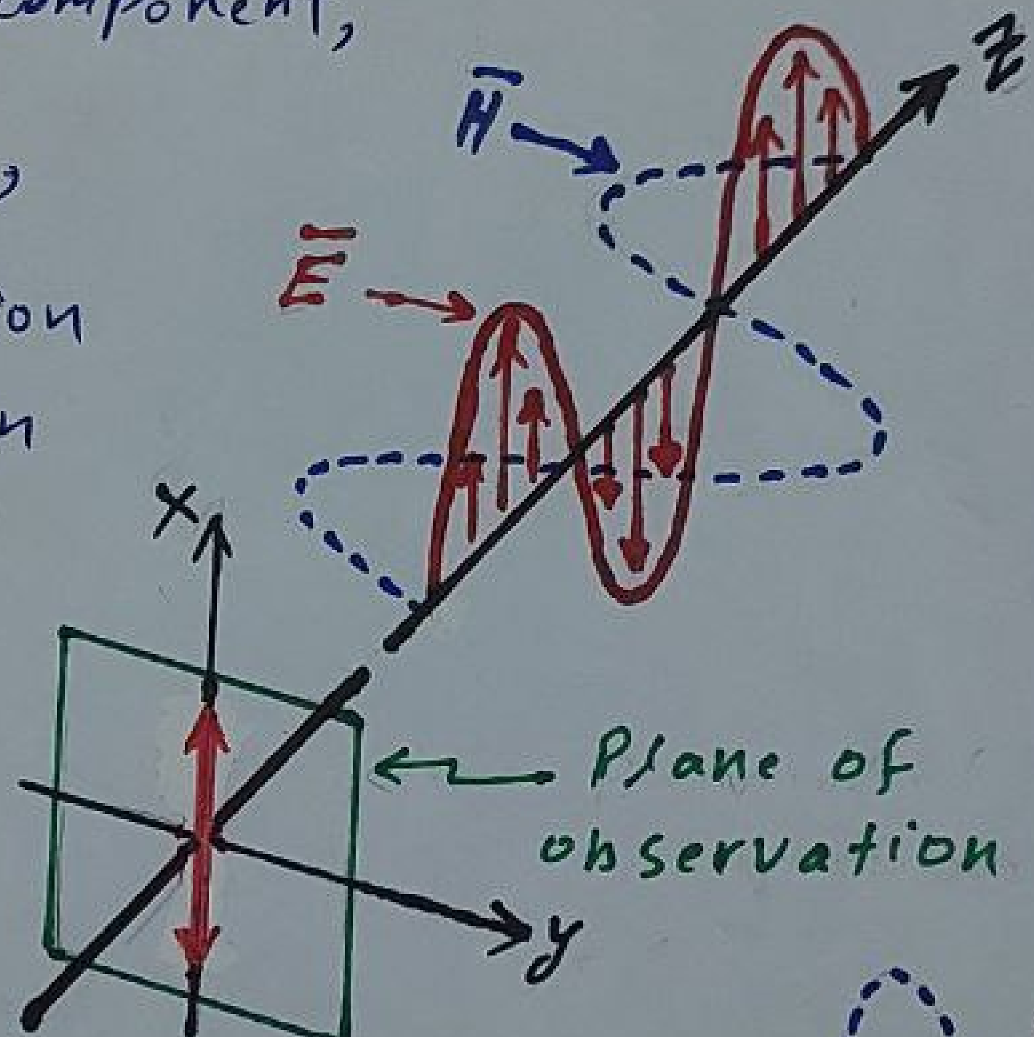
① Linear Polarization:

The Polarization in which, on the observation Plane, seen that, the electric field vector ($\bar{E}$) is always orient. along the same straight line as a function of time.

- The wave has only E_x component,

$$E(z,t) = E_x \sin(wt - kz)\,\bar{x},$$

then, the linear polarization called Vertical Polarization as seen in ⓐ

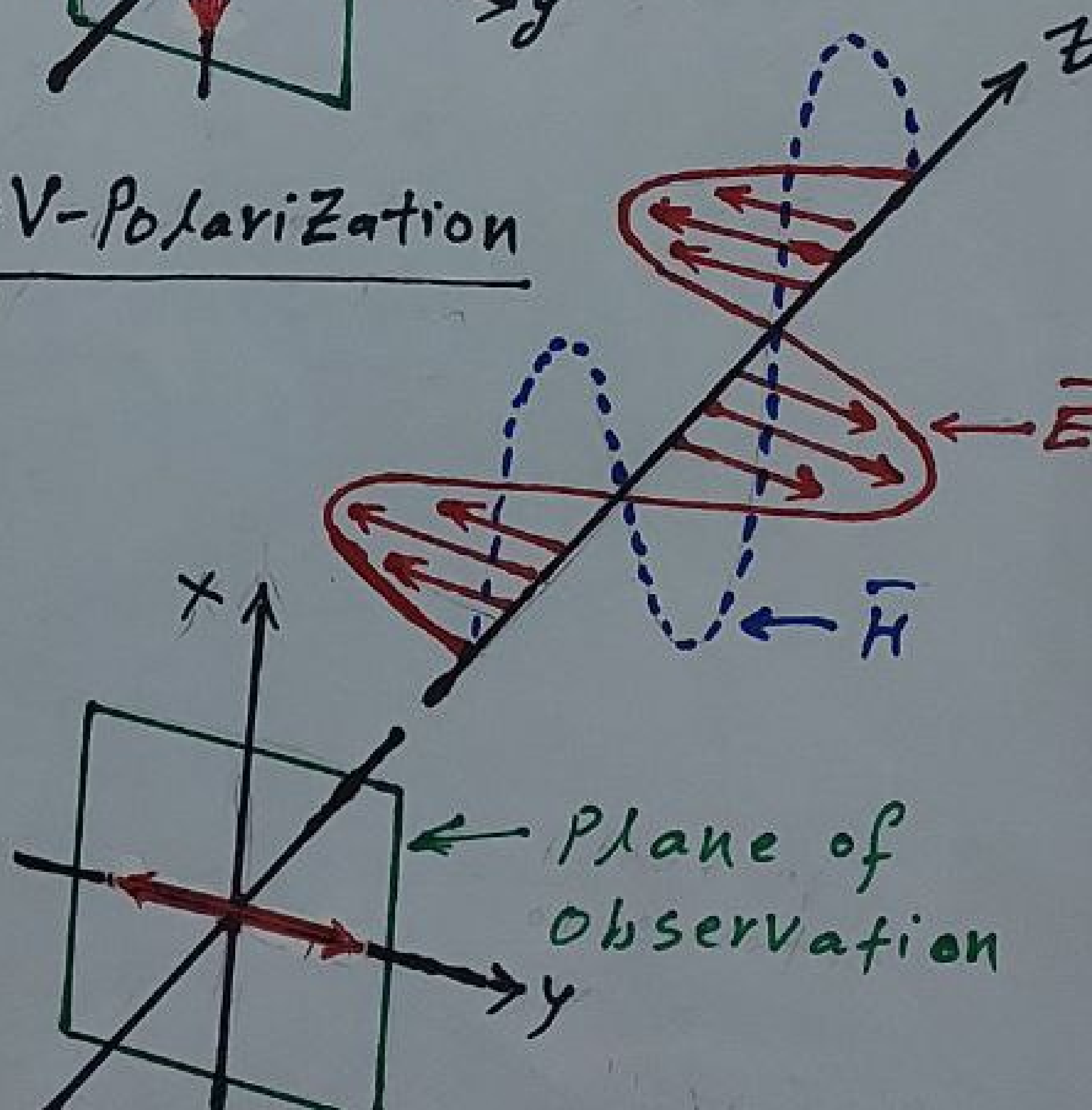


ⓐ V-Polarization

- The wave has only E_y component,

$$E(z,t) = E_y \sin(wt - kz)\,\bar{y},$$

then, the linear Polarization called Horizontal Polarization as seen in ⓑ



ⓑ H-Polarization

- The wave has both components (E_x & E_y),

$$E(z,t) = E_x \sin(wt - kz)\,\bar{x} + E_y \sin(wt - kz + \delta)\,\bar{y}$$

which it not common & called angular linear polarization where ($E_1 \neq E_2$) & δ is 45°

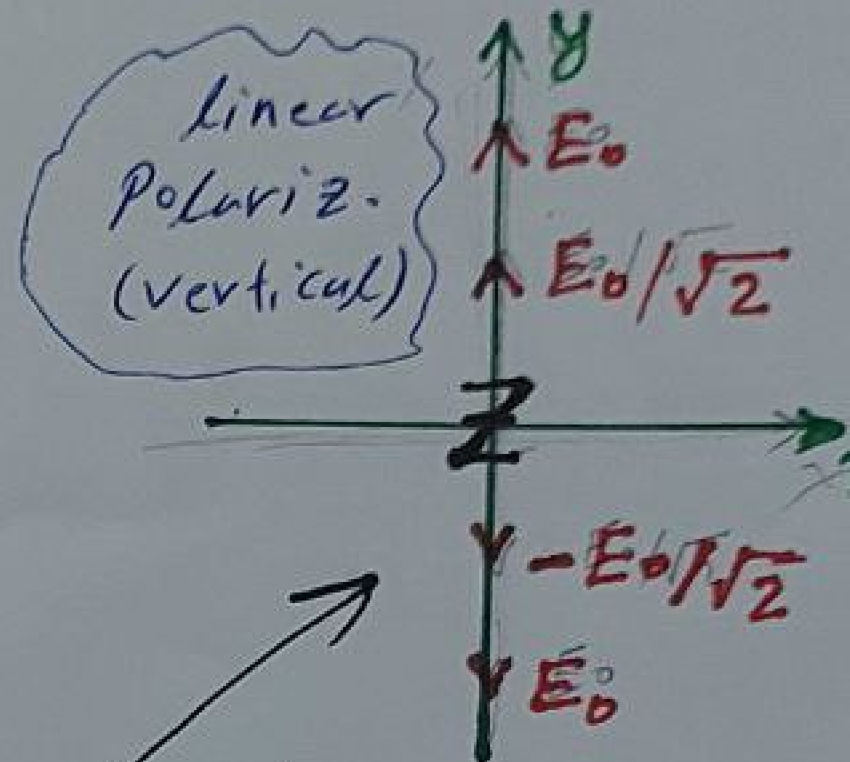
ex-1

Let $E(Z,t) = E_0 \cos(wt - KZ)\bar{y}$. compute with draw, the wave polarization at fixed space $(Z=0)$

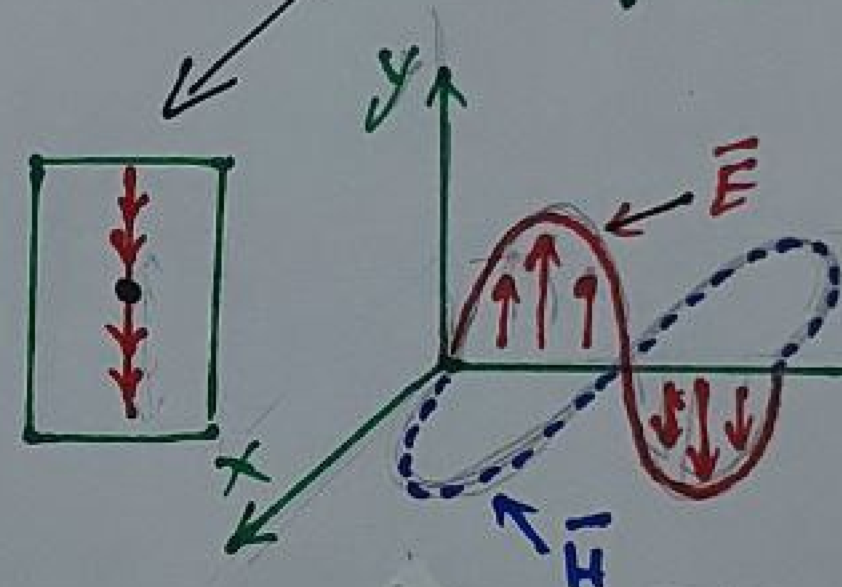
solution: $\because Z = 0 \Rightarrow$

$$E(Z,t) = E_0 \cos(wt - KZ)\bar{y} \Rightarrow$$

$$E(0,t) = E_0 \cos(wt)\bar{y}$$



wt	E(0,t)
0°	$E_0\,\bar{y}$
45°	$E_0/\sqrt{2}\;\bar{y}$
90°	0
135°	$-E_0/\sqrt{2}\;\bar{y}$
180°	$-E_0\,\bar{y}$

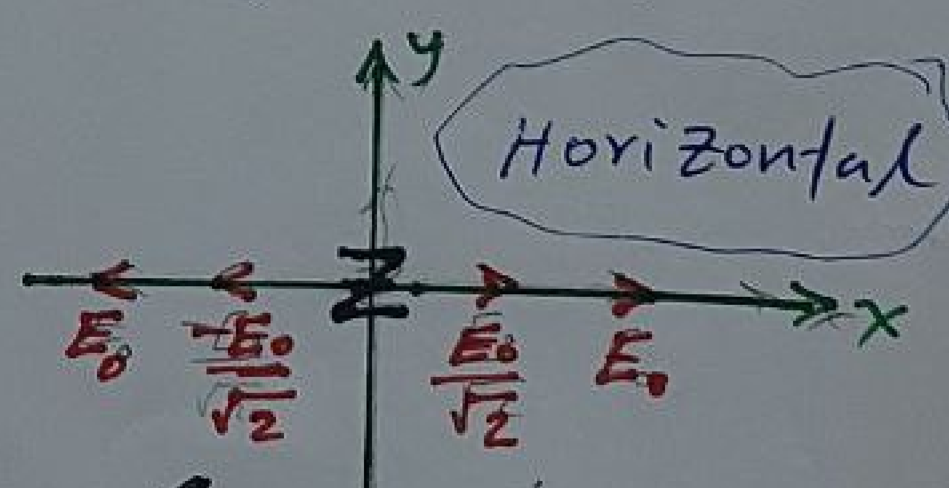


ex-2: let $E(Z,t) = E_0 \cos(wt - KZ)\bar{x}$. Compute with draw, the wave polarization at $(Z=0)$ fixed space.

solution $\because Z = 0 \Rightarrow$

$$E(Z,t) = E_0 \cos(wt - KZ)\bar{x} \Rightarrow$$

$$E(0,t) = E_0 \cos(wt)\bar{x}$$



wt	E(0,t)
0°	$E_0\,\bar{x}$
45°	$E_0/\sqrt{2}\;\bar{x}$
90°	0
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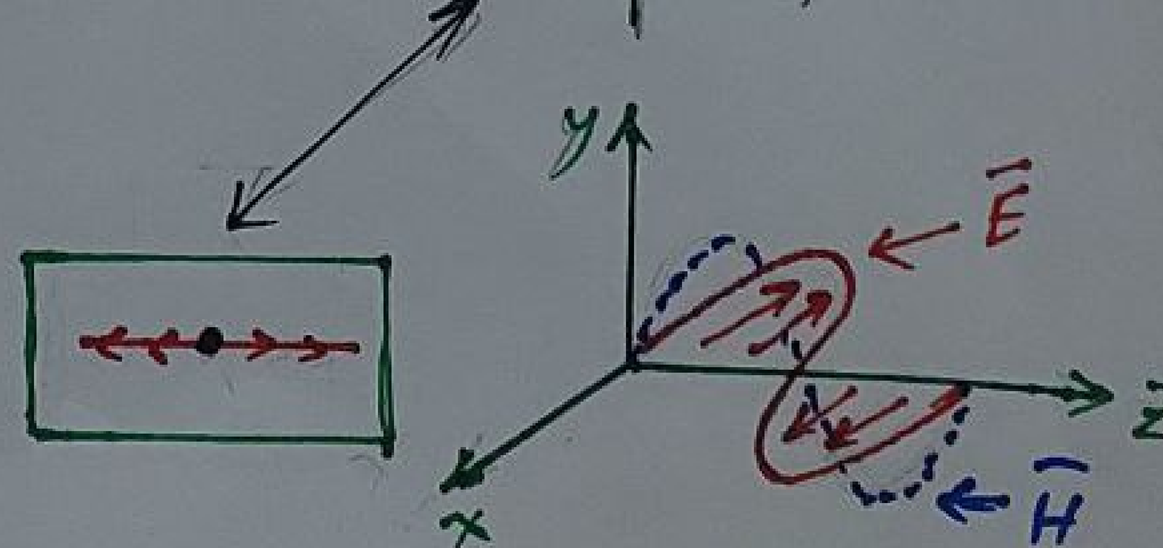


- Because of linear polarization has single component of electric field, then, axial ratio $= AR = \frac{E_2}{E_1} = \frac{E_2}{0} = \infty$, where $1 \leq AR \leq \infty$
- Linear polarization seen in arial, dipole & yagi antennas.

(2) Circular Polarization :

is the polarization in which, on the observation plane, the tip (↑) of electric field vector $(\bar{E})$ traces a circle as a function of time on a plane normal to the direction of wave propagation.

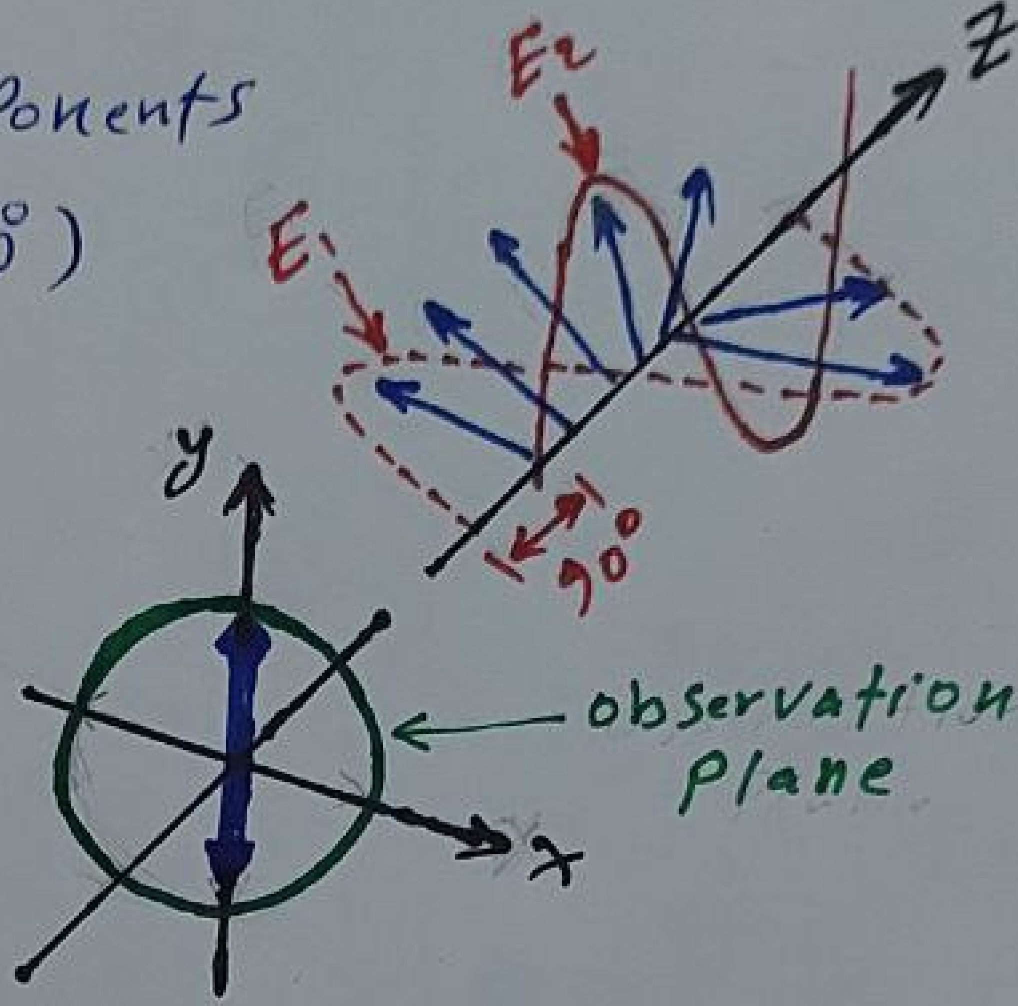
- It is comes from elliptical polarization (so, it is a spesific form of elliptical polarization)
- It is seen in helical antenna.
- The electric field must consists of two perpendicular components,

$$\bar{E}(z,t) = E_0 \sin(wt - kz)\bar{x} + E_0 \sin(wt - kz \mp \frac{\pi}{2})\bar{y}$$

that are,

1- these two components are equals in magnitude $(E_1 = E_2 = E_0)$, so Axial ratio $= AR = E_2/E_1 = 1$

2- ∓ 90° out of phase between these two components of E-field (i-e, $\delta = \mp 90°$)



3- If $\delta = +90°$, then this polarization called Right circular polarization or left hand circular polarization.

5- If $\delta = -90°$, then this polarization called Left circular polarization or right hand circular polarization.