

Homework # 9

① Question 4-22 on page 221 of your textbook. Do parts (a) and (c) only.

② A 300 MHz plane wave is given in phasor domain ($e^{j\omega t}$ time convention) as

$$\vec{E}(\vec{r}) = [\hat{a}_x (2 + j2\sqrt{3}) + \hat{a}_z 4 e^{j5\pi/6}] e^{-jk_y y}$$

Assume free-space propagation and k is the wave number

- At $t = 0, 10^{-9}, 2 \times 10^{-9}, 3 \times 10^{-9}$ seconds, plot the x-component of the field w.r. to y from 0 to 2 meters.
- Repeat part (a) for the z-component. What happens as the time goes on?
- Assume that you are supplied only with the plots at $t = 0$ and $t = 10^{-9}$ seconds. How do you find the speed of the wave?
- At $y = 0$, plot both the x and z components of the field w.r. to time. Make a guess about the polarization by using these plots. Explain.
- Find the polarization by using the given field expression.
- Assume that we desire to change the travelling direction to $-y$. Write the new expression for the electric field, if the polarization will remain the same.

③ A transmitting antenna A has radiated electric field given by

$$\vec{E}(\vec{r}) = [\hat{a}_\theta \sin(\theta) \cos(\phi) - \hat{a}_\phi \sin(\phi) \cos(\theta)] f(r, \theta, \phi) \text{ where } f \text{ is a scalar.}$$

- Determine the direction of the linearly polarized receiving antenna, which minimizes the polarization loss on the y-z plane.
- Repeat part (a) for the x-y plane.
- Plot the polarization loss factors (PLF) on the x-z plane w.r. to θ for your receiving antennas in parts (a) and (b), when antenna A is used as a transmitter.
- A circularly polarized plane-wave travelling in the $-x$ direction is received by the antenna A. Calculate PLF (in dB) on the x-axis, if the polarization is clockwise. Do the same if the polarization is counterclockwise. What happens if the plane wave is traveling in the $-y$ direction?

④ An antenna is known to have the radiation intensity

$$U(\theta, \phi) = \begin{cases} U_0 \cos^3(\theta) & 0^\circ \leq \theta \leq \theta_0, \quad 0^\circ \leq \phi \leq 2\pi \\ 0 & \text{otherwise} \end{cases}$$

(a) Maximum effective aperture of the antenna is given as 0.25 m^2 at 600 MHz .

Find θ_0

(b) What happens to effective aperture (find it) if the beam is adjusted as $\theta_0 = 3^\circ$.