ASSIGNMENT 5
(due Thursday November 3, 2022)

1. (20 points) An antenna has a conical <u>field pattern</u> $\bar{E}(\theta,\varphi)$, which is independent of φ but depends on θ in the following manner:

$$\bar{E}(\theta)=\begin{cases}1, & 0^\circ<\theta<30^\circ \\ 0, & 30^\circ<\theta<75^\circ \\ 0.2, & 75^\circ<\theta<105^\circ \\ 0, & 105^\circ<\theta<180^\circ\end{cases}$$

a) Draw the linear (not in dB) <u>power pattern</u> in the elevation plane $\bar{U}(\theta)$. (A sketch by hand is acceptable.)
b) Find the radiated power Π assuming that the maximum field magnitude is M.
c) Find the maximum directivity D_0.
d) Find the beam efficiency of the main beam.

2. (30 points) A small dipole is made of aluminum pipe (σ=3.5×10^7 S/m). Its length is $L=\lambda/8$ and the radius of the aluminum pipe is $b=3\times10^{-4}\lambda$. The operating frequency is $f=30$ MHz.

(a) Calculate the (high-frequency) loss resistance R_l assuming a linear (triangular) distribution of the current magnitude along the dipole. Use the methodology outlined in the Example on pages 24 to 26 in Lecture 4.

(b) Simulate this same dipole in *FEKO* to obtain the input antenna resistance R_A ($R_A = R_r + R_l$). Obtain also the antenna radiation efficiency *e*. From the efficiency and R_A obtain the antenna loss resistance R_l. **Note**: You do not need to actually simulate a pipe in FEKO; you can still use a thick wire model because the skin effect limits the current flow to a very thin surface layer on the outside of the pipe.

(c) How does the loss resistance obtained from the simulation in part (b) compare to your analytical calculation in part (a)? Give an error estimate (relative error) assuming that the *FEKO* result is the true reference value.

3. (20 points) A uniform plane wave is traveling in the $+z$ direction. Find: (1) the type of polarization (linear, circular or elliptical), (2) the sense of rotation (RH or LH), (3) the axial ratio (AR), (4) the tilt angle τ with respect to the *x*-axis in degrees, and (5) the polarization vector, when:

a) $E_x = 0.5E_y,\ \Delta\varphi=\varphi_y-\varphi_x=\frac{\pi}{2}$

b) $E_x = E_y,\ \Delta\varphi=\varphi_y-\varphi_x=-\frac{\pi}{2}$

c) $E_x = 0.5E_y,\ \Delta\varphi=\varphi_y-\varphi_x=0$

In each case, sketch the curves traced by the extremity of the **E** vector. Hand-drawn sketches are fine. Denote all axes and the sense of rotation on your sketches.

4. (30 points) For the top-hat antenna project from Assignment #3 or #4, determine the polarization of the antenna using the far-field post-processing features of *FEKO*.

- Plot the 3-D linear gain pattern for E_θ, for E_φ, and for the total field. [Note: Activate legends in your plot in order to observe units and scales.] Which field component dominates?
- Plot the axial ratio (AR) as a function of the angular position—comment on the values you see.

- Plot the 3-D linear gain pattern for the RH-CP and for the LH-CP components of the field. Are they different? How do you explain your observations for the RH and LH gain plots?
- Plot the handedness of the far field polarization in 3-D.
- Comment on the agreement of these polarization plots with the theoretical values expected from the very small top-hat antenna.