**ECE 3317**
**Fall 2023**

## Homework #11

1) Consider an open-circuited transmission line of length $h$. Use the formula for the input impedance to argue why a dipole wire antenna should have a capacitive input impedance if the half-length $h$ of the dipole antenna is less than one-quarter of a free-space wavelength, and why it should have an inductive input impedance if the half-length $h$ is more than one-quarter of a free-space wavelength. (Consider the dipole wire antenna to be an "unfolded" version of the open-circuited transmission line.)

2) A certain application requires that a field strength of 0.001 [V/m] be maintained at a distance of 2.0 km from an antenna located in free space, in the horizontal plane ($\theta = 90^o$). What power must be fed to the antenna if it is:

   (a) An isotropic antenna (a hypothetical antenna that radiates equally in all directions)
   (b) A resonant half-wavelength dipole wire antenna.

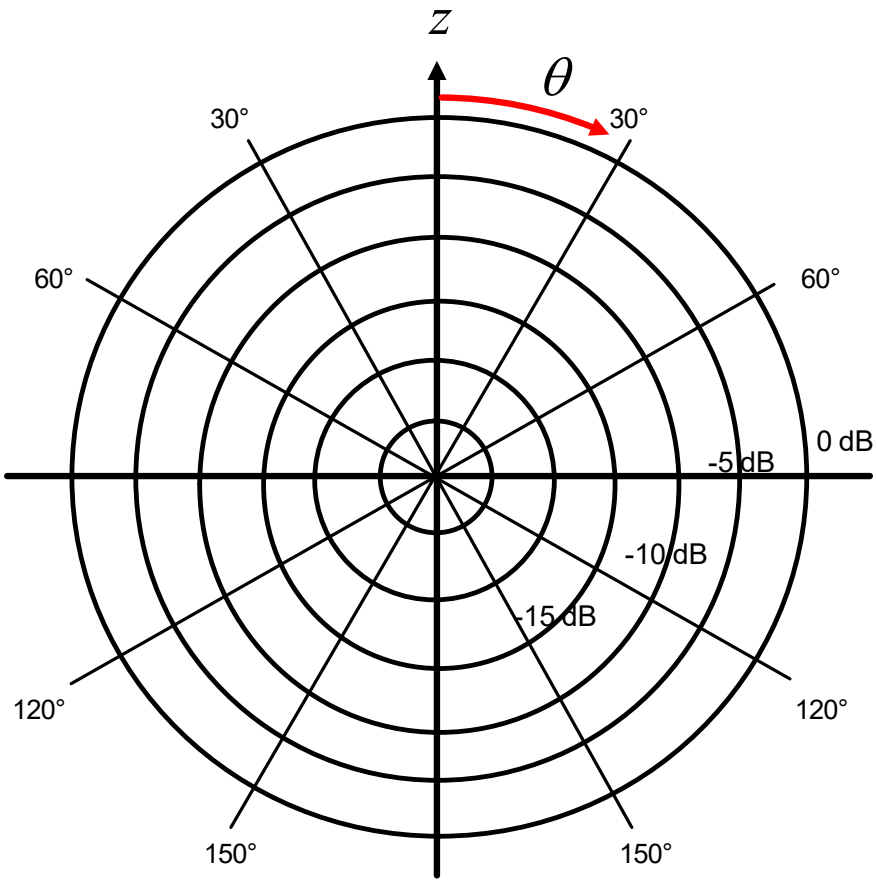
   Neglect losses (i.e., the radiation efficiency is 100%). Recall that the directivity of the resonant half-wavelength dipole antenna is 1.643.

3) A certain antenna has a far-field radiation pattern that is described by

$$\underline{E}^F(\theta,\phi) = \begin{cases} \underline{\hat{\theta}}\cos\theta\cos\phi + \underline{\hat{\phi}}\cos\theta\sin\phi, & 0 < \theta < \pi/2 \\ 0, & \pi/2 < \theta < \pi. \end{cases}$$

   The radiation pattern is zero for $\theta > \pi / 2$ because there is a ground plane present in the antenna design. Determine the directivity $D(\theta, \phi)$. Where is the beam maximum? What is the directivity at the beam maximum?

4) For the antenna in the previous problem, plot the normalized radiation pattern in dB, in the plane $\phi = 0$. Remember that the normalized pattern is zero dB at the beam maximum. Plot on the graph given below, which has a scale with 5 dB/division, with zero dB at the outer circle and -30 dB at the center.




5) Suppose we wish to communicate between two resonant dipole wire antennas at 100 [MHz]. The antennas are located 1.0 [km] apart. The receive antenna is connected to a conjugate-matched load of 73 [Ω]. Suppose we wish the load to pick up a voltage at the load that is at least 0.001 [V]. (This is the amplitude of the phasor received voltage across the load.) How much power must be input to the transmit antenna? Assume that the radiation efficiencies of both antennas are 100%.

6) Calculate the effective area of a resonant dipole antenna at a frequency of 100 [MHz]. Repeat if the frequency if the resonant dipole is 10 [GHz]. Next, calculate the effective area of a dish antenna that has a diameter of one meter, assuming that the dish has a fixed aperture efficiency of 75%. Does the effective area of the dish change with frequency?