Exercise 1 (8 points)

a) Define directivity, gain and radiation efficiency; explain the importance of these parameters.

b) Define the half-power beamwidth and the first-null beamwidth.

Exercise 2 (14 points)

The EM field radiated by a short dipole is given by the following formulas (in spherical coordinates):

$$\mathbf{E} = \frac{I\Delta z}{4\pi} j\omega\mu \left[1 + \frac{1}{j\beta r} - \frac{1}{(\beta r)^2}\right] \frac{e^{-j\beta r}}{r} \sin\theta\, \hat{\boldsymbol{\theta}} + \frac{I\Delta z}{2\pi}\sqrt{\frac{\mu}{\varepsilon}}\left[\frac{1}{r} - j\frac{1}{\beta r^2}\right]\frac{e^{-j\beta r}}{r}\cos\theta\, \hat{\mathbf{r}}$$

$$\mathbf{H} = \frac{I\Delta z}{4\pi} j\beta \left[1 + \frac{1}{j\beta r}\right] \frac{e^{-j\beta r}}{r} \sin\theta\, \hat{\boldsymbol{\phi}}$$

a) Explain the meaning of the far-field of an antenna; write the formulas for the far-field of the short dipole and justify the answer.

b) Plot the radiation pattern of the short dipole in the E-plane.

c) Calculate the total power radiated by the short dipole.

d) Define the following quantities used to characterize an antenna: input impedance, input resistance, radiation resistance.

e) Calculate the radiation resistance of the short dipole.

f) Calculate the directivity of the short dipole.

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Exercise 3 (12 points)

A uniform array is composed of 3 isotropic antennas. The signal frequency is 3 GHz, the distance between two antennas is 0.1 m and the phase delay from one antenna to the next is 2π.

a) Find the maximum directions and the null directions of the radiation pattern.

b) Plot the radiation pattern.

c) If each antenna of the array is replaced by a short dipole perpendicular to the direction of alignment of the array, how does the total radiation pattern change? Plot the new radiation pattern.