Problems 9-10 -- Using the Numerical Electromagnetic Code (NEC)

9. Using the NEC Code, calculate the gain, feed point impedance, and the radiation patterns of the following antennas:

    a. A vertical monopole antenna of height 0.20λ.

    b. An inverted L-antenna where the height of the antenna is 0.20λ and the length of the horizontal branch is 0.1λ.

    c. A T-antenna where the height of the antenna is 0.20λ and the lengths of the two horizontal branches are 0.1λ each.

    Compare the feed point impedances, the gains and the radiation patterns of the three antennas and draw conclusions about the merits/demerits of each of the antennas.

    Take frequency = 1.4 MHz.

10. Repeat Problem 9 with height of the vertical branch of each of the antennas increased to 0.25λ and the lengths of the horizontal arms increased to 0.25λ. Compare the antennas of Problem 10 to the corresponding antennas of Problem 9.

11. Calculate the power received P_r from the DBS(Direct Broadcasting Satellite) by a parabolic antenna of specifications given in the following:

    $$D = 1.9 \text{ feet}$$
    $$\text{Frequency} = 12.1 - 12.7 \text{ GHz (center frequency} = 12.4 \text{ GHz)}$$

    It is given that the DBS radiates a power of 100 W per channel and the effective area of the transmitting antenna is 5 m^2. The DBS is in a synchronous orbit at a distance of 23,500 miles from the receiving site. (1 mile = 1.609 km)

    Assuming that the effective resistance of the receiving antenna is 400 ohms, calculate the open-circuit voltage V_A developed across this antenna.

    $$\text{Hint: } V_{oc} = V_A = \sqrt{8R_A P_r}$$

12. A 10 GHz microwave communication link uses a parabolic transmitting antenna of diameter 3.0 feet. Calculate the power density at a receiving site a distance of 20 miles away for a transmitter power of 20 W.

What is the attenuation in decibels of the microwave link if an identical antenna is used for the receiver?

Assume aperture efficiency of both the transmitting and receiving antennas to be 0.65. Thus **Gain** $= 0.65 \left(4\pi A_{physical} / \lambda^2\right) = 0.65\pi^2 \left(d^2/\lambda^2\right)$ where d is the diameter both for transmitting and receiving antennas.

13. A cellular telephone monopole antenna of equivalent impedance $Z_A = 20 - j100$ ohms is to be matched to a transmission line of characteristic impedance $Z_O = 50$ ohms at the midband transmission frequency of 1900 MHz. Design an inverted-L two reactance network for this purpose. Use minimum possible reactances for your designed circuit and calculate the values of inductances or capacitances that are needed.

14. A cellular telephone monopole antenna of equivalent impedance $Z_A = 20 - j100$ ohms is to be matched for maximum power transfer from the power amplifier of source impedance $Z_S = 70 + j20$ ohms at the midband transmission frequency of 1900 MHz. Design a two reactance or a three reactance network for this purpose.

What open-circuit RF voltage would the power amplifier need to generate in order to provide a radiated power of 600 mW for the antenna?

15. For the matching circuit designed in Problem 14, calculate the power delivered to the antenna that may vary in impedance by $\pm 10\%$ i.e. to $Z_A = 18 - j90$ ohms or $Z_A = 22 - j110$ ohms. Note that the reactances used for matching do not change and are the same that are calculated for Problem 14.

16. Calculate the radiation patterns and directivities/gains of the following x-directed antenna arrays of 0.5λ dipoles for $\theta = 90°$, i. e., the x y plane

   a. $N = 10, d_x/\lambda = 0.4, \alpha = 0°$

   b. $N = 10, d_x/\lambda = 0.4, \alpha = -45°$

   c. $N = 10, d_x/\lambda = 0.4, \alpha = -90°$

   d. $N = 10, d_x/\lambda = 0.4, \alpha = -144°$

   e. $N = 10, d_x/\lambda = 0.4, \alpha = -162°$

   f. $N = 10, d_x/\lambda = 0.4, \alpha = -180°$

Assume the magnitudes of the currents in each of the antenna elements to be the same and the antenna arrays to be stretched **along the x-axis**.

Calculate the 3-dB beamwidth for each of the above antenna arrays. Neglecting mutual impedance effects, calculate the directivity for each of the antennas. Interpret your results and draw conclusions about the radiation patterns obtained for various phase angles.

17. Repeat Problem 16, parts a and d, for $\theta = 30°$ and $60°$ planes. Give the angles ϕ for which the fields are maximum for these two planes.

In decibels, how much lower is the maximum power density for $\theta = 30°$ and $60°$ planes as compared to $\theta = 90°$ for each of the two antenna arrays.