Antennas and Free-Space Propagation

Exercise 1: If the effective area of an antenna is 1 m^2, what is the path loss, in dB, at a distance of 100 m? At the distance to a geo-stationary satellite ($\approx 36,000$ km)? How does it increase (in dB) with distance?

Exercise 2: What is the directivity of an isotropic radiator?

Exercise 3: For some types of antennas, such as reflectors, the effective aperture can be approximated by the physical area of the antenna[1] . What are the approximate effective aperture and directivity of a 1-m diameter satellite dish antenna receiving signals at ≈ 15 GHz ("Ku-band")?

[1] However, for many antennas, such are wire antennas, the effective area is *not* related to the physical area.

Exercise 4: What is the maximum value of k?

Exercise 5: Another useful approximation relates the gain of an antenna to it's beamwidth. Since a sphere has a surface "solid angle" of 4π steradians (≈ 41253 square degrees), we can approximate the gain by dividing this by the solid angle covered by an ideal (rectangular, "brick-wall") antenna pattern. What is the approximate directivity of an antenna with beamwidths of 15×120 degrees? If the antenna's efficiency is $k = 70\%$, what is the gain?

Exercise 6: A point-to-point link uses a transmit power of 1 Watt, transmit and receive antennas with gains of 20dB and operates at 3 GHz. How much power is received by a receiver 300m away?

Exercise 7: What is the far-field distance for an antenna in a cell phone operating at 2.4 GHz that has a physical size of $0.1 \times 0.1 \times 3$ cm? For a 100 m parabolic reflector antenna operating at 2.2 GHz?

Exercise 8: If we kept the *effective aperture* (not gain) constant at one end of a link (transmitter or receiver), how would the path loss change as a function of frequency? What if we kept it constant at both ends? Is this a feasible approach for mobile systems?