# Mobile Communication Networks

## Exercices 3

1. Consider the expression “The antenna has a gain of 3 dBi”.
    a. Explain the information conveyed in the expression.
    b. If output power of the transmitter coupled to this antenna is 10W, what is the total output power (consider no losses), and output power density in the direction of the highest gain (give your answer in linear scale an in dB)?

2. Find the optimum wavelength and frequency for a half-wave dipole of length 10 m.

3. The audio power of the human voice is concentrated at about 300 Hz. Antennas of the appropriate size for this frequency are impracticably large, so that to send voice by radio the voice signal must be used to modulate a higher (carrier) frequency for which the natural antenna size is smaller.
    a. What is the length of an antenna one-half wavelength long for sending radio at 300 Hz?
    b. An alternative is to use a modulation scheme for transmitting the voice signal by modulating a carrier frequency, so that the bandwidth of the signal is a narrow band centered on the carrier frequency. Suppose we would like a half-wave antenna to have a length of 1 m. What carrier frequency would we use?

4. Suppose a transmitter produces 50 W of power.
    a. Express the transmit power in units of dBm and dBW.
    b. If the transmitter's power is applied to a unity gain antenna with a 900-MHz carrier frequency, what is the received power in dBm at a free space distance of 100 m?
    c. Repeat (b) for a distance of 10 km.
    d. Repeat (c) but assume a receiver antenna gain of 2.

5. Instead of assuming a free space environment of the previous exercise, assume an urban area cellular radio scenario. Use a path loss exponent of n = 3.1 and a transmitter power of 50 W.
    a. What is the range of path loss exponents for this environment?
    b. If the transmitter’s power is applied to a unity gain antenna with a 900-MHz carrier frequency, what is the received power in dBm at a free space distance of 100 m?
    c. Repeat (b) for a distance of 10 km.
    d. Repeat (c) but assume a receiver antenna gain of 2.

6. A “CS student” designed a wireless communication system for use in free space with transmission frequency f = 300 MHz, isotropic antennas, and transmission power $P_T$ = 1 W. However, he realized that the received power is still two times lower than the required threshold. Assuming that the distance remains the same, and the “CS student” can change only one system parameter, provide him all possible options and corresponding numerical values to guarantee successful data transmission.

7. A microwave transmitter has an output of 0.1 W at 2 GHz. Assume that this transmitter is used in a microwave communications system where the transmitting and receiving antennas are parabolas, each 1.2 m in diameter.
    a. What is the gain of each antenna in decibels?
    b. Taking into account antenna gain, what is the effective radiated power of the transmitted signal?
    c. If the receiving antenna is located 24 km from the transmitting antenna over a free space path, find the available signal power out of the receiving antenna in dBm units.

8. GPS satellites fly at an altitude of about 20.000 km on a path in the orbit and broadcast radio signals to earth. GPS receivers on earth receive these signals. If a receiver has line-of-sight paths to ≥4 satellites it can calculate its own location. Satellites transmit at 50 W at a frequency 1.575 GHz. Satellites are assumed to have an antenna gain of 5 dB; GPS devices are assumed to have isotropic antennas (gain of 0 dB).
    a. What is the wavelength of the transmitted signal?
    b. Give an estimate of the required receiver sensitivity Θ of a GPS device.
    c. What if the value of the overall path loss (only due to space propagation) in dB?
    d. If the distance between the GPS satellites and a GPS receiver is doubled, what will be the change in the required receiver sensitivity?

9. Use the path loss model to estimate the maximum cell radius of UMTS. A base station transmits with a maximum power of $P_T$ = 20 W. A mobile device requires –116 dBm for acceptable speech quality. The environment can be modeled with a path loss exponent α = 3.5. The antenna of the mobile device is assumed to be isotropic. The antenna of the base station has a gain of 2.5 dB in the direction toward the mobile device.

10. Suppose that a car is moving through a suburban environment that has a wireless channel with a coherence time of 10 ms and a coherence bandwidth of 600 kHz. The bit rate of the signal being used is 50 kbps. Characterize the channel.
    a. Is the channel slow or fast fading?
    b. Is the channel flat or frequency-selective fading?

11. Suppose a wireless channel has a coherence bandwidth of 100 kHz. What range of bit rates can be supported to have flat fading?