**ECE 732: Mobile Communication Systems**
**Prof. B.-P. Paris**
**Homework 2**
**Due: September 18, 2018**

**Reading:** Goldsmith chapters 2 and 3.

**Problems**

1. **Link Budget**
   A wireless communication system's transmitted signals are attenuated according to the following path loss model:

$$L_{P(dB)} = -50 + 10 \cdot \log_{10}(f_c) + 30 \cdot \log_{10}(d),$$

   where $d$ denotes the distance between transmitter and receiver in meters and the carrier frequency $f_c = 1$ GHz. Further, the system is characterized by

   - transmit and receive antenna gains $G_T = G_R = 0$ dB,
   - receiver implementation loss $L_R = 2$ dB,
   - noise figure $F = 2$ dB,
   - thermal noise PSD $kT_0 = -174$ dBm/Hz,
   - signal bandwidth and symbol rate $B = R_S = 1$ MHz,
   - required $\frac{E_S}{N_0} = 10$ dB.

   (a) Compute the receiver sensitivity.

   (b) Assuming the transmitter power equals 1 Watt, what is the transmission range $d$?

   (c) How much transmit power is required to communicate over a distance of 2 km.

   (d) For a given transmit power, by how much does the range increase if the symbol rate $R_S$ is reduced to 100 KHz?

   (e) Assume now that the path loss is subject to log-normal fading with standard deviation $\sigma = 4$ dB. Assume further that the system is characterized by the parameters tabulated above and that the transmit power equals $P_t = 30$ dBm.
   What is the probabability that $\frac{E_S}{N_0}$ is below 10 dB?

   (f) What provisions must be made to ensure that the probability that $\frac{E_S}{N_0}$ is below 10 dB is smaller than $10^{-3}$?

2. Modify the MATLAB function two_ray_loss.m to include a second reflector. For example, you may include a wall behind one of the antennas. Plot the resulting path loss; you may use plot_two_ray_loss.m as a starting point. Describe what you did and explain if the path loss makes sense.
3. Goldsmith: Problem 2.18
4. Goldsmith: Problem 2.23
5. Goldsmith: Problem 2.25