Assignment #2

Due: Sep. 27, Wed. 8:30, SMD 224 (beginning of the tutorial). Hard copy only, no email submissions. *Late entries will not be accepted!*

Before doing the assignment, please read appropriate sections of Chapter 4 of the course textbook (by Rappaport, 2nd edition).

1) Assuming that a mobile receiver is located 10 km from a 20 W transmitter, the carrier frequency is 900 MHz, free space propagation, $G_t = 1, G_r = 2$, find: (a) the power at the receiver; (b) the magnitude of the E-field at the receiver antenna; (c) the open-circuit rms voltage applied to the receiver input assuming that the receiver antenna has a purely real impedance of 50 Ω and is matched to the receiver; (d) find the received power at the mobile using the two-ray ground reflection model assuming the height of the transmitting antenna is 50 m, receiving antenna is 2 m above the ground, and the ground reflection is -1.

2) In this question, we compare the received power for the two-ray ground reflection model using the exact and approximate expressions. The exact expression does not use the far-field approximation and is based on equation (4.47) in the textbook to compute the received power, where E_0, d_0 are found from the free-space propagation model. The approximate expression is equation (4.52) in the textbook, which makes use of the far-field approximations. Assume the height of the transmitter is 40 m and the height of the receiver antenna is 3 m. The frequency is 1800 MHz, the transmit power is P_t = 43 dBm and unity gain antennas are used. Plot the received power for both exact and approximate expressions continuously over the range of distances from 1 km to 20 km assuming the ground reflection coefficient of -1. Redo this for the case where the ground reflection coefficient is 1 and comment on the difference, if any.

3) Referring to Figure P4.9, compute the first Fresnel zone distance d_f between transmitter and receiver (i.e. the distance at which the 1st Fresnel zone barely touches the ground plane) for the two-ray ground-reflection model, in terms of h_t, h_r and λ. This is the distance at which path loss begins to transition from d^2 to d^4 behavior, assuming Γ = -1.

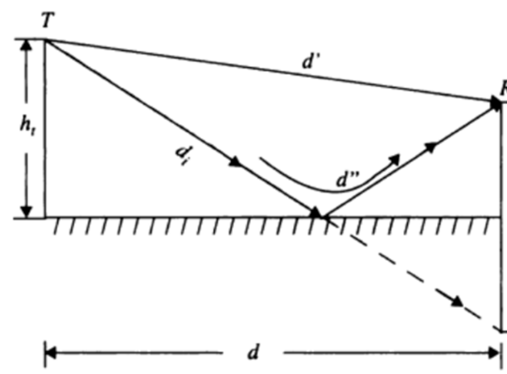

Figure P4.9 Illustration of two-ray ground reflection model.

T.S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall, 2002. (2nd Edition).

4) A general design rule for microwave links is 50% clearance of the first Fresnel zone. For a 1 km link at 2.5 GHz, what is the maximum first Fresnel zone radius? What clearance is required for this system?

5) If P_t = 10W, G_t = 10 dB, G_r = 3dB and L = 1 dB at 900 MHz, compute the received power for the knife-edge diffraction geometry shown in Figure P4.19. Compare this value with the theoretical free space received power if an obstruction did not exist. What is the extra path loss due to diffraction for this case? If the geometry and all other system parameters remain exactly the same, but the frequency is changed, redo the previous problem for the case of (a) f = 50 MHz and (b) f = 1900 MHz. Comment on the impact of frequency on the received power and explain it.

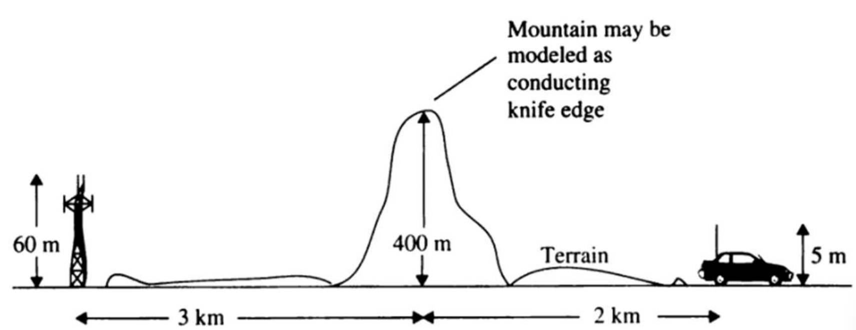

Figure P4.19 Knife-edge geometry for Problem 4.19.

T.S. Rappaport, Wireless Communications: Principles and Practice, Prentice Hall, 2002. (2nd Edition).

6) If the received power at a reference distance d_0 = 1 km is equal to 1 microwatt, find the received powers at distances of 2 km, 5 km, 10 km, and 20 km from the same transmitter for the following path loss model: (a) free space; (b) the path loss exponent model with $\nu = 3$ (path loss exponent); (c) the same as before with $\nu = 4$, (d) two-ray ground reflection model using the exact expression; and (e) Hata model for a large city environment. Assume f = 1800 MHz, h_t = 40 m, h_r = 3 m, $G_t = G_r$ = 0 dB. Plot each of these models on the same graph over the range of 1 km to 20 km. Comment on the differences between these five models. Now assume the received power at a reference distance d_0 = 1 km is equal to 1 microwatt, and f = 1800 MHz, h_t = 40 m, h_r = 3 m, $G_t = G_r$ = 0 dB. Compute, compare, and plot the exact two-ray ground reflection model of eq. (4.47) in the course textbook with the approximate expression given in eq. (4.52) for distances from 0.1 to 10 km (using log scale as in Lecture 2, p. 23) . At what T-R separations do the models agree and disagree?

Please read appropriate chapters of the textbook first, study all the examples, attempt to do them with the closed book.

Remember the learning efficiency pyramid!

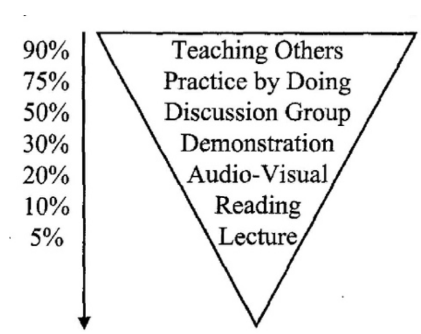

Figure 1. The Learning Pyramid, adapted from David Sousa, *How the Brain Learns*, Reston, VA, The National Association of Secondary School Principals, 1995, ISBN 0-88210-301-6.

Please include in your solutions all the intermediate results and their numerical values (if applicable). **Detailed solutions with explanations are required**, not just the final answers/equations; **all symbols used must be defined**, including units used (e.g. f = frequency [Hz], L = path loss [dB]). Missing explanations, symbol definitions/units will be penalized. Your answers should demonstrate the full extent of your knowledge and the latter will determine your marks.

Plagiarism (i.e. "cut-and-paste" from a student to a student, other forms of "borrowing" the material for the assignment) is absolutely unacceptable and will be penalized. Each student is expected to submit his own solutions. If two (or more) identical or almost identical sets of solutions are found, each student involved receives 0 (zero) for that particular assignment. If this happens twice, the students involved receive 0 (zero) for the entire assignment component of the course in the marking scheme and the case will be send to the Dean's office for further investigation.