EE 6340 Wireless Communications
HW 1
Due: 23/1/2021 by 12 pm.

1. Derive the approximate path loss for the two ray path loss model.

2. For the two-ray model, derive an approximate expression for the distance values below the critical distance dc at which signal nulls occur.

3. Consider the received signal for the 2 ray model, where $u(t) = exp(j2\pi f_s t)$, $G_1 = 2G_2 = 1$; d = 10 km, $h_t = 2h_r$ = 50 m. (a) Compute the delay spread. Assuming distance d is uncertain within 1%, what range does the delay spread lie in? (b) Compute the phase difference between the signal components in the following cases: i) f_s= 1/m where m is the mid point of the range identified above ii) f_s = 1/2m iii) fs = 1/100 m In which of the above cases does the approximation $u(t) \approx u(t - \tau)$ hold best (why)?

4. Consider the ten-ray model described in Section 2.4.2 of the text AG (read it).
   (a) What is the average power falloff with distance that you expect for the ten-ray model? Why?
   (b) If the transmitter and receiver are at the same height in the middle of a street of width 25 m. The transmitter-receiver separation is 510 m. The transmitter is very close to the street (i.e. the height is very low). Find the delay spread for this model.

5. Consider a cellular system operating at 910 MHz where propagation follows free space path loss with variations about this path from log-normal shadowing with $\sigma = 6$ dB. Suppose that for acceptable voice quality a signal-to-noise power ratio of 15 dB is required at the mobile. Assume the base station transmits at 1 W and its antenna has a 3 dB gain. There is no antenna gain at the mobile and the receiver noise in the bandwidth of interest is -40 dBm. Find the maximum cell size so that a mobile on the cell boundary will have acceptable voice quality 90% of the time.

6. Time varying channel impulse: Consider a two-ray channel consisting of a direct ray plus a ground-reflected ray, where the transmitter is a fixed base station at height h and the receiver is mounted on a truck (at height $h/4$). The truck starts next to the base station and moves away at velocity v. Assume that signal attenuation on each path follows a free-space path-loss model. Find the time-varying channel impulse at the receiver for transmitter-receiver separation $d = vt$ suficiently large for the length of the reflected ray to be approximated by $r + r'$ approx $d + h^2/2d$. Please assume the reflection coefficient $R = -1$ and antenna gains are unity.

7. Estimating path loss parameters (Problem 2-18): Table 1 lists a set of empirical path loss measurements. Assume d_0 = 1 m, and fc = 900 MHz.
   (a) Find the parameters of a simplified path-loss model plus log-normal shadowing that best fit this data.
   Hint: The simplified path-loss model has two parameters that must be estimated based on the provided data: K and γ. Additionally, you must estimate the shadow-fading variance: σ-dB .
   (b) Find the path loss at 2 km based on this model.
   (c) Find the outage probability at a distance d assuming the received power at d due to path loss alone is 10 dB above the required power for non-outage.

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Table 1: Empirical measurements

Distance from transmitter (m)	Pr/Pt (in dB)
5	-60
25	-80
65	-105
110	-115
400	-135
1000	- 150

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