EE536 Wireless Communications (Fall 25-26)
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Date: 04/01/2026 **Final Exam** Time: 3 Hours

Problem 1 (12 points).

a) For each of the autocorrelation functions given below, state whether the process might be wide-sense stationary (WSS) or cannot be WSS.

1) $R_X(t_1, t_2) = e^{t_1} e^{-t_2}$

2) $R_X(t_1, t_2) = e^{(t_1^2 - t_2^2)}$

b) A random variable X has a probability density function of the form

$$f_X(x) = e^{-2|x|} \qquad -\infty < x < \infty$$

A second random variable Y is related to X by $Y = X - 2$.

1) Find the probability that Y is positive.

2) Find the probability that $2Y$ is less than X.

Problem 2 (12 points).

Consider a cellular system operating at 900 MHz where propagation follows free space path loss with variations about this path from log-normal shadowing with σ = 4 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 -90 dBm.

(a) Define the outage probability and fade margin.

(b) Find the maximum cell size so that a mobile on the cell boundary will have acceptable voice quality 95% of the time. (Hint: $Q(-x) = 1-Q(x)$).

(c) Determine the required fade margin to have the same outage probability at the cell edge if σ = 8 dB.

Problem 3 (12 points)

(a) What makes the wireless channel frequency selective?

(b) Define the coherence time and explain how it affects the signal transmitted over the wireless channel.

(c) The BS of a GSM-900 system (200 kHz BW) has a height of 25 m and is 2.5 km away from the mobile user, who has a height of 2 m. The antenna gain of the BS and the mobile are 4 and 3 dBi, respectively. The transmit power is 1 dBW.

i. Calculate the received power with ground reflection.

ii. Compare the result with free-space path loss. (6 points)

Problem 4 (12 points).

a) Name a class of codes belongs to Orthogonal Space-Time Block Codes (OSTBC).

b) Illustrate in brief the advantages of using MIMO technique.

c) Relating to information transfer in communication links, explain in brief the capacity and entropy.

d) For the MIMO system, suppose CSI is known at both transmitter and receiver. If we are willing to decrease the rate at the transmitter, which technique is used at the transmitter to get much less value of BER?

e) Consider a MISO system with channel gain vector $h = [1+j \quad 3+4j]$ is known at the receiver, and there is a total transmit power of $P_t = 10$ mW across the two transmit antennas, AWGN with power $N_0 = 10^{-9}$ W/Hz at the receive antenna, and bandwidth BW = 100 KHz. Determine the SNR of each symbol at the receiver resulting from using Alamouti code method. (6 points)

Problem 5 (12 points).

Three users are transmitting 1 bit each simultaneously using CDMA technique.

User	Bit to transmit	Spreading Code (4 chips)	Bit Rate R_b (kbps)
1	1 (+1)	[1,-1,1,-1]	1 000
2	0 (-1)	[1,1,-1,-1]	1 000
3	1 (+1)	[1,-1,-1,1]	1 000

1- Spread each user's bit using its code.

2- Find the received CDMA signal.

3- Decode the bit for user 2 from the received signal.

4- Determine the chip rate and required BW of the system.

Good Luck