Georgia Institute of Technology
School of Electrical and Computer Engineering

ECE6604 Personal & Mobile Communications

Final Exam

Spring 2008

- Attempt all questions.
- All questions are of equal value.
- Open book, open notes, exam.

1) Consider the reverse link of a cellular system that uses a 7-cell reuse cluster with omnidirectional base station antennas. Ignore envelope fading and shadowing, and assume the simple path loss model

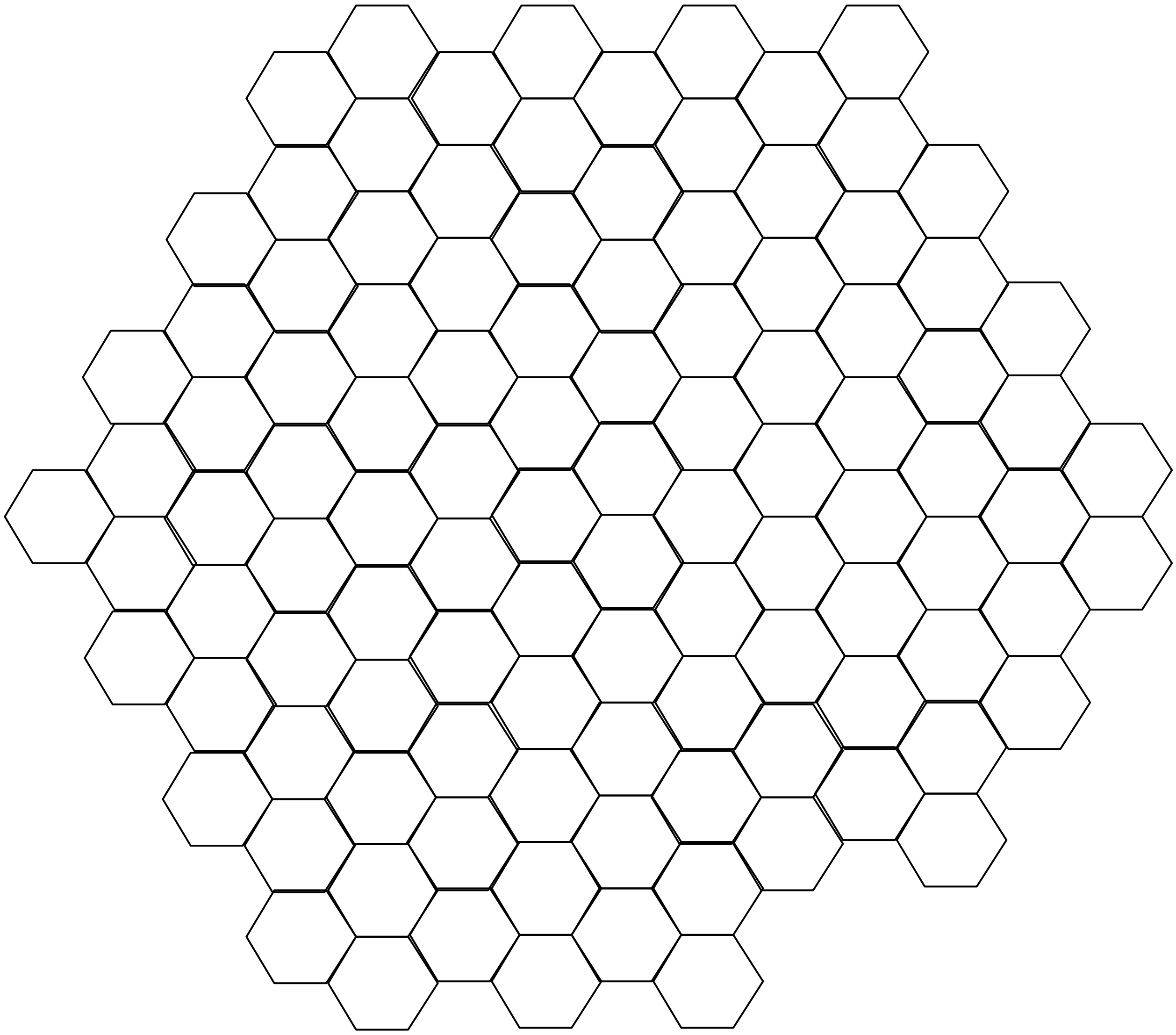
$$\mu_{\Omega_p \text{ (dBm)}}(d) = \mu_{\Omega_p \text{ (dBm)}}(d_o) - 10\beta \log_{10}(d/d_o) \quad \text{(dBm)} \ ,$$

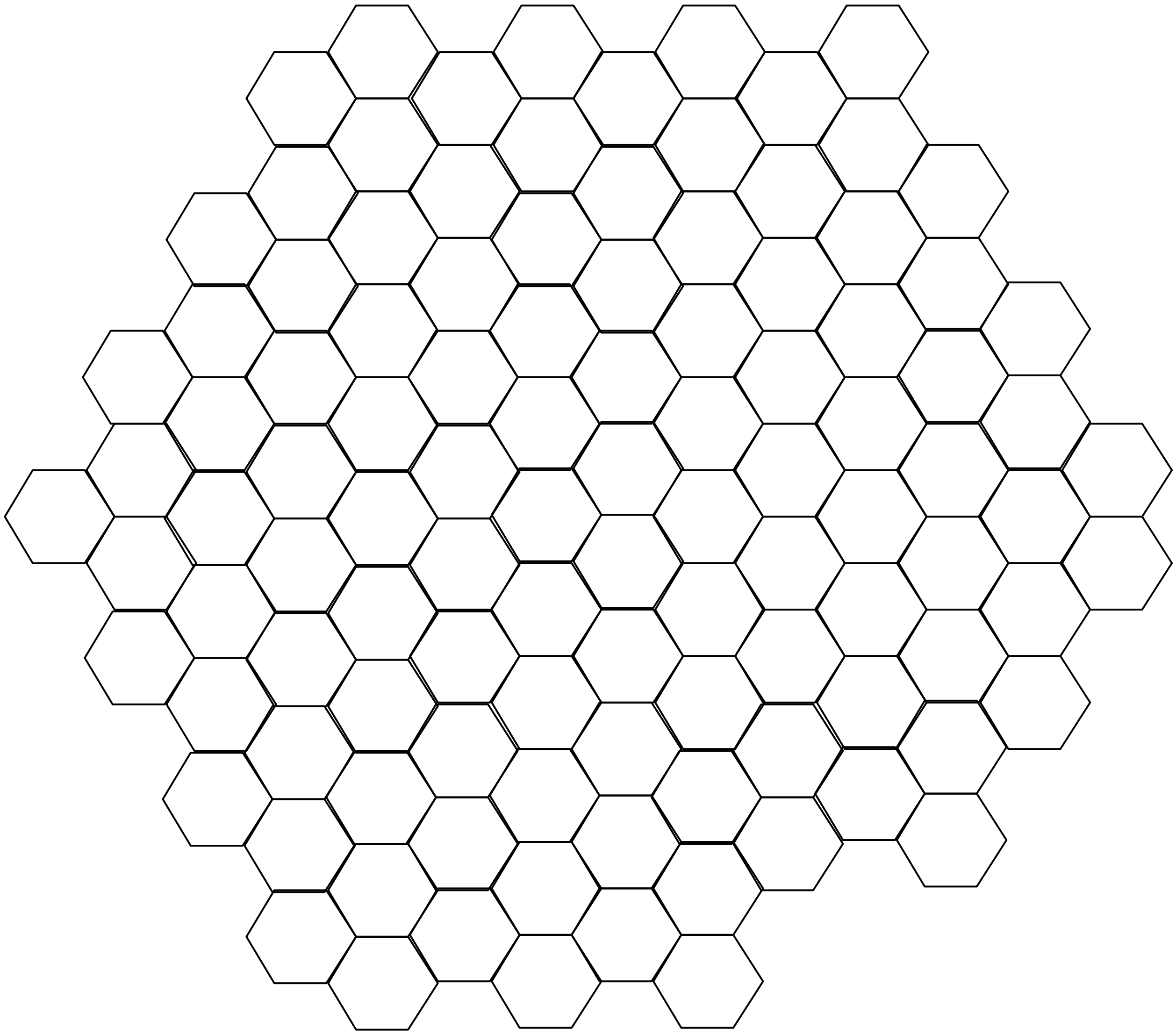
where $\beta = 3.5$. Also assume that all mobile stations are transmitting at the same power level.

a) 3 marks: Show graphically the worst case co-channel interference geometry for the reverse channel. *Use the hex grid on the next page.*

b) 4 marks: Calculate the worst case carrier-to-interference ratio, Λ in terms of the co-channel reuse factor D/R.

c) 3 marks: Repeat parts a) and b) if 120° cell sectoring is used.





2) Consider Jakes' fading simulator shown in Fig. 2.30 of the textbook.

a) 5 marks: With the choice that $\alpha = 0$ and $\beta_n = \pi n/(M+1)$ show that

$$\begin{aligned} < g_I(t) g_Q(t) > &= 0 \\ < g_Q^2(t) > &= M+1 \\ < g_I^2(t) > &= M \end{aligned}$$

b) 5 marks: Rederive the time averages in part a) for the choice $\alpha = 0$ and $\beta_n = \pi n/M$.

3) Consider a system that uses M-ary orthogonal modulation with non-coherent detection. The error probability on an AWGN channel is known to be

$$P_b = \frac{M}{2(M-1)} \sum_{k=1}^{M-1} \frac{(-1)^{k+1}\binom{M-1}{k}}{k+1} \exp\left\{-\frac{k\gamma_s}{(k+1)}\right\}$$

where $\gamma_s = \alpha^2 E_s/N_o$ is the received *symbol*-energy-to-noise ratio.

a) 6 marks: Derive the corresponding expression for the probability of bit error on a slow flat Rayleigh fading channel. Express your result in terms of the received *bit*-energy-to-noise ratio, $\gamma_b = \alpha^2 E_b/N_o$, and simplify to closed form.

b) 4 marks: Repeat part b) for a slow flat Rician fading channel. Simplify as much as possible.

4) An OFDM signal with a large number of sub-carriers N has a complex envelope that can be approximated as a zero-mean complex Gaussian random process. Assume an "ideal" OFDM signal spectrum, where the power spectrum is

$$S_{\tilde{s}\tilde{s}}(f) = \begin{cases} S_0 & |f| \leq 1/2T_s \\ 0 & \text{elsewhere} \end{cases}$$

where $T = NT_s$.

a) 4 marks: Using the above Gaussian approximation, what is the distribution of the magnitude of the complex envelope $\tilde{s}(t)$ at any time t.

b) 3 marks: Suppose that a power amplifier will clip the OFDM waveform if the complex envelope $\tilde{s}(t)$ will exceeds the level ΘR_{rms}, where R_{rms} is the rms envelope level $\sqrt{E[|\tilde{s}(t)|^2]}$. What is the probability that the OFDM waveform will be clipped at any time t?

b) 3 marks: How many times per second will the envelope be clipped?

5) Consider the length-7 m-sequences that are generated by the polynomials

$$\begin{aligned} p_1(x) &= 1 + x + x^3 \\ p_2(x) &= 1 + x^2 + x^3 \end{aligned}$$

a) 2 marks: Find and sketch the full period autocorrelation functions of the sequences.

b) 2 marks: Find and sketch the aperiodic autocorrelation function of the sequences.

c) 2 marks: Find and sketch the full period cross-correlation function of the two sequences.

d) 4 marks: Find the DTFT of the aperiodic autocorrelation function, $\Phi_{a,a}(f)$, for each sequence.