THE UNIVERSITY OF BRITISH COLUMBIA
DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
EECE 563 : Wireless Communication Systems
1999/2000 Winter Session Term 2

MID-TERM EXAMINATION
3:30 – 6:20 PM
March 3, 2000

This exam has thirteen (13) questions. The marks for each question are as indicated. There are a total of 50 marks. Answer all questions. Write your answers in the exam book provided. Show your work. You may answer the questions in any order. Books, notes and calculators are allowed. You may keep this exam paper.

Show your work.

Question 1 (4 marks)

Consider a cellular system with hexagonal cells. Assume only the first ring of interferers generates significant interference and that the path loss follows a power law with an exponent of 3.5.

(a) What is the minimum feasible cluster size that will give an SIR of 20 dB everywhere in the cell? (ignore fading)

(b) What is the frequency reuse factor?

Question 2 (7 marks)

An antenna pattern was measured. The following table shows the measured power density at 13 evenly-spaced points surrounding an antenna.

		1		
	2	2	2	
1	2	5	2	1
	2	2	2	
		1		

The measurement device is not calibrated but it displays a quantity that is proportional to $\mathrm{W/m^2}$.

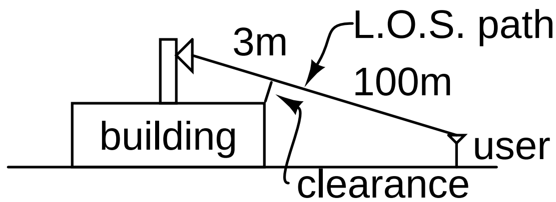
(a) compute the directivity of this antenna.

(b) compute the effective area (in m^2) at a frequency of 900 MHz.

(c) Assume the transmitter antenna gain (G_t) is equal to the directivity (D) computed above. What field strength (in volts/metre) will be created by this antenna at a distance of 1 km if the transmitter power is 100 W?

Question 3 (2 marks)

The following diagram shows an antenna mounted on a tower above a building. A line-of-sight path from the antenna to the nearest user passes near the edge of the building. The distance from the antenna to the edge is 3 metres and from the edge to the user is 100m as shown. The system operates at a frequency of 900 MHz.



By how much must the line-of-sight (LOS) path clear the edge of the building to ensure that diffraction effects are negligible?

Question 4 (4 marks)

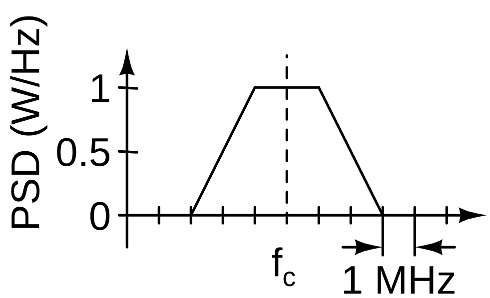
Compute the median path loss using Hata's path loss model for a distance of 1 km, a frequency of 900 MHz, transmitter and receiver effective antenna heights of 30 metres and 1 metre respectively, for a small city.

Question 5 (3 marks)

You are designing a trunked radio system which allows many users to share a fixed number of channels. Your have been able to acquire licenses for 25 channels. To make sure your customers will be satisfied, you want to ensure that at most one of every 20 calls will fail because all channels are in use. Each user makes an average of 3 calls/hour and each call lasts an average of 2 minutes. You may assume blocked calls are not delayed or retried. How may customers will your system be able to support?

Question 6 (5 marks)

A radio signal has the following power spectral density:



Compute the bandwidth of the signal using the following definitions:

(a) absolute bandwidth

(b) null-to-null bandwidth

(c) -3 dB bandwidth

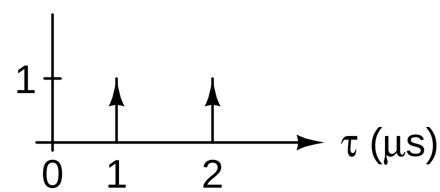
(d) 99% total power bandwidth

Question 7 (2 marks)

A cellular radio system with 30 kHz channels provides an SIR of 20 dB at the cell boundary. Assuming methods are employed to eliminate the effects of fading and that the interference can be treated as AWGN, what is the maximum bit rate that could be transmitted error-free over each channel?

Question 8 (3 marks)

The following figure shows the power delay profile of a radio channel.



(a) Compute the rms delay spread (in microseconds).

(b) Would this be considered a frequency-selective channel if the bandwidth of the signal was 4 MHz?

Question 9 (6 marks)

An FM broadcast receiver in a car is tuned to a radio station at a frequency of 100 MHz. The vehicle is traveling at a speed of 30 km/h in an urban area. You can assume there is no direct line of sight to the transmitter and the angle-of-arrival distribution is uniform. The mean (rms) signal level is -70 dBm. The FM receiver output has unacceptable quality (has a low SNR or "fades") when the signal level is below -85dBm.

(a) What fraction of the time is the signal level acceptable?

(b) How often does the signal "fade"?

(c) What is the mean duration of each such fade?

Question 10 (4 marks)

An analog FM transmitter has a peak frequency deviation of 10 kHz. The modulating signal extends from 0 to 4 kHz.

(a) What is the modulation index?

(b) What is the approximate bandwidth?

Question 11 (4 marks)

What is the error rate of DBPSK on an AWGN channel at an E_b/N_0 of 12 dB? What is the average BER for the same modulation in a Rayleigh fading channel with the same average E_b/N_0?

Question 12 (3 marks)

The base station for a wireless packet-based data communication system employs two receivers. Each receiver is connected to its own antenna. Each receiver independently demodulates the signal received on its antenna and outputs the received bit stream to a computer. This computer checks each packet's checksum and forwards to the data network the packet from the first receiver whose checksum is correct.

(a) What type of diversity mechanism is being used in this system (time, space, etc)?

(b) Which of the three combining methods discussed in the course (selection, maximal-ratio combining, switching) is most similar to the combining method used in this system? Explain briefly.

Question 13 (3 marks)

A k=1, n=3 block code is defined by the following table:

input	output		
0	1	0	1
1	0	1	0

(a) What is rate of this code?

(b) What is the minimum distance of this code?

(c) If the code word 1 1 0 is received, what would be the output of a maximum-likelihood decoder?