

**Bilkent University
Computer Engineering Department**

**CS 515
Mobile and Wireless Networking
Midterm Exam
Date: 29 November, 2002
Duration: 120 minutes**

Name of the Student	
ID of the Student	

GRADE

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1 – (30)	
2 – (10)	
3 – (5)	
4 – (11)	
5 – (9)	
6 – (10)	
7 – (10)	
8 – (10)	
9 – (5)	

Please try to write as clean as possible!

Good Luck!

Problem 1 (30 points)

Put a tick under T (True) or F (False) for each of the statements below. A correct answer will get +2 points, a wrong answer will get -1 points (.i.e two wrong answers will cancel a correct answer). Hence, there is a chance of getting a negative total grade if you mark without knowing the answers.

	Statement	T	F
a	Both TDMA and FDMA systems require digital modulation.		
b	Cellular phones usually use higher data-rate speech coding than cordless phones because they are more complex.		
c	GPRS and EDGE are examples of 2.5G networks and EDGE supports more data-rates than GPRS.		
d	Rayleigh fading is more likely to occur for low symbol-rate (narrowband) message signals compared to the high symbol-rate (wideband) message signals.		
e	Low-tier systems has usually lower user/system capacity in a region than high-tier systems.		
f	RMS delay spread value is usually smaller in micro-cell environments compared to macro-cells.		
g	Fast fading occurs when the coherence time of the RF channel is smaller than the symbol period of the message.		
h	If a receiver station is stationary, then no small-scale fading occurs.		
i	A periodic sinusoidal signal has larger spectral bandwidth than a periodic square wave signal.		
j	Frequency selective fading does not cause inter-symbol interference.		
k	Ricean fading occurs when there is one LOS component in a multipath channel.		
l	Amplitude modulation performs better in multipath environment than frequency modulation.		
m	QPSK is more bandwidth efficient then BPSK.		
h	Adding error control codes on digital messages reduces the power efficiency of a modulation technique, because messages gets larger and we need to consume more energy.		
o	CDPD is overlaid on AMPS US cellular telephone system.		

Problem 2 (10 point)

a) (4) If a mobile radio link operates with 30 dB SNR and uses 200 kHz RF channel for transmission, find the theoretic data-rate limit that can be transported over this channel

b) (3x2) A multi-path radio environment has an RMS delay spread (σ) value of 2 μ s.

1. Find the 50% coherence bandwidth for the channel

2. Can a GSM cellular system operate in this environment without needing an equalizer? (yes or no)

3. A signal that is to be transmitted over this channel has symbol-rate of 721 Kbps. Does signal experiences flat fading or frequency selective fading when transmitted over this multi-path channel.

Problem 3 (5 points)

You are driving on a straight and endless Central-Anatolian highway with your car. Ahead of you, at the horizon, a policeman stands and points his radar to you and measures your speed. The radar he is using is working on Doppler shift principle at 900Mhz. It detects a frequency shift of 450 Hz in the reflected signal from your car compared to the transmitted signal. What is the speed of your car measured by the radar? Express you answer in km/hour.

Problem 4 (15 points)

A macro-cell base station transmits at a power of 100 W at 1800 MHz. . A mobile receiver, that is traveling in a direction that makes 30 degrees angle with the direction of the received signals from the base station, measures the received signal strength as -53.9 dBm and reports this to the base station over a reverse channel. After 20 seconds later, the mobile again measures the received signal strength, this time as -41.4 dBm and reports it to the base station. Assume the 30 degrees angle nearly remains constant during the 20 seconds travel. Assume antenna gain of 1 for both receiver and transmitter antennas and assume free space propagation model ($n = 2$) between base station and mobile.

- a) (7) What is the speed of the mobile expressed in km/hour?
- b) (4) What is the Doppler shift experienced by the mobile?

Problem 6 (10 points)

In a street micro-cell environment, a base station transmits at a power level of 1W at 900 MHz. The reference distance d_0 is 100m. For a mobile receiver that is moving along the street, the path loss exponent (n) is 2 between 100m and to a break-point distance. After that break-point distance, the path loss exponent (n) is 4. The mobile receiver measures the received power as -58.6 dBm at a distance of 1000 meters from the base station. What is the break-point distance at which the path loss exponent changes from 2 to 4 (Assume free space propagation model between transmitter and reference distance; assume antenna gains are 1).

Problem 7 (10 points)

	IS-95	GSM	IS-136	PDC
Uplink Frequencies (MHz)	824-849 MHz	890-915 MHz	824-849 MHz	810-826 MHz
Downlink Frequencies	869-894 MHz	935-960 MHz	869-894 MHz	940-956 MHz
Duplexing	FDD	FDD	FDD	FDD
Multiple Access	CDMA	TDMA with FDMA	TDMA with FDMA	TDMA with FDMA
Modulation	BPSK	GMSK	$\pi/4$ DQPSK	$\pi/4$ DQPSK
Channel Bandwidth	1.25 MHz	200 KHz	30 KHz	25 KHz
Channel Data Rate	1.228 Mbps	270.833 Kbps	48.6 Kbps	42 Kbps
Voice circuits per channel	64	8	3	3
Speech Coding	CELP at 13Kbps	RPE-LTP at 13 Kbps	VSELP at 7.95 Kbps	VSELP at 6.7 Kbps
Frequency Reuse Factor	1	1/3	1/4	1/4

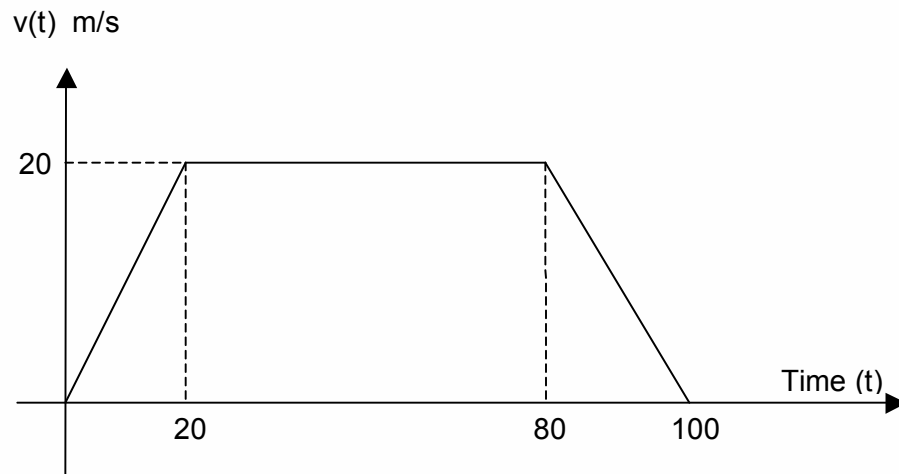
Using the table above, compute the parameters asked in a) and b) for the following systems (Assuming that a user uses exactly one voice channel –or- circuit):

- IS-95 (USA CDMA based digital cellular system),
- GSM (European digital cellular system),
- IS-136 (USA TDMA based digital cellular system)
- PDC (Japanese digital cellular system).

a) (4) The modulation bandwidth efficiency of each system.

- b) (6) System capacity of each system normalized to GSM system capacity. (Assume the range of a cell is same for all systems). (By normalized I mean: you will take the system capacity of GSM as 1 and express the system capacity of other systems with respect to this).

Problem 8 (10 points)

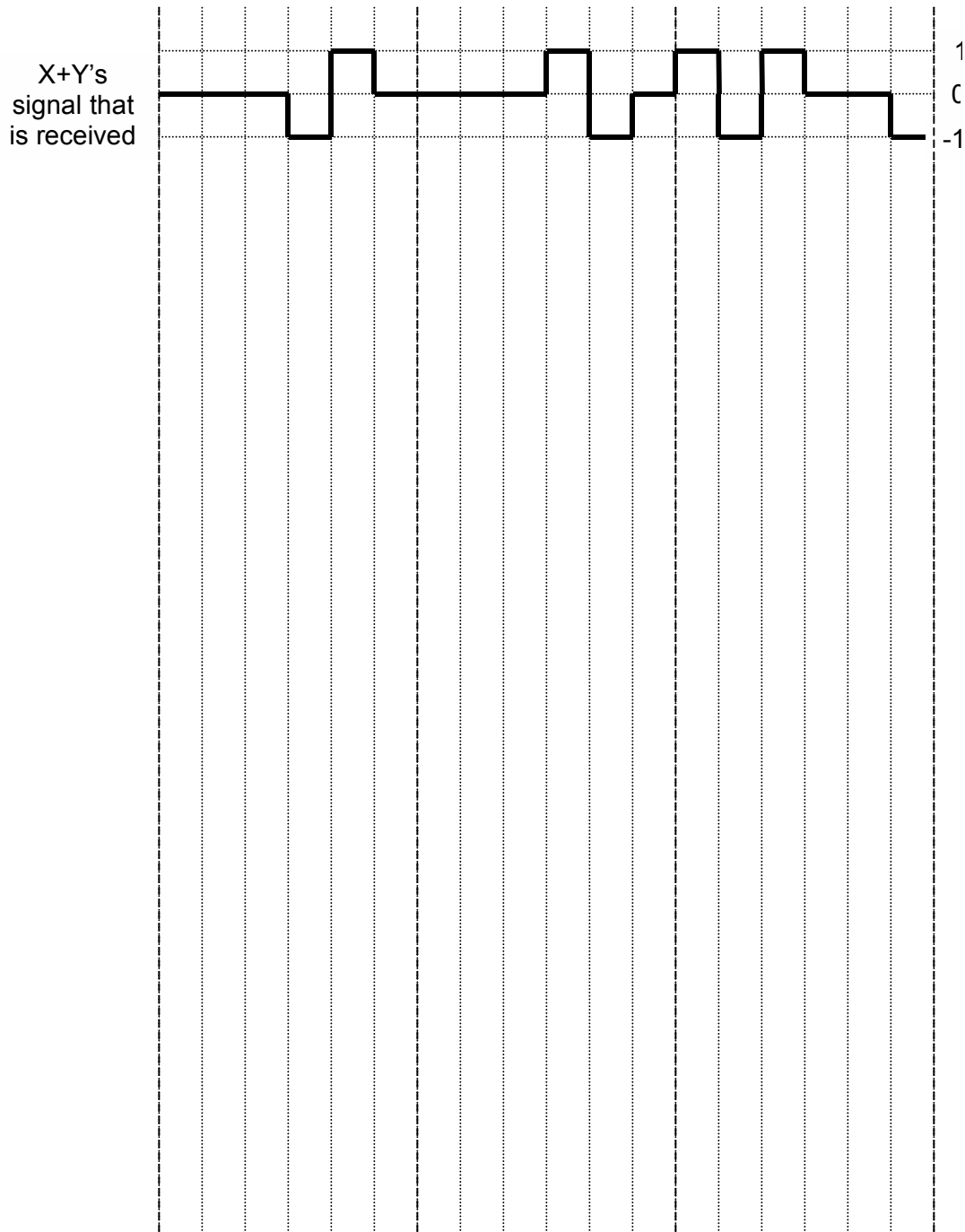


A car is traveling along a street with velocity $v(t)$ as shown in the figure. The received signal experiences multi-path Rayleigh fading on a 900 MHz CW (continuous wave) modulated carrier. Assume $\rho=0.1$ and ignore large-scale fading effects.

- a) (5) What is the average level crossing rate over the 100s interval?
- b) (5) What is the average fade duration over the 100s interval?

Problem 9 (5 points)

Two mobiles, X and Y, are transmitting concurrently using code division multiple access (CDMA) technique. A receiver hearing both of these transmissions, receives the combined signal $X+Y$ and uses CDMA technique to despread it and obtain the original message signal (data bits) of mobile X. The receiver has the codeword of X as **010011**. Obtain the data bits (message signal) that is transmitted from X.



Write down your answer for this question here: _____