(28) 00051

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Electrical and Computer Engineering

Study Programme	: Bachelor of Technology Honors in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: EEX6539 Wireless Communications** / ECX6239
Academic Year	: 2017/18
Date	: 13th February 2019
Time	: 09:30-12:30hrs
Duration	**: 3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of Section A (50 out of 100 marks) and Section B (each question worth of 25 marks).
3. Answer **ALL** the questions in Section A.
4. Answer **only two questions** from Section B.
5. Relevant figures, tables, charts/ codes are provided.
6. This is a Closed Book Test (CBT).
7. Calculators are permitted to use.

SECTION A

Question 1 **(15 marks)**

1. Explain why multiple access techniques are useful in a wireless communication network.

2. List four different multiple access techniques and clearly state how interference between users are reduced in each of these techniques.

3. Describe two advantages of using power control in a CDMA system.

Question 2 **(35 marks)**

1. Propagation models are useful to compute the signal strength of wireless signal propagation through a medium to be received by receiving antenna located at a finite distance. Consider received signal components shown in Figure 1. Explain which propagation types are suitable to characterize the signal propagation each scenario. (05 marks)

2. Clearly state the condition that should be satisfied to model signal propagation using the free space model. In your answer use two appropriate examples from existing wireless communication systems with suitable diagrams. (10 marks)

3. Transmitter transmits a signal with 50 W power using unity gain antenna. The frequency of the signal is 1.35 GHz. The receiver is located 500 m from the transmitter. The receiving antenna also has a unity gain. Assuming there are no obstructions in the signal path, calculate the received power in dBm. (10 marks)

4. Compute the diffraction loss of a signal which has a frequency of 0.1 GHz propagating over a signal path obstructed with a knife-edge obstacle exists in between the transmitter and the receiver. The obstacle is at 15 m measured from the transmitter. The receiver and transmitter are separated by 35 m. When measured from the ground level, the obstacle is at 30 m. The transmitter and the receiver are at heights 15 m measured from the ground. Figure 2 shows the variation of the knife edge diffraction gain with the Fresnel diffraction parameter. (10 marks)

SECTION B

Question 3 **(25 marks)**

1. Consider a channel of 900 MHz with the following variation of average power and excess delay as shown in Table 1. (15 marks)
   a. Based on the data shown in Table 1, draw the power delay profile of the channel.
   b. Calculate the following measures.
      i. RMS delay spread
      ii. Coherence bandwidth
      iii. Coherence time
   c. Calculate the signal bandwidth for flat fading.
   d. Calculate the signal bandwidth for slow fading conditions.

Table 1

Average power (dB)	Excess Delay (μs)
0	1
-10	3
-20	6

2. State four limitations when using the Okumura model to compute the path loss. (04 marks)

3. Consider a wireless communication system operating in an urban environment. The variation of the correction factor with frequency and the median attenuation relative to the free space with frequency are shown in Figures 3 and 4. (06 marks)
   The following information are provided.
   Distance from the base station (d) = 70 km
   Height of the base station (h_{te} = 50 m
   Height of the mobile antenna (h_{re}) = 10 m
   Carrier frequency = 700 MHz
   Effective isotropic radiation power of the base station = 0.5 kW.
   a. Calculate the free space path loss.
   b. Using the Okamura model calculate the median path loss of the signal.

Question 4 **(25 marks)**

1. Explain the operation of a cellular mobile system considering the perspective of a mobile user at location L1, who is making a voice call while moving at a constant speed of V meters/second and stops at L3. The call duration is t seconds. The path of the mobile user is shown in Figure 5. (12 marks)

2. In a cellular mobile communication system, both co-channel interference and adjacent channel interference need to be minimized. (06 marks)
   a. Explain whether it is possible to mitigate the co-channel interference by increasing the carrier power at the transmitter.
   b. Explain how adjacent channel interference can degrade the expected performance for servicing the mobile users.
   c. Describe an existing technique which can minimize the adjacent channel interference.

3. A cellular system is allocated 40MHz bandwidth to provide full duplex voice channels, each of 50kHz. From the allocated bandwidth, 1.2MHz is allocated for control channels. Determine the cell reuse ratio if at least 92 full duplex channels and at least 3 control channels are allocated per cell during channel assignment. (03 marks)

4. Explain the principle of operation in orthogonal frequency division multiple access system. (04 marks)

Question 5 **(25 marks)**

1. Briefly explain two applications of wireless sensor networks. (05 marks)

2. Identify and explain suitable diversity techniques which can be used to improve the signal reception under following channel conditions. (06 marks)
    a. Slow fading channels
    b. Flat fading channels
    c. Correlated channels (temporal/frequency/spatial)

3. Compare the advantages and limitations of selective combining (SC) and equal gain combining (EGC) diversity combining techniques. (05 marks)

4. State why channel coding is important in a wireless system. (04 marks)

5. (i) Clearly state any assumptions and conditions to satisfy the requirement of the designed code to be a linear block code. (02 marks)
   (ii) Design a block encoder which has a code rate of 2/3 and minimum distance of 2 to encode the following information sequence 00, 01, 11, 00, 10, 01, 11. (03 marks)

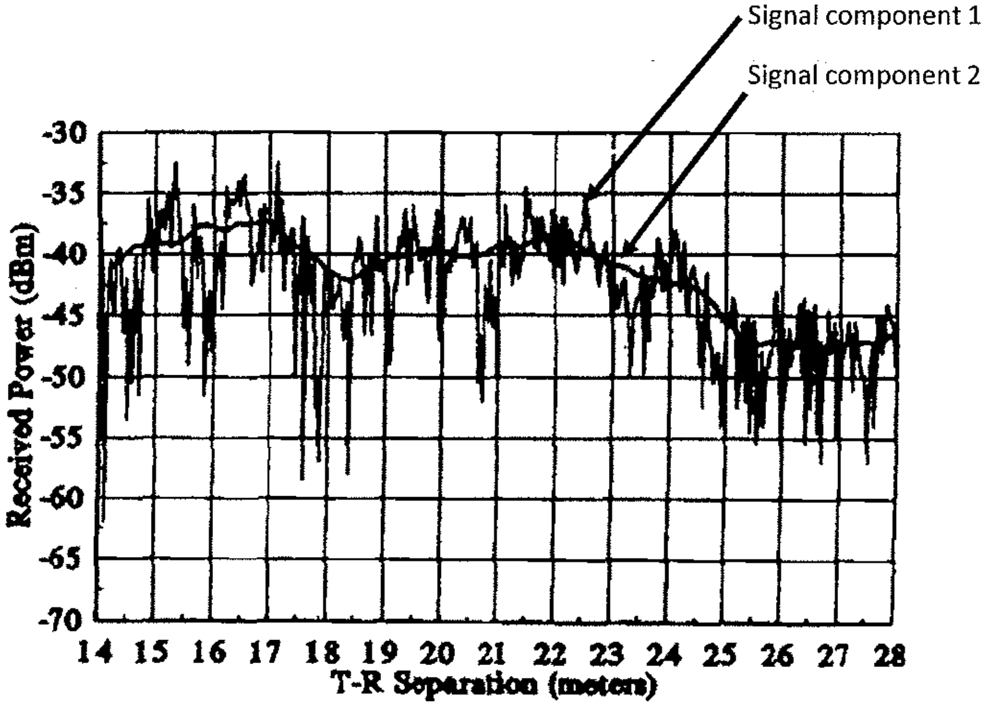

Figure 1: Received signal strength (dBm) variation with the transmitter (T) - receiver (R) separation distance.

Source: Rappaport, "Wireless Communication Principles and Practices", Second Edition, Prentice Hall, ISBN 0-13-042232-0.

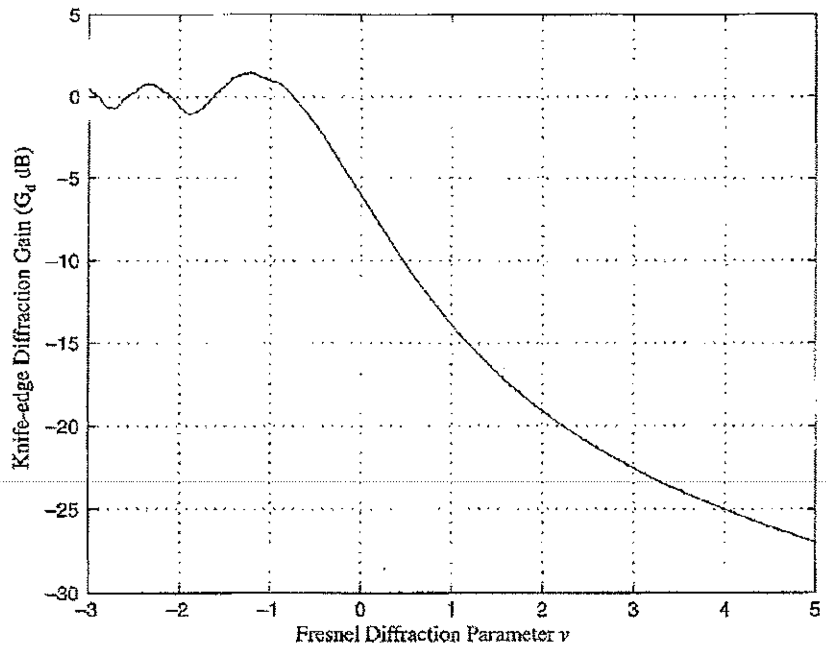

Figure 2: Variation of the knife edge diffraction gain with the Fresnel diffraction parameter.

Source: Rappaport, "Wireless Communication Principles and Practices", Second Edition, Prentice Hall, ISBN 0-13-042232-0.

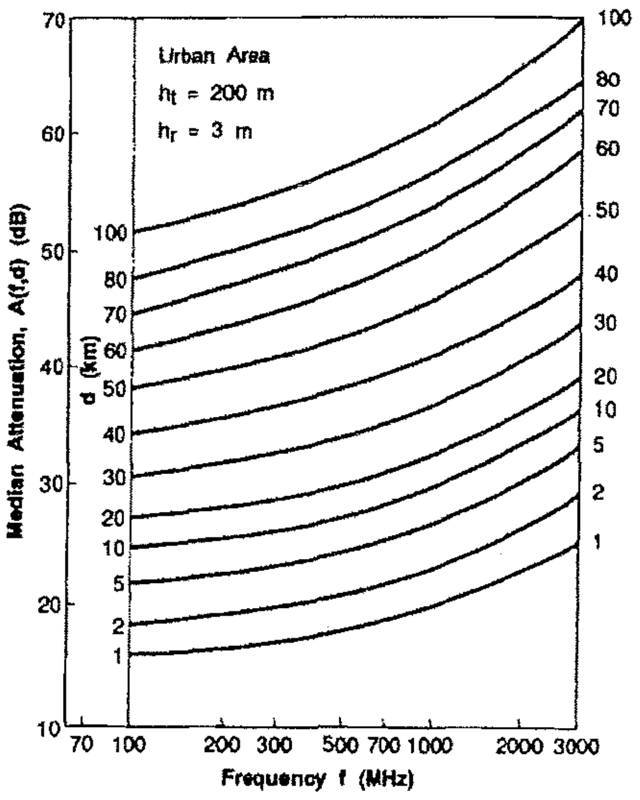

Figure 3: Median attenuation relative to free space (A(f,d), where f is the frequency in MHz and d is the distance in meters), over a quasi-smooth terrain [Oku68]

Source: Rappaport, "Wireless Communication Principles and Practices", Second Edition, Prentice Hall, ISBN 0-13-042232-0.

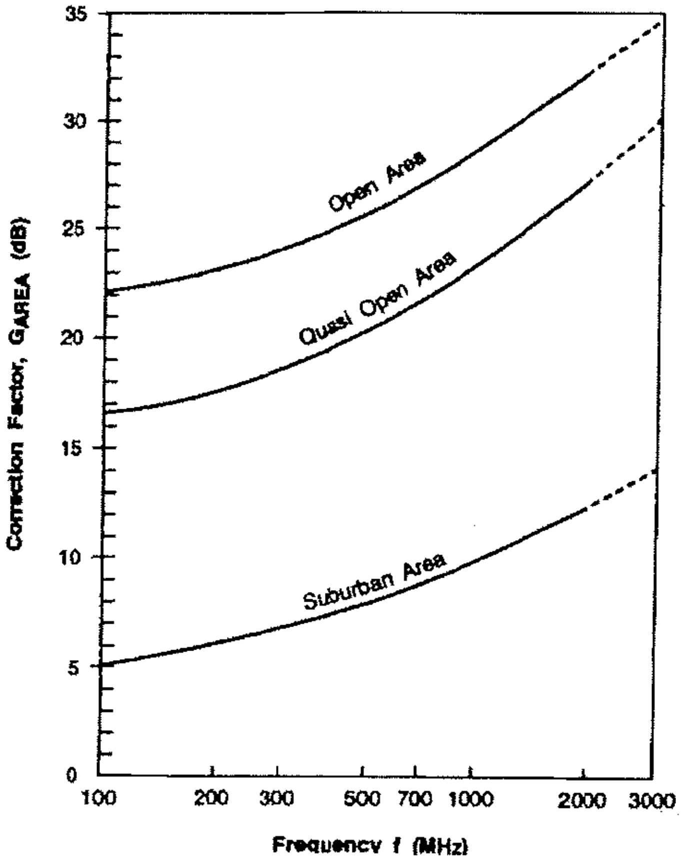

Figure 4: Correction factor, G_{AREA}, for different types of terrain [Oku68]

Source: Rappaport, "Wireless Communication Principles and Practices", Second Edition, Prentice Hall, ISBN 0-13-042232-0.

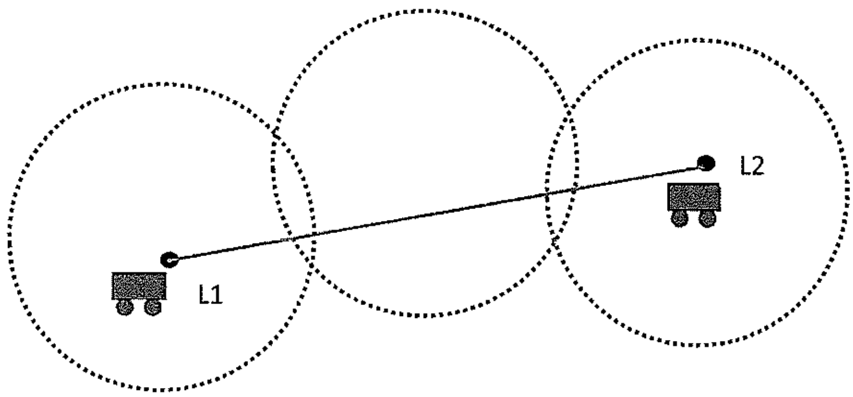

Figure 5: Path of the mobile user over time. Cell boundary is shown as Starting and destination locations are denoted as L1 and L2 respectively.

Appendix 1.1
Blocked-Calls-Cleared (Erlang *B*) (*Continued*)

	A, erlangs												
	B												
N	1.0%	1.2%	1.5%	2%	3%	5%	7%	10%	15%	20%	30%	40%	50%
21	12.8	13.1	13.5	14.0	14.9	16.2	17.3	18.7	20.8	22.8	27.3	32.8	40.2
22	13.7	14.0	14.3	14.9	15.8	17.1	18.2	19.7	21.9	24.1	28.7	34.5	42.1
23	14.5	14.8	15.2	15.8	16.7	18.1	19.2	20.7	23.0	25.3	30.1	36.1	44.1
24	15.3	15.6	16.0	16.6	17.6	19.0	20.2	21.8	24.2	26.5	31.6	37.8	46.1
25	16.1	16.5	16.9	17.5	18.5	20.0	21.2	22.8	25.3	27.7	33.0	39.4	48.1
26	17.0	17.3	17.8	18.4	19.4	20.9	22.2	23.9	26.4	28.9	34.4	41.1	50.1
27	17.8	18.2	18.6	19.3	20.3	21.9	23.2	24.9	27.6	30.2	35.8	42.8	52.1
28	18.6	19.0	19.5	20.2	21.2	22.9	24.2	26.0	28.7	31.4	37.2	44.4	54.1
29	19.5	19.9	20.4	21.0	22.1	23.8	25.2	27.1	29.9	32.6	38.6	46.1	56.1
30	20.3	20.7	21.2	21.9	23.1	24.8	26.2	28.1	31.0	33.8	40.0	47.7	58.1
31	21.2	21.6	22.1	22.8	24.0	25.8	27.2	29.2	32.1	35.1	41.5	49.4	60.1
32	22.0	22.5	23.0	23.7	24.9	26.7	28.2	30.2	33.3	36.3	42.9	51.1	62.1
33	22.9	23.3	23.9	24.6	25.8	27.7	29.3	31.3	34.4	37.5	44.3	52.7	64.1
34	23.8	24.2	24.8	25.5	26.8	28.7	30.3	32.4	35.6	38.8	45.7	54.4	66.1
35	24.6	25.1	25.6	26.4	27.7	29.7	31.3	33.4	36.7	40.0	47.1	56.0	68.1
36	25.5	26.0	26.5	27.3	28.6	30.7	32.3	34.5	37.9	41.2	48.6	57.7	70.1
37	26.4	26.8	27.4	28.3	39.6	31.6	33.3	35.6	39.0	42.4	50.0	59.4	72.1
38	27.3	27.7	28.3	29.2	30.5	32.6	34.4	36.6	40.2	43.7	51.4	61.0	74.1
39	28.1	38.6	29.2	30.1	31.5	33.6	35.4	37.7	41.3	44.0	52.8	62.7	76.1
40	29.0	29.5	30.1	31.0	32.4	34.6	36.4	38.8	42.5	46.1	54.2	64.4	78.1
41	29.9	30.4	31.0	31.9	33.4	35.6	37.4	39.9	43.6	47.4	55.7	66.0	80.1
42	30.8	31.3	31.9	32.8	34.3	36.6	38.4	40.9	44.8	48.6	57.1	67.7	82.1
43	31.7	32.2	32.8	33.8	35.3	37.6	39.5	42.0	45.9	49.9	58.5	69.3	84.1
44	32.5	33.1	33.7	34.7	36.2	38.6	40.5	43.1	47.1	51.1	59.9	71.0	86.1
45	33.4	34.0	34.6	35.6	37.2	39.6	41.5	44.2	48.2	52.3	61.3	72.7	88.1
46	34.3	34.9	35.6	36.5	38.1	40.5	42.6	45.2	49.4	53.6	62.8	74.3	90.1
47	35.2	35.8	36.5	37.5	39.1	41.5	43.6	46.3	50.6	54.8	64.2	76.0	92.1
48	36.1	36.7	37.4	38.4	40.0	42.5	44.6	47.4	51.7	56.0	65.6	77.7	94.1
49	37.0	37.6	38.3	39.3	41.0	43.5	45.7	48.5	52.9	57.3	67.0	79.3	96.1
50	37.9	38.5	39.2	40.3	41.9	44.5	46.7	49.6	54.0	58.5	68.5	81.0	98.1
51	38.8	39.4	40.1	41.2	42.9	45.5	47.7	50.6	55.2	59.7	69.9	82.7	100.1
52	39.7	40.3	41.0	42.1	43.9	46.5	48.8	51.7	56.3	61.0	71.3	84.3	102.1
53	40.6	41.2	42.0	43.1	44.8	47.5	49.8	52.8	57.5	62.2	72.7	86.0	104.1
54	41.5	42.1	42.9	44.0	45.8	48.5	50.8	53.9	58.7	63.5	74.2	87.6	106.1
55	42.4	43.0	43.8	44.9	46.7	49.5	51.9	55.0	59.8	64.7	75.6	89.3	108.1
56	43.3	43.9	44.7	45.9	47.7	50.5	52.9	56.1	61.0	65.9	77.0	91.0	110.1
57	44.2	44.8	45.7	46.8	48.7	51.5	53.9	57.1	62.1	67.2	78.4	92.6	112.1
58	45.1	45.8	46.6	47.8	49.6	52.6	55.0	58.2	63.3	68.4	79.8	94.3	114.1
59	46.0	46.7	47.5	48.7	50.6	53.6	56.0	59.3	64.5	69.7	81.3	96.0	116.1
60	46.9	47.6	48.4	49.6	51.6	54.6	57.1	60.4	65.6	70.9	82.7	97.6	118.1
61	47.9	48.5	49.4	50.6	52.5	55.6	58.1	61.5	66.8	72.1	84.1	99.3	120.1
62	48.8	49.4	50.3	51.5	53.5	56.6	59.1	62.6	68.0	73.4	85.5	101.0	122.1
63	49.7	50.4	51.2	52.5	54.5	57.6	60.2	63.7	69.1	74.6	87.0	102.6	124.1
64	50.6	51.3	52.2	53.4	55.4	58.6	61.2	64.8	70.3	75.9	88.4	104.3	126.1
65	51.5	52.2	53.1	54.4	56.4	59.6	62.3	65.8	71.4	77.1	89.8	106.0	128.1
66	52.4	53.1	54.0	55.3	57.4	60.6	63.3	66.9	72.6	78.3	91.2	107.6	130.1
67	53.4	54.1	55.0	56.3	58.4	61.6	64.4	68.0	73.8	79.6	92.7	109.3	132.1
68	54.3	55.0	55.9	57.2	59.3	62.6	65.4	69.1	74.9	80.8	94.1	111.0	134.1
69	55.2	55.9	56.9	58.2	60.3	63.7	66.4	70.2	76.1	82.1	95.5	112.6	136.1
70	56.1	56.8	57.8	59.1	61.3	64.7	67.5	71.3	77.3	83.3	96.9	114.3	138.1