

# CELLULAR AND MOBILE COMMUNICATIONS

## UNIT I

**CELLULAR MOBILE RADIO SYSTEMS:** Introduction to Cellular Mobile System, uniqueness of mobile radio environment, operation of cellular systems, consideration of the components of Cellular system, Hexagonal shaped cells, Analog and Digital Cellular systems.

**CELLULAR CONCEPTS:** Evolution of Cellular systems, Concept of frequency reuse, frequency reuse ratio, Number of channels in a cellular system, Cellular traffic: trunking and blocking, Grade of Service; Cellular structures: macro, micro, pico and femto cells; Cell splitting, Cell sectoring.

## UNIT II

**INTERFERENCE:** Types of interferences, Introduction to Co-Channel Interference, real time Co-Channel interference, Co-Channel measurement, Co-channel Interference Reduction Factor, desired C/I from a normal case in a omni directional Antenna system, design of Antenna system, antenna parameters and their effects, diversity receiver, non-cochannel interference-different types.

## UNIT III

**FREQUENCY MANAGEMENT AND CHANNEL ASSIGNMENT:** Numbering and grouping, setup access and paging channels, channel assignments to cell sites and mobile units: fixed channel and non-fixed channel assignment, channel sharing and borrowing, overlaid cells.

**CELL COVERAGE FOR SIGNAL AND TRAFFIC:** Signal reflections in flat and hilly terrain, effect of human made structures, phase difference between direct and reflected paths, straight line path loss slope, general formula for mobile propagation over water and flat open area, near and long distance propagation, antenna height gain, form of a point to point model.

## UNIT IV

**CELL SITE AND MOBILE ANTENNAS :** Sum and difference patterns and their synthesis, omni directional antennas, directional antennas for interference reduction, space diversity antennas, umbrella pattern antennas, minimum separation of cell site antennas, high gain antennas.

## UNIT V

### HANDOFF STRATEGIES

Concept of Handoff, types of handoff, handoff initiation, delaying handoff, forced handoff, mobile assigned handoff, intersystem handoff, vehicle locating methods, dropped call rates and their evaluation.

## UNIT VI

**DIGITAL CELLULAR NETWORKS:** GSM architecture, GSM channels, multiple access schemes; TDMA, CDMA, OFDMA; architecture of 3G cellular systems.

### TEXTBOOKS :

1. Mobile Cellular Telecommunications – W.C.Y. Lee, Tata McGraw Hill, 2nd Edn., 2006.
2. Principles of Mobile Communications – Gordon L. Stuber, Springer International 2nd Edition, 2007.

### Question Bank:

S.No	Question: (UNIT-I) Short Answer type	Blooms Level	Taxonomy
1.	Give two advantages of cellular mobile systems over telephone systems.	Understand	
2.	Write the equation to calculate offered load in mobile transmission.	Remember	
3.	Define FCC?	Understand	
4.	Define Trunking efficiency.	Remember	
5.	Mention the elements of basic cellular systems.	Understand	
6.	What are the functions of MTSO?	Remember	

7.	Write short notes on voice quality can be tested.	Understand
8.	What is known as circuit merit?	Remember
9.	What are the items required for service quality.	Understand
10.	Give the relation between received carrier power and distance measured from transmitter to the receiver end.	Understand
11.	Define fading effect.	Remember
12.	What is known as Rayleigh fading?	Understand
13.	What are the main parts of mobile radio environment?	Remember
14.	Define delay spread.	Remember
15.	Define coherence bandwidth.	Remember
16.	What is meant by direct wave path?	Understand
17.	Define line of sight path and obstructive path.	Remember
18.	Write briefly about noise figure?	Understand
19.	What is the significance of hexagonal shaped cells?	Remember
20.	Define ignition noise.	Remember
21.	Explain performance criteria.	Understand
22.	List out the elements of cellular mobile systems?	Remember
23.	What is interference and co-channel interference?	Understand
24.	Differentiate between co-channel interference and adjacent channel interference?	Understand
25.	What do you mean by Erlang?	Remember
26.	If a maximum call per hour is 3500 and average calling time is 1.76 minutes, find the offered load.	Remember
27.	Define co-channel interference.	Remember
28.	Define co-channel interference reduction factor.	Remember
29.	What is meant by frequency reuse distance?	Understand
30.	Define cell splitting.	Remember
31.	Define micro cells.	Remember
32.	What is mean by macro cell?	Understand
33.	What is the value of co-channel interference reduction factor in a 7-cell reuse pattern?	Understand
34.	What is the demerit of cell splitting?	Remember
35.	Write short notes on any two components of cellular system.	Understand
<b>S.No</b>	<b>Question: (UNIT-I) Long Answer type</b>	<b>BT Level</b>
1.	Discuss in detail about the operation of cellular mobile system with block diagram.	Understand
2.	Explain the call initialization, call progress and call termination process.	Understand
3.	Define and Explain amplifier noise and ignition noise in detail.	Understand
4.	What is multi path effect; explain its effects in mobile propagation.	Remember
5.	What is the uniqueness of mobile radio environment, Explain why hexagonal shaped cells are used for mobile communication?	Remember
6.	Explain the significance of fading of fading in mobile environment.	Understand
7.	Compare analog and digital cellular systems with at least 15 points each.	Remember

8.	Discuss in detail about the 1G-AMPS and any one 2G cellular standard in detail.	Understand
9.	Define and explain the following terms used in wireless communications, i. Base Station ii. Control Channel. iii. Forward Control Channel iv. Full Duplex Channel System v. Half Duplex Channel System vi. Hand off vii. Mobile Station	Remember
10.	Write the significance of Omni-directional antenna system.	Understand
11.	What is co-channel interference with first tier and second tier with an example.	Understand
12.	Discuss the limitations of conventional mobile telephone system	Understand
13.	Explain in detail a) Concept of frequency channels and b) Co-channel interference.	Understand
14.	Explain the concept of co-channel interference in detail.	Understand
15.	Define and Discuss in detail about the cell splitting technique.	Understand
16.	What is meant by co-channel interference reduction factor? Explain with all.	Remember
17.	Write the normal case of carrier to interference ratio with Omni-directional.	Understand
18.	List out and Explain in detail about the components of basic cellular system.	Understand
19.	What is cell-splitting? Explain its types in detail about cell splitting.	Remember
1.	Calculate the transmit and receive carrier frequencies for, i) AMPS channel 4 and ii) AMPS channel 991.	Remember
2.	Consider maximum number of calls in one hour in one cell is 3500 and an Average calling time $t''$ is 1.76 minutes. Calculate the offered load in the cell.	Understand
3.	Consider a metropolitan area of 1100 square km is to be covered by cells with cell radius of 2 km. Calculate the number of cells that would be needed	Remember
4.	A mobile transmitter produces a power of 25W as measured at antenna and its supply power is 47W. Calculate its efficiency.	Understand
5.	Assume a cellular system operates with traffic of 2500 Erlangs. If each user in the system uses phone for 3 minutes of busiest hour on an average case, then find the number of users which can be accommodated under even distribution	Remember
6.	A receiver equivalent noise figure value is 3 db. Find its equivalent noise temperature.	Understand

7	Consider a cellular system which consists of 34 cells with the cell radius as 1.4 km. a total frequency bandwidth is capable of supporting 343 traffic channels. Find what geographical area in km can be covered and the number of channels available per call.[ Assume N=7 reuse cellular pattern].	Remember
8	For a seven cell reuse pattern find the reuse factor if the minimum distance between centers of co-channel-cells is 18 km. Radius of cell is 3 km and the distance between adjacent cells in the seven cell pattern is 6 km.	Understand
9	Calculate the maximum data rate required for transmission if the signal to noise of the communication link is 20 dB and the RF bandwidth is 40 KHz.	Remember
10	Assume a cellular phone transmitter has deviation of 11 kHz frequency. If the transmitter operates at a maximum deviation with voice frequencies 500 Hz and 3500 Hz, calculate their modulation index value.	Understand
<b>S.No</b>	<b>Question: (UNIT-II &amp; UNIT-IV) Short Answer type Question</b>	<b>Blooms Taxonomy Level</b>
1.	Define co-channel interference.	Remember
2.	If the actual signal is $e_1$ and interference is $e_2$ what will be the received signal.	Remember
3.	Mention two advantages of Omni-directional antenna.	Understand
4.	Given the co-channel interference reduction factor $q$ is 6 what will be the cluster size?	Remember
5.	If co-channel interference reduction factor $q$ is 5.2 and the cluster size is $q$ what will be the carrier to interference ratio.	Understand
6.	Comment on the lowering antenna height method in a valley.	Remember
7.	If antenna height is lowered in foliage area what are the effects that would take place.	Understand
8.	What are the advantages of having a notch in the antenna radiation pattern?	Remember
9.	Write a short note on umbrella-pattern effect.	Understand
10.	List any two benefits of an umbrella cellular pattern.	Remember
11.	Give two uses of parasitic elements.	Understand
12.	Discuss adjacent channel interference?	Understand
13.	What is known as near end-far-end interference?	Understand
14.	Define cross talk and ring combiner.	Remember
15.	What are the effects of cell site antenna height analysis?	Understand
16	Explain the methods to reduce adjacent channel interferences?	Remember
1.	Explain subjective versus objective test measurements and SINAD in detail.	Understand
2.	Define and explain real time co-channel interference of cellular mobile communications.	Understand
3	What is co-channel interference of cellular mobile communications? Explain its measurements.	Remember

4	Compare and explain co-channel and non-co-channel interferences in detail.	Understand
5	Discuss in detail about antenna system design methods of cellular mobile communications.	Remember
6	List out all Parasitic elements and Discuss in detail about the Parasitic elements.	Understand
7	Define diversity receiver“ in detail?	Remember
8	What are the types of non-co-channel interferences in cellular system?	Understand
9	Explain antenna system design and different test methods in detail.	Understand
10	Explain the types of non-co-channel interferences in cellular system.	Understand
11	What is meant by diversity receiver and SINAD measurements?	Understand
12	Explain non-co-channel interference effects on coverage and interferences.	Understand
13	Distinguish Co-channel interference and Non Co-channel interference?	Understand
14	Explain the effects of coverage and interference by power decrease.	Understand
15	What is meant by UHF TV interference?	Understand
16	Write briefly about cell site components.	Understand
1	Assume a cellular system wherein a car travels at 200 km per hour speed. Calculate how often (approximately) handoffs would occur if the radius of the cell is 8 km?	Remember
2	Calculate the far field distance for an antenna with largest dimension 1.5m and the corresponding frequency of 1200 MHz	Understand
3	Calculate the time period between handoffs if the cell radius is 10 kms where the vehicle travels at a speed of 130 kmph.	Understand
4	a. Explain the Co- channel interference reduction factor and derive the general formula for C/I. b. Determine the frequency reuse distance for $K = 4,7,12,19$ .	Remember
5	a. Draw the block diagram of a cellular system and explain how a cellular telephone call is made between the landline and the mobile user and when the call is initiated by the landline customer. Draw suitable timing diagrams. b. Explain briefly about 3G CDMA techniques.	Understand
<b>S.No</b>	<b>Question: (UNIT-II &amp; UNIT-IV)</b> <b>shortAnswer type Question</b>	<b>Blooms Taxonomy Level</b>
1	What are human made structures?	Remember
2	What are natural terrains?	Remember
3	Give two examples for natural terrain and human made structures	Understand
4	Write a short note on point-to-point model.	Remember
5	Write a short note on signal reflections in a flat terrain.	Understand
6	Give any two effects of human made structures.	Understand
7	What are the three main types of point-to-point model?	Remember
8	Write the equation of effective antenna height gain.	Understand
9	Draw the diagram of human made structures to find propagation path loss curve.	Remember

10	Write a short note on constant standard deviation along a path loss curve.	Understand
11	Draw the graph of an 8db local mean spread.	Remember
12	Draw the simple model for propagation over water.	Understand
13	Give the general formula for mobile radio propagation.	Remember
14	Write a short note on foliage loss.	Understand
15	Write a short note on characteristics of foliage environment.	Remember
16	What is the significance of a 1m intercept under propagation in near-in distance case?	Understand
17	What are near and long distance propagation.	Remember
18	List the merits of point to point model.	Understand
19	Write short note on about signal reflections in a hilly terrain.	Remember
20	Compare a hilly and flat terrain with two important points.	Understand
21	Write a short note on sum-and-difference pattern.	Remember
22	Give the general formula for sum-and-difference pattern.	Understand
23	What is known as Dolph-Chebyshev synthesis?	Remember
24	Write a short note on Taylor synthesis and bayle's synthesis	Understand
25	What is known as symmetrical pattern?	Remember
26	What is known as abnormal antenna configuration?	Remember
27	List out the directional antennas?	Understand
28	Define space diversity technique.	Remember
29	What are the advantages of space diversity technique?	Remember
30	What is the use of two-branch space diversity antenna?	Understand
31	Draw a simple diagram of diversity antenna spacing concept in cell site.	Remember
32	Write short note on high-gain broadband umbrella pattern antenna.	Remember
	Long answer type	
1	Define human made structures and natural terrain structures and their	Understand
2	What is signal reflections in flat and hilly terrain contours and their influences	Understand
3	Discuss the phase difference between direct and reflected paths in detail.	Remember
4	Write constant standard deviation along a path loss curve in detail.	Understand
5	Explain point to point model with its equations.	Remember
6	What is meant by propagation of mobile signal over water and a flat open area.	Understand
7	Derive the general formula used for signal propagation over water and flat.	Remember
8	Explain foliage losses and propagation in near-in distance.	Understand
9	Write short notes long distance propagation.	Remember
10	Explain the sum-and-difference patterns and their synthesis in detail.	Understand
11	Design aspects and merits of an omni-directional antenna in cell	Remember
12	What is known as directional antennas? Explain directional antennas	Understand
13	Discuss space diversity antennas in detail.	Understand

14	Write short notes on a) Umbrella pattern antenna. b) Space diversity antennas.	Understand
15	Define umbrella pattern antenna and omni-directional antennas in detail.	Understand
16	Explain about minimum separation of cell-site receiving antennas.	Understand
1	Explain in detail about, a) Human made structures and b) Point-to-point model in detail.	Remember
2	i. What is the need for frequency reuse? Explain the frequency reuse concept and show that $N=i^2 +ij+j^2$ Where N is the number of cells per cluster. ii. Derive an expression for signal to interference ratio (S/I) for 7 cell cluster system.	Remember
2	Explain in detail about a) Broadband umbrella pattern antenna structures. b) Radiation pattern of normal umbrella-pattern antenna.	Understand
3	Discuss in detail about a) Glass-mounted antennas. b) Horizontally and vertically oriented space-diversity antennas.	Remember
<b>S.No</b>	<b>Question: (UNIT-III) short answer type</b>	<b>Blooms Taxonomy Level</b>
1	What is meant by frequency management?	Understand
2	What is meant by channel assignment?	Remember
3	Differentiate the terms frequency management and channel assignment.	Remember
4	Write short note on set-up channels.	Understand
5	List few points on frequency spectrum utilization.	Remember
6	What is known as access channels?	Understand
7	What is known as FOCC?	Remember
8	Define paging channel.	Understand
9	Give the equation for number of calls in the cell site.	Remember
10	Define location management and handoff management.	Remember
11	Explain how to avoid interference between two systems while assigning setup channels.	Remember
12	Give two points related to non-uniform compact channel allocation algorithm.	Understand
13	Draw an underlay and overlay structures.	Understand
14	What is the use of tilted antennas?	Remember
15	Write short note on channel sharing.	Remember
16	Differentiate channel sharing and borrowing.	Understand
17	Define adjacent channel assignment.	Remember
18	What is meant by fixed channel assignment?	Understand
19	Define sectorization.	Remember
20	Write short note on non-fixed channel assignment.	Understand
	<b>Long answer type</b>	
1	Explain in detail about i. Set-up channels ii. Paging channel iii. Access channels.	Understand

2	Explain numbering and grouping concept in detail.	Understand
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3	Explain in detail about a) Frequency channel utilization b) Significance of frequency management chart.	Understand
4	What is known as channel assignment? Explain fixed channel assignment.	Remember
5	Explain in detail about i. Supervisory audio tone. ii. Channel borrowing and iii. Channel assignments to travelling mobile units.	Understand
6	Explain underlay and overlay cellular structures in detail with examples.	Understand
7	Explain channel sharing and channel borrowing concepts in detail.	Understand
8	Explain cell sectorization technique.	Understand
9	Explain non-fixed channel assignment in detail.	Understand
10	What is known as dynamic channel assignment average blocking and handoff	Remember
1	Calculate the total available channels for a cellular system having a total 50km simplex channels to provide full duplex voice and control channels. Assume that the system uses nine cell reuse pattern and 1MHZ of the total bandwidth is allocated for control channels also calculate the number of control channels and voice channels per cell.	Remember
2	What do you understand by non-fixed channels assignment? Describe the corresponding algorithms.	Understand
3	Compare the average blocking in spatially uniform and non-uniform traffic distribution for FCA, BCA and FBCA.	Remember
4	If a transmitter produces 50W of power express the transmitter power in units of (i) dBm (ii) dBW, if 50W is applied to a unity gain antenna with a 900MHz carrier frequency find the received power in dBm at a free space distance of 100m from the antenna. What is Pr (10Km)? Assume unity for the receiver antenna?	Remember
<b>S.No</b>	<b>Question: (UNIT-V&amp; UNIT-VI) short answer type</b>	<b>Blooms Taxonomy Level</b>
1	Define handoff.	Remember
2	What are the types of handoff?	Understand
3	Define dropped call.	Remember
4	What will be the number of handoffs 8 per call if cell size is smaller as 3.2 to 8 km?	Understand
5	If the cell of 16 to 24 km what will be the number of handoffs per call?	Remember
6	Write short note on initiation of handoff.	Understand
7	What is known as delaying handoff?	Remember
8	Comment on two-hand off level algorithm.	Understand
9	Draw a simple two-level handoff scheme diagram.	Remember
10	What are the advantages of delayed handoffs?	Understand
11	What is meant by forced handoffs?	Remember
12	What is known as handoff queuing.	Understand
13	Define MAHO?	Remember

14	Define soft handoff.	Understand
15	What is the advantage of soft handoff over hard handoff?	Remember
16	Write short note on inter system handoff.	Understand
17	What is known as dropped call rate?	Remember
18	What is meant by controlling a handoff?	Understand
19	What is known as a hole in handoff analysis?	Remember
20	What is the significance of handoff?	Understand
<b>Long answer type</b>		
1	Explain "Initiation of handoff".	Understand
2	Explain delaying a handoff with an algorithm in detail.	Understand
3	What are the advantages of delayed handoff? Also explain the parameters	Remember
4	Explain forced handoff and creating a handoff.	Understand
5	Write in detail about following handoff techniques. a) Controlling a handoff. b) Forced handoff in detail.	Understand
6	Explain MAHO and soft handoff techniques.	Understand
7	Define handoff; explain it's important in detail with its types.	Remember
8	Explain "Dropped call rate" in detail.	Understand
9	Define handoff? Explain in detail about inter system handoff.	Remember
10	Draw the GSM architecture and discuss various interfaces used in GSM.	Understand
11	What is meant by handoff? Describe the classification of handoff processes?	Remember
12	What is meant by handoff initiation? Explain the different methods of handoff initiation with suitable diagrams?	Understand
1	Explain the following terms. i) Forced Handoff ii) Hard Handoff iii) Delaying Handoff	Remember
2	What type of handoff is used when a call initiated in one cellular system enters another system before terminating? Explain how it works?	Understand
3	i. What are the various methods of delaying the handoff? Explain briefly. ii. What is meant by a dropped call? Explain the factors that influence the dropped call rate.	Remember

### ASSIGNMENT-I

#### UNIT-I INTRODUCTION TO CELLULAR MOBILE RADIO SYSTEMS

S. No	Question	Blooms Taxonomy Level	Course Outcome
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1	Discuss the uniqueness of Mobile radio environment.	Remember	1
2	Write short notes on Doppler spread and coherence time.	Remember	1
3	Write short notes on First, Second, Third and fourth generation Cellular wireless systems.	Remember	1
4	Explain cell splitting technique.	Understand	1
5	Explain the operation of cellular mobile system with block diagram.	Understand	1
6	What is the significance of hexagonal shaped cells?	Understand	1
7	Explain the concept of frequency reuse.	Understand	1
8	Discuss the limitations of conventional mobile telephone system.	Remember	1
9	Explain the concept of co-channel interference.	Understand	1
10	Derive the expression for Desired C/I for a normal case in a Omni-directional antenna.	Understand	1

**UNIT-II  
CO-CHANNEL INTERFERENCE**

S. No	Question	Blooms Taxonomy Level	Course Outcome
1	Discuss the significance of Time diversity and the Space Diversity.	Understand	2
2	What is channel combiner?	Understand	2
3	What are the methods to reduce adjacent channel interferences?	Remember	2
4	Write short notes on measurement of real time Co-Channel interference.	Understand	2
5	Discuss the significance of Frequency diversity.	Understand	2
6	What is frequency-agile combiner?	Remember	2
7	Compare and explain co-channel and non-co-channel interferences in detail.	Understand	2
8	What is known as near end-far-end interference?	Understand	2
9	Write a short note on umbrella-pattern effect.	Remember	2
10	Explain the Cross talk.	Remember	2
11	Explain Adjacent channel interference.	Understand	2
12	How receiver sensitivity is measured.	Remember	2

**UNIT-III  
CELL COVERAGE FOR SIGNAL AND**

S. No	Question	Blooms Taxonomy Level	Course Outcome
1	Explain signal reflections in flat and hilly terrain contours and their influences in signal transmissions in mobile transmissions.	Understand	3
2	Discuss in detail about the phase difference between direct and reflected paths.	Understand	3
3	Explain constant standard deviation along a path loss curve in detail.	Understand	3
4	List out all the point to point model with its equations.	Understand	3
5	Explain propagation of mobile signal over water and a flat open area.	Understand	3
6	Derive the general formula used for signal propagation over water and flat open area.	Understand	3
7	Explain foliage losses and propagation in near-in distance.	Understand	3

**UNIT-IV  
ASSIGNMENT-II**

8	Write the equation of effective antenna height gain.	Understand	4
9	Draw the diagram of human made structures to find propagation path loss curve.	Understand	4
10	Draw the simple model for propagation over water.	Understand	4
11	Explain the design aspects and merits of an Omni-directional antenna in cell site.	Understand	4
12	What is known as directional antennas? Explain directional antennas for interference in detail.	Understand	4
13	Explain about minimum separation of cell-site receiving antennas.	Understand	4
14	Explain the following, a) Umbrella pattern antenna. b) Space diversity antennas.	Understand	4

<b>UNIT-IV FREQUENCY MANAGEMENT AND CHANNEL</b>			
<b>S. No</b>	<b>Question</b>	<b>Blooms Taxonomy Level</b>	<b>Course Outcome</b>
1	Explain underlay and overlay cellular structures in detail with examples.	Understand	3
2	Define and Discuss in detail about the channel sharing and channel borrowing concepts in detail.	Understand	3
3	Explain in detail about cell sectorization technique.	Understand	3
4	What is meant by frequency management?	Understand	3
5	What is meant by channel assignment?	Remember	3
6	Differentiate the terms frequency management and channel assignment.	Understand	3
7	Write short note on set-up channels.	Remember	3
8	Define paging channel.	Remember	3
9	Explain non-fixed channel assignment in detail.	Understand	3
10	What is known as dynamic channel assignment average blocking and handoff blocking? Explain.	Remember	3
<b>UNIT-V HANDOFFS AND DROPPED CALLS</b>			
<b>S. No</b>	<b>Question</b>	<b>Blooms Taxonomy Level</b>	<b>Course Outcome</b>
1	Define and Discuss in detail about the “Initiation of handoff”.	Understand	5
2	Explain delaying a handoff with an algorithm in detail.	Understand	5
3	What are the advantages of delayed handoff? Also explain the parameters for handling a handoff.	Remember	5
4	Explain forced handoff and creating a handoff.	Understand	5
5	Define and Discuss in detail about the MAHO and soft handoff techniques	Understand	5
6	Write short note on initiation of handoff.	Remember	5
7	Define and Explain in detail about the delaying handoff?	Understand	5
8	Comment on two-hand off level algorithm.	Understand	5
9	What is meant by forced handoffs?	Remember	5
10	Define and Discuss in detail about the handoff queuing.	Understand	5
<b>UNIT-VI GSM Architecture</b>			
1	GSM Architecture	Understand	6
2	TDMA frame structure	Understand	6
3	Different multiple access techniques	Understand	6
4	Explain OFDM	Understand	6

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