

SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

QUESTION BANK



VII SEMESTER

PEC606 – MASSIVE MIMO NETWORKS

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QUESTION BANK

SUBJECT : PEC606 – MASSIVE MIMO NETWORKS

YEAR /SEM :IV /VII

UNIT I MASSIVE MIMO NETWORKS				
Definition of Massive MIMO, Correlated Rayleigh Fading, System Model for Uplink and Downlink, Basic Impact of Spatial Channel Correlation, Channel Hardening and Desirable propagation techniques, Local Scattering Spatial Correlation Model				
PART – A				
Q. No.	Questions	CO	BT Level	Competence
1.	Define Massive MIMO.	CO1	BTL 1	Remembering
2.	What is meant by Multiple-Input Multiple-Output (MIMO)?	CO1	BTL 1	Remembering
3.	Define Correlated Rayleigh Fading.	CO1	BTL 1	Remembering
4.	State the significance of spatial correlation in Massive MIMO systems.	CO1	BTL 1	Remembering
5.	Define channel hardening.	CO1	BTL 1	Remembering
6.	What is meant by favorable propagation in Massive MIMO?	CO1	BTL 1	Remembering
7.	Write the basic architecture of a Massive MIMO system.	CO1	BTL 2	Understanding
8.	Outline the uplink system model in Massive MIMO.	CO1	BTL 2	Understanding
9.	Outline the downlink system model in Massive MIMO.	CO1	BTL 2	Understanding
10.	Give the effect of spatial channel correlation on system performance.	CO1	BTL 2	Understanding
11.	How channel hardening improves communication reliability.	CO1	BTL 2	Understanding
12.	Give the concept of favorable propagation with an example.	CO1	BTL 2	Understanding
13.	List the advantages of Massive MIMO technology.	CO1	BTL 1	Remembering
14.	Define the Local Scattering Spatial Correlation Model.	CO1	BTL 1	Remembering
15.	Give the role of antenna arrays in Massive MIMO systems.	CO1	BTL 2	Understanding
16.	Why correlated fading differs from independent fading.	CO1	BTL 2	Understanding

17.	Give the importance of channel estimation in Massive MIMO systems.	CO1	BTL 2	Understanding
18.	Write the relationship between channel hardening and the number of antennas.	CO1	BTL 2	Understanding
19.	Give the importance of the Local Scattering Spatial Correlation Model in wireless communication.	CO1	BTL 2	Understanding
20.	State any two applications of Massive MIMO technology.	CO1	BTL 1	Remembering
21.	List any four benefits of favorable propagation.	CO1	BTL 1	Remembering
22.	Write the difference between uplink and downlink transmission in Massive MIMO.	CO1	BTL 2	Understanding
23.	Why spatial correlation affects spectral efficiency.	CO1	BTL 2	Understanding
24.	How Massive MIMO supports next-generation (5G/6G) wireless communication systems.	CO1	BTL 2	Understanding

PART – B

Q. No.	Questions		COs	BT Level	Competence
1.	Illustrate a detailed system model for a Massive MIMO network and explain the uplink and downlink transmission process with suitable block diagrams.	(16)	CO1	BTL 3	Applying
2.	Examine the architecture of Massive MIMO systems and explain how they improve spectral efficiency, energy efficiency, and system capacity compared to conventional MIMO systems.	(16)	CO1	BTL 4	Analyzing
3.	Apply the Correlated Rayleigh Fading model to describe wireless channel behavior and analyze its impact on Massive MIMO system performance.	(16)	CO1	BTL 3	Applying
4.	Explore the influence of spatial channel correlation on channel capacity, reliability, and user performance in Massive MIMO networks.	(16)	CO1	BTL 4	Analyzing
5.	Illustrate the uplink and downlink system models of Massive MIMO and explain the signal transmission process with appropriate mathematical expressions.	(16)	CO1	BTL 3	Applying
6.	Examine the differences between uplink and downlink communication in Massive MIMO systems and discuss their	(16)	CO1	BTL 4	Analyzing
7.	Apply the concept of channel hardening to explain how increasing the number of antennas improves communication reliability in Massive MIMO systems.	(16)	CO1	BTL 3	Applying
8.	Analyze the phenomenon of channel hardening and discuss its advantages and limitations in practical Massive MIMO deployments.	(16)	CO1	BTL 4	Analyzing

9.	Illustrate the concept of favorable (desirable) propagation to evaluate user channel orthogonality in Massive MIMO systems.	(16)	CO1	BTL 3	Applying
10.	Examine the conditions required for favorable propagation and explain its effect on interference reduction and spectral efficiency.	(16)	CO1	BTL 4	Analyzing
11.	Apply the Local Scattering Spatial Correlation Model to characterize wireless propagation channels and explain its assumptions.	(16)	CO1	BTL 3	Applying
12.	Explore the Local Scattering Spatial Correlation Model and discuss its advantages over independent fading models in practical deployments.	(16)	CO1	BTL 4	Analyzing
13.	Compare and classify correlated and uncorrelated Rayleigh fading channels with respect to channel estimation accuracy and system performance.	(16)	CO1	BTL 4	Analyzing
14.	Examine the combined effects of channel hardening and spatial correlation on the performance of Massive MIMO systems using suitable illustrations.	(16)	CO1	BTL 4	Analyzing
15.	Apply suitable propagation techniques to improve the performance of Massive MIMO systems under correlated channel conditions.	(16)	CO1	BTL 3	Applying
16.	Explore the impact of antenna array size and spatial correlation on the achievable performance of Massive MIMO networks with suitable examples.	(16)	CO1	BTL 4	Analyzing
17.	Develop the complete Massive MIMO network architecture by integrating correlated Rayleigh fading, channel hardening, favorable propagation, and spatial correlation models to evaluate overall system performance.	(16)	CO1	BTL 4	Analyzing

UNIT II MASSIVE MIMO PROPAGATION CHANNEL

Deterministic Channels- Upper Bound Capacity - Linear Processing- Singular Values - Random Channels- Independent Rayleigh Fading- Uniformly Random Line-of-Sight (UR-LoS) - Finite Dimensional Channels

PART A

Q. No	Questions	CO	BT Level	Competence
1.	Define a deterministic channel.	CO2	BTL 1	Remembering
2.	What is meant by channel capacity?	CO2	BTL 1	Remembering
3.	Define upper bound capacity in Massive MIMO systems.	CO2	BTL 1	Remembering
4.	What is linear processing in Massive MIMO?	CO2	BTL 1	Remembering
5.	Define singular values of a channel matrix.	CO2	BTL 1	Remembering
6.	What is an independent Rayleigh fading channel?	CO2	BTL 1	Remembering
7.	Outline the characteristics of a deterministic channel.	CO2	BTL 2	Understanding

8.	Discuss the significance of upper bound capacity in wireless communication.	CO2	BTL 2	Understanding
9.	Discuss the purpose of linear processing in Massive MIMO systems.	CO2	BTL 2	Understanding
10.	Write the importance of singular values in MIMO channel analysis.	CO2	BTL 2	Understanding
11.	Outline the characteristics of a random channel.	CO2	BTL 2	Understanding
12.	Give the concept of independent Rayleigh fading.	CO2	BTL 2	Understanding
13.	Define Uniformly Random Line-of-Sight (UR-LoS).	CO2	BTL 1	Remembering
14.	What is meant by a finite dimensional channel?	CO2	BTL 1	Remembering
15.	Explain the difference between deterministic and random channels.	CO2	BTL 2	Understanding
16.	Explain how linear processing improves system performance in Massive MIMO.	CO2	BTL 2	Understanding
17.	Give the role of singular values in determining channel quality.	CO2	BTL 2	Understanding
18.	Write the advantages of UR-LoS channels in Massive MIMO systems.	CO2	BTL 2	Understanding
19.	Give the significance of finite dimensional channels in practical wireless systems.	CO2	BTL 2	Understanding
20.	List any two assumptions of the independent Rayleigh fading model.	CO2	BTL 1	Remembering
21.	State any four applications of linear processing techniques in Massive MIMO.	CO2	BTL 1	Remembering
22.	Write the impact of channel conditions on system capacity.	CO2	BTL 2	Understanding
23.	Give the relationship between singular values and channel capacity.	CO2	BTL 2	Understanding
24.	Why random channel models are widely used in Massive MIMO performance evaluation.	CO2	BTL 2	Understanding

PART B

Q. No.	Questions	Marks	COs	BT Level	Competence
1.	Develop a deterministic channel model for a Massive MIMO system and explain its characteristics with suitable mathematical expressions.	(16)	CO2	BTL 3	Applying
2.	Explore the deterministic channel model and discuss its advantages and limitations in Massive MIMO communication systems.	(16)	CO2	BTL 4	Analyzing
3.	Apply the concept of upper bound capacity to determine the maximum achievable capacity of a Massive MIMO propagation	(16)	CO2	BTL 3	Applying
4.	Discuss the factors affecting the upper bound capacity of Massive MIMO systems and discuss their impact on system performance.	(16)	CO2	BTL 4	Analyzing
5.	Illustrate the principles of linear processing techniques used in Massive MIMO systems and explain their role in signal detection and transmission.	(16)	CO2	BTL 3	Applying

6.	Elaborate various linear processing techniques and compare their performance in terms of complexity, interference suppression, and spectral efficiency.	(16)	CO2	BTL 4	Analyzing
7.	Illustrate the concept of singular values to evaluate the quality of a MIMO channel matrix and explain its significance in communication systems.	(16)	CO2	BTL 3	Applying
8.	Explore the relationship between singular values, channel rank, and channel capacity in Massive MIMO systems.	(16)	CO2	BTL 4	Analyzing
9.	Develop a random channel model based on Independent Rayleigh Fading and explain its characteristics with suitable assumptions.	(16)	CO2	BTL 3	Applying
10.	Analyze the performance of Independent Rayleigh Fading channels and discuss their advantages and limitations in Massive MIMO networks.	(16)	CO2	BTL 4	Analyzing
11.	Apply the Uniformly Random Line-of-Sight (UR-LoS) model to describe propagation characteristics in Massive MIMO systems.	(16)	CO2	BTL 3	Applying
12.	Analyze the UR-LoS propagation model and compare its performance with Independent Rayleigh Fading channels.	(16)	CO2	BTL 4	Analyzing
13.	Apply the finite dimensional channel model to evaluate the practical behavior of Massive MIMO propagation channels.	(16)	CO2	BTL 3	Applying
14.	Examine the limitations of finite dimensional channels and explain their influence on channel capacity and communication reliability.	(16)	CO2	BTL 4	Analyzing
15.	Develop a comparative analysis of deterministic, random, and UR-LoS channel models with respect to channel characteristics, propagation behavior, and system performance.	(16)	CO2	BTL 4	Analyzing
16.	Evaluate the combined effects of channel models, singular values, and linear processing techniques on the overall performance of Massive MIMO systems.	(16)	CO2	BTL 4	Analyzing
17.	Examine the propagation characteristics of Massive MIMO channels by integrating deterministic channels, upper bound capacity, linear processing, singular values, random channels, Independent Rayleigh Fading, UR-LoS, and finite dimensional channel models.	(16)	CO2	BTL 4	Analyzing

UNIT-III: SINGLE-CELL SYSTEMS

Introduction to Single cell systems - Channel Estimation – Precoding techniques – Channel state information - Orthogonal Pilots- De-Spreading of the Received Pilot Signal - Interpretation of the Effective SINR Expressions - Limiting Factors: Number of Antennas and Mobility.

PART A

Q. No.	Questions	CO	BT Level	Competence
1.	Define a single-cell Massive MIMO system.	CO3	BTL 1	Remembering
2.	What is channel estimation?	CO3	BTL 1	Remembering
3.	Define precoding in Massive MIMO systems.	CO3	BTL 1	Remembering

4.	What is Channel State Information (CSI)?	CO3	BTL 1	Remembering
5.	Define orthogonal pilot sequences.	CO3	BTL 1	Remembering
6.	What is meant by de-spreading of the received pilot signal?	CO3	BTL 1	Remembering
7.	Write the architecture of a single-cell Massive MIMO system.	CO3	BTL 2	Understanding
8.	What is the purpose of channel estimation in wireless communication?	CO3	BTL 2	Understanding
9.	What is the role of precoding techniques in Massive MIMO systems?	CO3	BTL 2	Understanding
10.	Why is Channel State Information (CSI) important for reliable communication?	CO3	BTL 2	Understanding
11.	Why are orthogonal pilots used in channel estimation?	CO3	BTL 2	Understanding
12.	How is the received pilot signal de-spread?	CO3	BTL 2	Understanding
13.	List the advantages of channel estimation.	CO3	BTL 1	Remembering
14.	Define Signal-to-Interference-plus-Noise Ratio (SINR).	CO3	BTL 1	Remembering
15.	Explain the significance of effective SINR in Massive MIMO systems.	CO3	BTL 2	Understanding
16.	Explain the relationship between CSI and precoding.	CO3	BTL 2	Understanding
17.	How does the number of antennas influence system performance?	CO3	BTL 2	Understanding
18.	What is the effect of user mobility on channel estimation accuracy?	CO3	BTL 2	Understanding
19.	What are the limiting factors affecting single-cell Massive MIMO systems?	CO3	BTL 2	Understanding
20.	State any two advantages of orthogonal pilot sequences.	CO3	BTL 1	Remembering
21.	List any four applications of precoding techniques.	CO3	BTL 1	Remembering
22.	Why is effective SINR important in evaluating communication quality?	CO3	BTL 2	Understanding
23.	What is the difference between uplink and downlink CSI acquisition?	CO3	BTL 2	Understanding
24.	How does mobility affect the performance of single-cell Massive MIMO systems?	CO3	BTL 2	Understanding

PART – B

Q. No.	Questions	Marks	COs	BT Level	Competence
1.	Develop the architecture of a single-cell Massive MIMO system and explain its operation with suitable block diagrams.	(16)	CO3	BTL 3	Applying

2.	Examine the characteristics and advantages of single-cell Massive MIMO systems in improving spectral efficiency and communication reliability.	(16)	CO3	BTL 4	Analyzing
3.	Apply suitable channel estimation techniques to estimate the wireless channel in a single-cell Massive MIMO system and explain the estimation process.	(16)	CO3	BTL 3	Applying
4.	Evaluate the factors affecting channel estimation accuracy and discuss their impact on system performance.	(16)	CO3	BTL 4	Analyzing
5.	Illustrate the working of precoding techniques used in single-cell Massive MIMO systems and explain their significance in downlink transmission.	(16)	CO3	BTL 3	Applying
6.	Compare different precoding techniques and compare their performance in terms of interference suppression, complexity, and throughput.	(16)	CO3	BTL 4	Analyzing
7.	Apply the concept of Channel State Information (CSI) to improve communication performance in Massive MIMO systems.	(16)	CO3	BTL 3	Applying
8.	Assess the importance of accurate CSI acquisition and explain its influence on channel estimation and precoding performance.	(16)	CO3	BTL 4	Analyzing
9.	Develop the procedure for orthogonal pilot transmission and explain its role in channel estimation with suitable illustrations.	(16)	CO3	BTL 3	Applying
10.	Examine the advantages and limitations of orthogonal pilot sequences in single-cell Massive MIMO systems.	(16)	CO3	BTL 4	Analyzing
11.	Apply the de-spreading process to the received pilot signal and explain how the channel response is extracted.	(16)	CO3	BTL 3	Applying
12.	Evaluate the de-spreading technique and discuss its contribution to improving channel estimation accuracy.	(16)	CO3	BTL 4	Analyzing
13.	Apply the Effective SINR expressions to evaluate the communication performance of a single-cell Massive MIMO system under different operating conditions.	(16)	CO3	BTL 3	Applying
14.	Interpret the Effective SINR expressions and explain their relationship with system throughput and reliability.	(16)	CO3	BTL 4	Analyzing
15.	Examine the limiting factors of single-cell Massive MIMO systems, including the number of antennas and user mobility, and discuss their impact on system performance.	(16)	CO3	BTL 4	Analyzing
16.	Develop a comparative analysis of channel estimation, CSI acquisition, orthogonal pilot transmission, and precoding techniques for enhancing the performance of single-cell Massive MIMO systems.	(16)	CO3	BTL 4	Analyzing
17.	Evaluate the complete operation of a single-cell Massive MIMO system by integrating channel estimation, Channel State Information (CSI), orthogonal pilots, de-spreading of received pilot signals, Effective SINR, precoding techniques, and the limiting factors of antenna count and user mobility.	(16)	CO3	BTL 4	Analyzing

UNIT IV MULTI-CELL SYSTEMS

Intoduction to Multi cell systems – Comparison between Single cell and Multi-cell systems - Downlink Data Transmission -Zero-Forcing – Maximum-Ratio, Asymptotic Limits with Infinite Numbers of Base Station Antennas – The Effects of Pilot Contamination – Non-Synchronous Pilot Interference – performance evaluation.

PART A

Q. No.	Questions	CO	BT Level	Competence
1.	Define a multi-cell Massive MIMO system.	CO4	BTL 1	Remembering
2.	What is downlink data transmission?	CO4	BTL 1	Remembering
3.	Define Zero-Forcing (ZF) processing.	CO4	BTL 1	Remembering
4.	What is Maximum-Ratio (MR) processing?	CO4	BTL 1	Remembering
5.	Define pilot contamination.	CO4	BTL 1	Remembering
6.	What is non-synchronous pilot interference?	CO4	BTL 1	Remembering
7.	Write the architecture of a multi-cell Massive MIMO system.	CO4	BTL 2	Understanding
8.	What are the differences between single-cell and multi-cell Massive MIMO systems?	CO4	BTL 2	Understanding
9.	What is the purpose of downlink data transmission in Massive MIMO?	CO4	BTL 2	Understanding
10.	How does Zero-Forcing (ZF) processing work?	CO4	BTL 2	Understanding
11.	How does Maximum-Ratio (MR) processing work?	CO4	BTL 2	Understanding
12.	What is the concept of asymptotic limits with an infinite number of base station antennas?	CO4	BTL 2	Understanding
13.	List the advantages of multi-cell Massive MIMO systems.	CO4	BTL 1	Remembering
14.	Define performance evaluation in Massive MIMO systems.	CO4	BTL 1	Remembering
15.	What are the causes of pilot contamination in multi-cell systems?	CO4	BTL 2	Understanding
16.	What is the impact of pilot contamination on system performance?	CO4	BTL 2	Understanding
17.	How does non-synchronous pilot interference affect communication reliability?	CO4	BTL 2	Understanding
18.	Why is asymptotic analysis significant in Massive MIMO systems?	CO4	BTL 2	Understanding
19.	Why is performance evaluation important in multi-cell Massive MIMO systems?	CO4	BTL 2	Understanding
20.	State any two advantages of Zero-Forcing (ZF) processing.	CO4	BTL 1	Remembering
21.	List any four advantages of Maximum-Ratio (MR) processing.	CO4	BTL 1	Remembering
22.	What are the differences between Zero-Forcing (ZF) and Maximum-Ratio (MR) processing?	CO4	BTL 2	Understanding
23.	How does the number of base station antennas affect system performance?	CO4	BTL 2	Understanding

24.	Why is pilot contamination considered a major challenge in multi-cell Massive MIMO systems?	CO4	BTL 2	Understanding	
PART – B					
Q. No.	Questions	Marks	COs	BT Level	Competence
1.	Develop the architecture of a multi-cell Massive MIMO system and explain its operation with suitable block diagrams.	(16)	CO4	BTL 3	Applying
2.	Compare the characteristics of single-cell and multi-cell Massive MIMO systems with respect to coverage, capacity, interference, and spectral efficiency.	(16)	CO4	BTL 4	Analyzing
3.	Illustrate the downlink data transmission process in a multi-cell Massive MIMO system using suitable mathematical expressions and block diagrams.	(16)	CO4	BTL 3	Applying
4.	Examine the challenges encountered during downlink data transmission in multi-cell Massive MIMO systems and discuss suitable mitigation techniques.	(16)	CO4	BTL 4	Analyzing
5.	Apply the Zero-Forcing (ZF) processing technique to suppress inter-user interference in a multi-cell Massive MIMO system and explain its operation.	(16)	CO4	BTL 3	Applying
6.	Evaluate the performance of Zero-Forcing (ZF) processing in terms of interference suppression, computational complexity, and spectral efficiency.	(16)	CO4	BTL 4	Analyzing
7.	Apply the Maximum-Ratio (MR) processing technique for downlink transmission in Massive MIMO systems and explain its working principle.	(16)	CO4	BTL 3	Applying
8.	Compare Maximum-Ratio (MR) and Zero-Forcing (ZF) processing techniques with respect to complexity, throughput, interference suppression, and energy efficiency.	(16)	CO4	BTL 4	Analyzing
9.	Illustrate the concept of asymptotic limits with an infinite number of base station antennas and explain its significance in Massive MIMO systems.	(16)	CO4	BTL 3	Applying
10.	Examine the influence of asymptotic limits on channel hardening, favorable propagation, and system capacity in Massive MIMO networks.	(16)	CO4	BTL 4	Analyzing
11.	Apply the concept of pilot contamination to explain its effect on channel estimation and communication performance in multi-cell Massive MIMO systems.	(16)	CO4	BTL 3	Applying
12.	Assess the effects of pilot contamination on spectral efficiency, channel estimation accuracy, and overall network performance.	(16)	CO4	BTL 4	Analyzing
13.	Illustrate the phenomenon of non-synchronous pilot interference and explain its impact on multi-cell Massive MIMO communication.	(16)	CO4	BTL 3	Applying

14.	Evaluate the impact of non-synchronous pilot interference on system throughput, reliability, and interference management in Massive MIMO systems.	(16)	CO4	BTL 4	Analyzing
15.	Apply suitable performance evaluation metrics to assess the effectiveness of a multi-cell Massive MIMO system under different operating conditions.	(16)	CO4	BTL 3	Applying
16.	Examine the performance of multi-cell Massive MIMO systems by considering downlink transmission, Zero-Forcing, Maximum-Ratio processing, pilot contamination, and non-synchronous pilot interference.	(16)	CO4	BTL 4	Analyzing
17.	Develop a comprehensive performance evaluation framework for a multi-cell Massive MIMO system by integrating downlink data transmission, Zero-Forcing, Maximum-Ratio processing, asymptotic limits, pilot contamination, and non-synchronous pilot interference.	(16)	CO4	BTL 4	Analyzing

UNIT-V: CASE STUDIES

Single-Cell Deployment Example: Fixed Broadband Access in Rural Area, Multi-Cell Deployment: Preliminaries and Algorithms, Multi-Cell Deployment Examples: Mobile Access – Dense Urban Scenario – Suburban Scenario – Minimum Per-Terminal Throughput Performance -Additional Observations – Comparison of Power Control Policies

PART A

Q. No.	Questions	CO	BT Level	Domain
1.	Define fixed broadband access in a rural area.	CO5	BTL 1	Remembering
2.	What is meant by multi-cell deployment?	CO5	BTL 1	Remembering
3.	Define power control in Massive MIMO systems.	CO5	BTL 1	Remembering
4.	What is per-terminal throughput?	CO5	BTL 1	Remembering
5.	Define a dense urban deployment scenario.	CO5	BTL 1	Remembering
6.	What is a suburban deployment scenario?	CO5	BTL 1	Remembering
7.	What are the advantages of single-cell deployment for rural broadband access?	CO5	BTL 2	Understanding
8.	What is the purpose of multi-cell deployment algorithms?	CO5	BTL 2	Understanding
9.	What are the characteristics of mobile access in multi-cell deployments?	CO5	BTL 2	Understanding
10.	What are the challenges of Massive MIMO deployment in dense urban environments?	CO5	BTL 2	Understanding
11.	What are the advantages of suburban deployment in Massive MIMO systems?	CO5	BTL 2	Understanding

12.	Why is interference management important in multi-cell deployments?	CO5	BTL 2	Understanding
13.	Why is minimum per-terminal throughput performance significant?	CO5	BTL 2	Understanding
14.	List the benefits of fixed broadband access using Massive MIMO.	CO5	BTL 1	Remembering
15.	Define throughput fairness in wireless communication.	CO5	BTL 1	Remembering
16.	Why are deployment algorithms important in multi-cell networks?	CO5	BTL 2	Understanding
17.	How does user density affect network performance in dense urban scenarios?	CO5	BTL 2	Understanding
18.	What is the role of power control policies in improving network performance?	CO5	BTL 2	Understanding
19.	What are the differences between rural, suburban, and dense urban deployment scenarios?	CO5	BTL 2	Understanding
20.	Why is performance evaluation important in deployment case studies?	CO5	BTL 2	Understanding
21.	State any two objectives of power control policies.	CO5	BTL 1	Remembering
22.	List any four factors affecting throughput performance in Massive MIMO deployments.	CO5	BTL 1	Remembering
23.	How does power control improve fairness among users in a multi-cell network?	CO5	BTL 2	Understanding
24.	How do deployment scenarios affect network capacity and coverage?	CO5	BTL 2	Understanding

PART – B

Q. No.	Questions	Marks	COs	BT Level	Competence
1.	Develop the deployment architecture of a single-cell Massive MIMO system for fixed broadband access in a rural area and explain its operation with suitable diagrams.	(16)	CO5	BTL 3	Applying
2.	Examine the characteristics of fixed broadband access in rural areas and explain how Massive MIMO improves coverage, capacity, and service quality.	(16)	CO5	BTL 4	Analyzing
3.	Apply suitable deployment principles to design a multi-cell Massive MIMO network and explain the role of deployment algorithms in improving network performance.	(16)	CO5	BTL 3	Applying
4.	Evaluate the objectives and performance of multi-cell deployment algorithms with respect to interference management, user distribution, and spectral efficiency.	(16)	CO5	BTL 4	Analyzing
5.	Illustrate the deployment of Massive MIMO for mobile access in a dense urban scenario and explain the associated communication process.	(16)	CO5	BTL 3	Applying
6.	Compare the performance of dense urban and suburban deployment scenarios in terms of coverage, user density, interference, and throughput.	(16)	CO5	BTL 4	Analyzing

7.	Apply suitable deployment strategies to improve mobile communication performance in suburban Massive MIMO networks.	(16)	CO5	BTL 3	Applying
8.	Examine the challenges encountered in dense urban Massive MIMO deployments and discuss suitable techniques for improving system performance.	(16)	CO5	BTL 4	Analyzing
9.	Illustrate the concept of minimum per-terminal throughput performance and explain its significance in Massive MIMO system design.	(16)	CO5	BTL 3	Applying
10.	Assess the factors affecting minimum per-terminal throughput performance and discuss their influence on fairness and Quality of Service (QoS).	(16)	CO5	BTL 4	Analyzing
11.	Apply suitable power control policies to enhance throughput and communication reliability in a multi-cell Massive MIMO system.	(16)	CO5	BTL 3	Applying
12.	Compare different power control policies with respect to throughput, fairness, energy efficiency, and interference mitigation in Massive MIMO systems.	(16)	CO5	BTL 4	Analyzing
13.	Develop a deployment strategy for a multi-cell Massive MIMO network considering rural, suburban, and dense urban environments to achieve efficient resource utilization.	(16)	CO5	BTL 3	Applying
14.	Evaluate the influence of deployment scenarios on system capacity, spectral efficiency, user fairness, and communication reliability in Massive MIMO networks.	(16)	CO5	BTL 4	Analyzing
15.	Illustrate the role of deployment algorithms and power control techniques in optimizing multi-cell Massive MIMO performance using suitable examples.	(16)	CO5	BTL 3	Applying
16.	Examine the additional observations obtained from deployment case studies and discuss their significance in practical Massive MIMO network planning.	(16)	CO5	BTL 4	Analyzing
17.	Develop an integrated deployment framework for Massive MIMO by incorporating fixed broadband access in rural areas, multi-cell deployment algorithms, dense urban and suburban scenarios, minimum per-terminal throughput performance, and power control policies to evaluate overall network performance.	(16)	CO5	BTL 4	Analyzing