

Course File

Subject Title/Subject Code: 5G Communication/6EC4-05

Semester: VI Year: III

Name of the Faculty: Mr. Hitesh Sen

E-mail id: hitesh.sen@technonjr.org

Class Schedule

Total Number of Lectures: 40

i) Course Objective

The objective of a course on 5G communication is to provide participants with a comprehensive understanding of the principles, technologies, and applications associated with the fifth generation of wireless communication. Specifically, the course aims to:

1. **Understand 5G Fundamentals:** Grasp the basic concepts and architectural framework of 5G networks, including key differences from previous generations (e.g., 4G).
2. **Explore Key Technologies:** Examine the core technologies that enable 5G, such as millimeter wave (mmWave), massive MIMO, beamforming, and network slicing.
3. **Analyze Use Cases and Applications:** Identify and evaluate the diverse applications of 5G across various sectors, including IoT, autonomous vehicles, smart cities, and enhanced mobile broadband.
4. **Discuss Network Design and Management:** Learn about the design principles and management strategies required to implement and optimize 5G networks.

INDEX - COURSE FILE

S. No.	CONTENT / ITEM NO.	PAGE NO.	Status
1	Vision And Mission Of The Institute		
2	Vision And Mission Of The Department		
3	Program Educational Objective Of Department (PEO's)		
4	Program Outcomes Of Department (PO's)		
5	Course Outcome (COs)		
6	COs mapping with Pos and PSOs		
7	Academic Calendar		
8	Evaluation Scheme		
9	Course Syllabus		
10	Prescribed Books		
11	Copy Of Time Table		
12	Course Schedule Plan		
13	Assignment Sheet (Unit Wise)		
14	Quiz Questions (One From Each Unit)		
15	Question Papers Of Mid Term Exam-I		
16	Marks and Gap Analysis in Mid Term I		
17	Remedial Action Taken To Remove the Gaps after mid Term I		
18	Question Papers Of Mid Term Exam-II		
19	Gap Analysis in Mid Term II		
20	Remedial Action Taken To Remove the Gaps after mid Term II		
21	Model Question Paper With Key Solution		
22	University Question Paper (Last one year)		
23	Student Performance Report		
24	Result Analysis		

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

VISSION & MISSION OF INSTITUTE

Vision

Empowering student with recent and emerging technologies to create innovative technical leaders capable of contributing to industrial and societal needs for betterment of mankind across the globe.

Mission

M1: To provide dynamic learning environment to students by providing constant exposure to latest technologies by linking closely with the industries.

M2: To establish effective interface with industry to obtain live problems to enhance critical thinking and problem solving skills among students and consultancy projects for faculty.

M3: To provide avenues and opportunities to faculty for domain specific trainings and qualification upgradation.

M4: To develop ethical leaders with strong communication skills.

VISION & MISSION OF DEPARTMENT

Department Vision

To increase student's learning of fundamentals of programming and latest technologies of IOT through industry-aligned project-based learning transforming students to be good Embedded and IT Professionals leading to innovation and incubation of new ideas.

Department Mission

M1: To create experimental learning through solving problems of Government, Society, Smart Cities, Industry and other entities.

M2: To teach the latest technologies of IOT and Programming Skills to the students as beyond the syllabus activity so that they are updated and industry ready.

M3: To enable engineering students understand industry-aligned technologies and learn to find solutions from their early engineering days and this is the only way to produce globally relevant engineers solving real-life problems applying current technologies.

M4: To enable students to generate projects through problem faced by and requirement of Smart cities, industry, Government and other entities whereby those outlined problem statements are to be studied deeply by a group of faculty members to convert them into real-time project format.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEOs1: Core Knowledge Development: Be competent in applying electronics and communication engineering principles to develop socially and environmentally acceptable engineering solutions.

PEOs2: Professional development: Have fulfilling career in electronic and communication engineering or associated industries or higher education and research, or as entrepreneurs.

PEOs3: Attitude towards lifelong learning: Enhance the ability and attitude to adapt to evolving technological and social challenges.

PROGRAM SPECIFIC OUTCOMES (PSO's)

PSO1: To be aware of and initiate some work on programming and new developments which may impact future embedded and IT industry jobs.

PSO2: Design and development of Embedded and IOT based systems.

PSO3: Get exposure to Embedded and IT Industry work culture

PROGRAMME OUTCOMES (POs)

A student will develop:

PO01. ENGINEERING KNOWLEDGE: Acquire the knowledge of mathematics, science, engineering fundamentals, and electronics and communication engineering, with an ability to understand, analyze and apply to the solution of engineering problems..

PO02. PROBLEM ANALYSIS: Identify, formulate, research literature, analyse and solve electronics and communication engineering problems.

PO03. DESIGN/ DEVELOPMENT OF SOLUTION: Design solutions for electronics and communication engineering problems with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO04. CONDUCTION OF INVESTIGATION OF COMPLEX PROBLEMS: Design and conduct experiments, analyse and interpret data, and synthesize information to provide valid conclusions.

PO05. MODERN TOOL USAGE: Apply appropriate techniques, resources, and modern hardware and software engineering tools to solve electronics and communication engineering problems.

PO06. THE ENGINEERING AND SOCIETY: Apply reasoning to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO07. ENVIRONMENT & SUSTAINABILITY: Demonstrate the understanding of the impact of the professional engineering solutions in societal and environmental contexts, and need for sustainable development.

PO08. ETHICS: Demonstrate the knowledge of professional and ethical responsibilities.

PO09. INDIVIDUAL AND TEAM WORK: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. COMMUNICATION: Comprehend and communicate confidently and effectively in both verbal and written form.

PO11. PROJECT MANAGEMENT & FINANCE: Apply the engineering and management principles for efficient project management.

PO12. LIFE-LONG LEARNING: Recognize the need and acquire confidence for independent and life-long learning.

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

COURSE OUTCOMES (COs) OF THE SUBJECT

CO No.	Mapping	Statement
CO35301.1	Remembering	Recall key concepts and terminology related to 5G communication, including definitions of important technologies (e.g., massive MIMO, network slicing).
CO35301.2	Understanding	Explain the fundamental principles of 5G communication and the differences between 5G and previous generations (e.g., 4G).
CO35301.3	Applying	Apply 5G technologies to propose solutions for specific communication challenges in real-world contexts.
CO35301.4	Analyzing	Evaluate different 5G applications and assess their potential impacts on various industries, considering benefits and challenges.
CO35301.5	Evaluating	Assess the effectiveness of proposed 5G solutions in addressing specific needs or problems in various contexts.
CO35301.6	Creating	Propose innovative ideas for future developments in 5G technology, considering trends and emerging challenges.

COS MAPPING WITH POs AND PSOs

Course Outcome	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	3	2	-	-	-	-	-	-	-	-	2	-
CO2	2	3	1	2	2	-	-	-	-	-	-	1	1	-	-
CO3	3	2	2	-	2	-	-	-	-	-	-	1	-	2	-
CO4	2	2	2	2	1	-	-	-	-	-	-	-	-	2	-
CO5	2	3	3	2	1	-	-	-	-	-	-	-	1	-	-

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

UNIVERSITY ACADEMIC CALENDAR

Academic Calendar for Even Semester for Session

Course: Bachelor of Technology (B.TECH.)				
Semester	II	IV	VI	VIII
Commencement of Classes	26-02-2024	15-02-2024	15-02-2024	2-01-2024
Commencement of First Mid Term	20-04-2024	25-03-2024	25-03-2024	15-02-2024
Commencement of Second Mid Term	05-06-2024	24-05-2024	24-05-2024	21-03-2024
Last Working Day	15-06-2024	31-5-2024	31-5-2024	20-04-2024
Commencement of Practical Exams	01-07-2024	04-6-2024	03-6-2024	22-04-2024
Commencement of Theory Exams	19-6-2024	15-6-2024	14-6-2024	02-05-2024
Project (VIII)	06.05.2024 to 15.05.2024			
Practical Training (After II Sem.)	15.07.2024 To 31.07.2024			
Practical Training (After IV Sem.)	01.07.2024 To 17.08.2024			
Practical Training (After VI Sem.)	01.07.2024 To 17.08.2024			

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Evaluation Scheme

FACULTY DETAILS:

Name of the Faculty : Mr. Hitesh Sen
Designation : Assistant Professor
Department : Electronics and Communication Engineering

1. TARGET

a) Percentage Pass : 95%
b) Percentage I class : 60 %

2. METHOD OF EVALUATION

- 2.1. Continuous Assessment Examinations (Mid-Term 1, Mid-Term 2)
- 2.2. Assignments / Seminars
- 2.3. Mini Projects
- 2.4. Quiz
- 2.5. Semester Examination
- Others _____

3. List out any new topic(s) or any innovation you would like to introduce in teaching the subject in this Semester.

1. Take the help of creative tools to stimulate creativity. Include slide presentations, demonstration or forms of visual exercises that will excite the young minds and capture their interest.

Signature of Faculty:

Signature of HOD

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))



UNIVERSITY SYLLABUS RAJASTHAN TECHNICAL UNIVERSITY, KOTA SYLLABUS

III Year - VI Semester: B.Tech. (Electronics & Communication
Engineering)

6EC4-05: 5G Communication

Credit: 3
3L+0T+0P

Max. Marks: 100(IA:30, ETE:70)
End Term

Exam: 3Hours

Unit	Topic	
1	Introduction: Introduction of 3G and 4G (LTE, LTEA, LTEA Pro), 5G overview, requirements, Spectrum access modes and Sharing for 5G . Channel Modeling : Channel modeling requirements, propagation scenarios and challenges in the 5G modeling	4
2	System Architecture: 5G core network architecture, Radio Access Network (RAN) architectures, Interference management, mobility management and handover in 5G. Physical Layer and Deployment: 5G Physical channels , signals and frame structure ; Small cell deployments: different types, Deployment scenarios, performance and analysis, 3GPP RAN standards for small cell	8
3	Modulation and Accesses Techniques : Orthogonal frequency division multiplexing (OFDM), filter bank multi-carriers (FBMC) , orthogonal frequency division multiple accesses (OFDMA), non-orthogonal multiple accesses (NOMA)	5
4	Device-to-device (D2D) and machine-to-machine (M2M) type communications: Extension of 4G D2D standardization to 5G, radio resource management for mobile broadband D2D, multi-hop and multi-operator D2D communications	5
5	Millimeter-wave Communications: Millimeter bands, radio-wave propagation, Physical layer design, beam-forming, interference and mobility management ; Massive MIMO (Sub 6GHz) -mm wave MIMO (above 6GHz), Smart Antennas for 5G	8
6	5G Network Slicing: Introduction of Network Slicing, E2E Slicing, SDN and NFV Slicing Vehicular Communication: From V2V to AV2X, key standards, VC architectures basics	6
		Total Lectures 40

Text books

1. Martin Sauter, From GSM to LTE—Advanced Pro and 5G: An Introduction to Mobile Networks and Mobile Broadband, Wiley-Blackwell
2. Afif Osseiran, Jose.F.Monserrat, Patrick Marsch, Fundamentals of 5G Mobile Networks , Cambridge University Press
3. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, New Directions in Wireless Communication Systems from Mobile to 5G, CRC Press
4. Theodore S.Rappaport, Robert W.Heath, Robert C.Daniels, James N.Murdock, Millimeter Wave Wireless Communications, Prentice Hall Communications

Reference Books

1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", John Wiley & Sons
2. Alagan Anpalagan, Mehdi Bennis, Rath Vannithamby, Design and deployment of small cell networks, Cambridge university press, 2015
3. M. Vaezi, Z. Ding, and H. V. Poor, Multiple Access techniques for 5G Wireless Networks

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))
and Beyond., Springer Nature, Switzerland, 2019

- Principles of Modern Wireless communication systems by Aditya k Jagannathan
- Manish, M., Devendra, G., Pattanayak, P., Ha, N., 5G and Beyond Wireless Systems PHY Layer Perspective, Series in Wireless Technology Springer, 2021
- Erik Dahlman, Stefan and Parkvall, Johan Skoid, 5G NR: The Next Generation Wireless Access Technology, Elsevier, First Edition, 2016

WEEKLY TIME TABLE OF THE TEACHER

First Time Table: with effect from (Date): 24-11-2023

Day	1	2	3	4	5	6	7
Monday							5G
Tuesday			5G				
Wednesday					5G		
Thursday	5G						
Friday						5G	
Saturday							

Revision: 1 with effect from (Date):

Day	1	2	3	4	5	6	7
Monday			5G				
Tuesday						5G	
Wednesday							5G
Thursday	5G						
Friday						5G	
Saturday							

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

COURSE-PLAN

UNIT	Lect. No.	TOPICS	Teaching Methods/ Teaching Aids
1	1	Introduction of 3G and 4G (LTE, LTEA, LTEA Pro)	White Board/PPT
1	2	5G overview	PPT
1	3	5G requirements	PPT
1	4	Spectrum access modes and Sharing for 5G	White Board/PPT
1	5	Channel Modeling	White Board/PPT
1	6	Channel modeling requirements	PPT
1	7	Propagation scenarios and challenges in the 5G modeling	PPT
2	8	System Architecture: 5G core network architecture and	White Board/PPT
2	9	Radio Accesses Network (RAN) architectures	White Board/PPT
2	10	Interference management, mobility management	White Board
2	11	Handover in 5G	White Board/PPT
2	12	Physical Layer and Deployment	White Board/PPT
2	13	5G Physical channels	PPT
2	14	Signals and frame structure	PPT
2	15	Small cell deployments: different types	PPT
2	16	Deployment scenarios, performance and analysis	White Board/PPT
2	17	3GPP RAN standards for small cell	PPT
3	18	Modulation and Accesses Techniques : Orthogonal frequency division multiplexing (OFDM)	White Board
3	19	Filter bank multi-carriers (FBMC)	White Board
3	20	Orthogonal frequency division multiple accesses (OFDMA)	White Board
3	21	Non-orthogonal multiple accesses (NOMA)	White Board
4	22	Device-to-device (D2D) and machine-to-machine (M2M) type communications	PPT
4	23	Extension of 4G D2D standardization to 5G	PPT
4	24	Radio resource management for mobile broadband D2D	White Board/PPT
4	25	Multi-hop and multi-operator D2D communications	White Board/PPT
5	26	Millimeter-wave Communications	White Board/PPT

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

5	27	Millimeter bands	PPT
5	28	Radio-wave propagation	White Board
5	29	Physical layer design	White Board
5	30	Beam-forming	White Board
5	31	Interference and mobility management	White Board/PPT
5	32	Massive MIMO(Sub 6Ghz) -mm wave MIMO (above 6GHz)	White Board/PPT
5	33	Smart Antennas for 5G	PPT
6	34	5G Network Slicing: Introduction of Network Slicing	White Board/PPT
6	35	E2E Slicing	PPT
6	36	SDN and NFV Slicing	PPT
6	37	Vehicular Communication	White Board/PPT
6	38	From V2V to AV2X	White Board/PPT
6	39	key standards	PPT
6	40	VC architectures basics	White Board/PPT

Signature of Faculty:

HOD

Signature of

Assignment – 1

1. Explain the Key Features of 5G Technology
2. Explain spectrum access modes and sharing for 5g.
3. Write channel modeling requirements for 5G communication.
4. Explain 5G core network architecture with the help of suitable diagram.
5. Explain Radio Access Network (RAN) architecture with the help of suitable diagram.
6. Explain OFDMA and NOMA techniques in detail.

Assignment – 2

1. Explain extension of 4G D2D standardization to 5G.
2. Explain multi-hop and multi-operator D2D communications.
3. Explain MIMO technology used for 5G communication.
4. Explain the concept of beam forming in detail.
5. Discuss about radio resource management for mobile broadband D2D.
6. Explain the concept of network slicing and vehicular communication.

SAMPLE QUIZ QUESTIONS

1. _____ is a transmission method used in MIMO wireless communications to transmit encoded data signals independently.
 - a) MU-MIMO
 - b) STTD
 - c) SM
 - d) Collaborative Uplink MIMO

2. MIMO was initially developed in the year _____
 - a) 1970
 - b) 1990
 - c) 1960
 - d) 1985

3. 5G was introduced in which year?
 - A) July 2015
 - B) July 2016
 - C) July 2017
 - D) July 2018

4. 5G was developed by _____
 - A) IBM
 - B) 3GPP's
 - C) TRAI
 - D) Google

5. Which of the following are some basic network requirements for 5G, as specified by the 3rd Generation Partnership Project (3GPP)?
 - A) Priority, policy, policy control and QoS
 - B) Network slice selection function, network repository function, user plane function and policy control function
 - C) Efficient signaling, fixed mobile convergence, enhanced mobility management and network capability exposure
 - D) Network slicing, efficiency, diverse mobility management and connectivity models

6. Which of the following are ways in which a subscriber can be identified in 5G?
 - A) Permanent Identity
 - B) Concealed Identity
 - C) Temporary Identity
 - D) Hidden Identity

7. 5G will offer latency of one millisecond or lower. What does latency refer to?
 - A) The delay between an input and a desired outcome
 - B) The time it takes to reboot a connection
 - C) The speed of detecting a disruption to the network
 - D) The length of time devices will automatically connect to the network

8. 5G is entirely safe and poses no health or safety concerns.

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

- A) True
- B) False
- C) None of the Above

9. To accommodate faster data transmission speeds, 5G has greater bandwidth. What other term is synonymous with bandwidth?

- A) Speed
- B) Capacity
- C) Strength
- D) Connection

10 . Network slicing is a network management feature that 5G will allow. What does this mean users can have?

- A) The ability to create multiple virtual networks within a single 5G network
- B) The ability to utilize connections from other nearby networks
- C) The ability to designate multiple passwords for one 5G network
- D) The ability to set up multiple connection points to one 5G network

11 . To generate high speeds, 5G utilizes the band of spectrum between 30 GHz and 300 GHz. What is this band of spectrum called?

- A) Millimeter wave
- B) Real-time spectrum
- C) Radio-frequency band
- D) Lower-frequency spectrum

12 . 5G will rely on compact, portable base stations that involve minimal power and can be placed in large quantities throughout geographical areas. What are these called?

- A) Miniature cells
- B) Small cells
- C) Frequent cells
- D) Short-range cells

13 . During the testing phase, 5G broke records of spectrum efficiency. What does spectrum efficiency measure?

- A) How many users can connect to one network
- B) How many connections can run securely at once
- C) How many base stations can communicate over one spectrum
- D) How many bits of data can be transmitted to a certain number of users per second

14 . Which is an operational requirement for network slicing, as specified by 3GPP?

- A) Operators must apply all the requirements to their allocated network resources.
- B) IP Multimedia Subsystem needs to be supported independent of network slices.
- C) Support is needed to provide connectivity to home and roaming users in the same network slice.
- D) Creation, modification and deletion of a network slice should have no or minimal impact on traffic and services in other network slices in the same network.

15 . Spectrum efficiency and MIMO rely on a system called beamforming. What does this term refer to?

- A) A connectivity system that identifies the closest base station for each user
- B) A connectivity system that caps the number of users utilizing the network at once

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

- C) A traffic-signaling system that identifies the route of least interference to deliver data to a user
- D) A traffic-signaling system that breaks down data into smaller packets for transport

16 . Millimeter waves cannot travel well through buildings or obstacles.

- A) True
- B) False
- C) None of the Above

17 . 5G Technology will allow for the introduction of _____

- A) Self-driving cars
- B) Faster internet speeds
- C) Smart homes (internet of things)
- D) All of the Above

18. What is the difference between SDN and NFV?

A) SDN enables effective deployment of cloud resources to the appropriate edge node for a given application and given fixed or mobile user; NFV provides for flexible and dynamic creation and management of paths.

B) SDN enables the movement of edge resources and services to dynamically accommodate mobile users; NFV creates paths that use an access node for one or both ends of a connection involving a wireless device.

C) SDN operates to monitor and enforce QoS requirements by controlling the behavior of the QoS flow for each slice; NFV implements the network functions in a network slice, enabling the isolation of each network slice from all other network slices.

D) All of the Above

19 . The frequency bands for 5G networks come in_____

- A) FR1
- B) FR2
- C) FR3
- D) Both (A) and (B)

20 . 5G utilizes a technology called beamforming.

- A) True
- B) False
- C) None of the Above

QUIZ-ANSWER KEY

Q1. c Q2. b Q3. b Q4. b Q5. d Q6. a Q7. a Q8. b Q9. b Q10. a
Q11. a Q12. b Q13. d Q14. d Q15. c Q16. a Q17. d Q18. c Q19. d Q20. a

Mid Term Paper-I

Roll No. _____

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (VI SEM.) – MT-I

5G Communication (6EC4-05)

Time: 3 Hr

Max. Marks: 70

Part- A (20 Marks)

Answer should be given up to 25 words only. (All questions are compulsory)

(10x2=20)

A.	What is 5G Communication?	CO1
B.	Write data rates of 3G, 4G and 5G communication.	CO1
C.	What is network slicing in 5G communication?	CO1
D.	Write the band names of 5G and mention frequency range for these bands.	CO1
E.	What are eMBB and URLLC in context of 5G communication?	CO1
F.	Write main requirements of 5G Communication.	CO2
G.	What do you mean by Non-Standalone 5G?	CO2
H.	Write the names of various propagation scenarios of 5G Communication.	CO2
I.	What is AMF in 5G core network?	CO2
J.	Which 5G network functions are involved in hand over process?	CO2

Part- B (50 Marks)

Attempt five questions. (Analytical/Problems/Descriptive/Analytical/Problem Solving/Design Question solving questions)

(5x10=50)

1. Explain the requirements of 5G communication in detail.	CO1
Or	
1. Explain spectrum access modes and sharing in 5G communication.	CO1
2. Discuss about channel model requirements of 5G.	CO1

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Or	
2. Explain different propagation scenario of 5G communication.	CO1

3. Explain 5G core network architecture with suitable diagram.	CO1
Or	
3. Explain the process of handover in 5G communication.	CO2

4. Explain different types of Radio Access Network (RAN) architectures.	CO2
Or	
4. What are differences between 4G and 5G communication?	CO2

5. Explain the working of 5G Communication.	CO2
Or	
5. Explain 5G standards in detail.	CO2

Marks and Gap Analysis of Mid-Term 1

Sr. No.	Roll Number	Student Name	Mid-Term 1 MM-70	Remark (Remedial Class need or not – Y/N)
1	21ETCEC001	Abbas Hakimuddin Fakhruddin	51	Y
2	21ETCEC002	Abhishek Kalal	65	N
3	21ETCEC003	Abhishek Rajwaniya	65	N
4	21ETCEC004	Alfez Umar Sheikh	68	N
5	21ETCEC005	Dhawal Purohit	65	N
6	21ETCEC006	Himanshi Soni	68	N
7	21ETCEC007	Jalaj Dashora	58	Y
8	21ETCEC008	Jatin Tailor	63	27
9	21ETCEC009	Manav Kumawat	70	N
10	21ETCEC010	Mohit Gour	61	N
11	21ETCEC013	Rachit Dutt	65	N
12	21ETCEC014	Sanidhya Sharma	58	Y
13	21ETCEC016	Shoaib Khan Pathan	58	Y
14	21ETCEC017	Snehil Sharma	56	Y
15	21ETCEC018	Sumit Israni	58	Y
16	21ETCEC019	Yuvraj Nagda	63	N
17	21ETCEC300	Sahil Bhoi	54	Y
18	22ETCEC200	Khushwant Singh Sarangdevot	68	N

*(Y, if obtained marks are $\leq 70\%$)

Signature of Faculty:

Signature of HOD

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Remedial Action Taken to Remove the Gaps (After Mid- Term 1)

S.no.	University Roll no.	Name of Student	Topics to be discussed in Remedial Class	Schedule Date of Remedial Class	Outcome Achieved
1.	21ETCEC001	Abbas Hakimuddim Fakhruddin	5G core network architecture, Ran architecture, Sharing of 5G, FMBC, NOMA, Orthogonal frequency division multiplexing	10-04-2024	CO1,CO2,CO3
2.	21ETCEC014	Sanidhya Sharma			
3.	21ETCEC017	Snehil Sharma			
4.	21ETCEC018	Sumit Israni			
5.	21ETCEC300	Sahil Bhoi			
6.	21ETCEC007	Jalal Dashora			
7.	21ETCEC016	Shoaib Khan Pathan			

Signature of Faculty:
HOD

Signature of

Mid Term Paper-II

Roll No. _____

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 2nd – YEAR (VI SEM.) – MT-II

5G Communication (6EC4-05)

For ECE

Time: 3 Hr

Max. Marks:70

Part- A (20 Marks)

Answer should be given up to 25 words only. (All questions are compulsory)

(10x2=20)

A.	Write difference between 4G and 5G communication?	CO1
B.	What is the need of network slicing?	CO1
C.	What do you mean by standalone communication?	CO2
D.	What is the need of handover process in communication?	CO2
E.	Draw the diagram of D2D communication.	CO3
F.	What is need of multi-operator D2D communication?	CO3
G.	What are millimeter bands?	CO4
H.	What are the advantages of beam forming?	CO4
I.	Write the names of different network slicing layers.	CO5
J.	What is vehicular communication?	CO5

Part- B (50 Marks)

*Attempt five questions. (Analytical/Problems/Descriptive/Analytical/Problem Solving/Design
Question solving questions)*

(5x10=50)

1. Explain the concept of spectrum sharing in 5G.	CO1
Or	
1. Explain 5G core network architecture with suitable diagram.	CO1

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

2. Explain orthogonal frequency division multiplexing (OFDM) in detail.	CO2
Or	
2. Explain non-orthogonal multiple access (NOMA) in detail.	CO2

3. Explain extension of 4G D2D standardization to 5G.	CO3
Or	
3. Explain multi-hop and multi operator D2D communication in detail.	CO3

4. Explain the concept of beam forming in detail.	CO4
Or	
4. Explain massive MIMO concept of 5G in detail.	CO4

5. What is network slicing? Explain in detail.	CO5
Or	
5. Write short note on- A) E2E network slicing B) SDN network slicing.	CO5

Mid Term Exam – II

Marks and Gap Analysis of Mid-Term II

Sr. No.	Roll Number	Student Name	Mid-Term II MM-70	Remark (Remedial Class need or not – Y/N)
1	21ETCEC001	Abbas Hakimuddin Fakhruddin	51	Y
2	21ETCEC002	Abhishek Kalal	61	N
3	21ETCEC003	Abhishek Rajwaniya	65	N
4	21ETCEC004	Alfez Umar Sheikh	58	N
5	21ETCEC005	Dhawal Purohit	58	N
6	21ETCEC006	Himanshi Soni	68	N
7	21ETCEC007	Jalaj Dashora	58	N
8	21ETCEC008	Jatin Tailor	65	N
9	21ETCEC009	Manav Kumawat	70	N
10	21ETCEC010	Mohit Gour	56	Y
11	21ETCEC013	Rachit Dutt	56	Y
12	21ETCEC014	Sanidhya Sharma	56	Y
13	21ETCEC016	Shoaib Khan Pathan	65	N
14	21ETCEC017	Snehil Sharma	63	N
15	21ETCEC018	Sumit Israni	58	N
16	21ETCEC019	Yuvraj Nagda	58	N
17	21ETCEC300	Sahil Bhoi	54	Y
18	22ETCEC200	Khushwant Singh Sarangdevot	63	N

*(Y, if obtained marks are <=70%)

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Signature of Faculty:

Signature of HOD

Remedial Action Taken to Remove the Gaps (After Mid- Term 1I)

S.no.	University Roll no.	Name of Student	Topics to be discussed in Remedial Class	Schedule Date of Remedial Class	Outcome Achieved
1.	21ETCEC001	Abbas Hakimuddim Fakhruddin	Extension of 4G D2D standardization to 5G, beam-forming, MIMO, Network Slicing, Vehicular Communication	10-06-2024	CO3,CO4,CO5
2.	21ETCEC300	Sahil Bhoi			
3.	21ETCEC014	Sanidhya Sharma			
4.	21ETCEC013	Rachit Dutt			
5.	21ETCEC010	Mohit Gour			

Signature of Faculty:

Signature of HOD

Model Question Paper

Roll No. _____

TECHNO INDIA NJR INSTITUTE OF TECHNOLOGY, UDAIPUR

B. TECH 3rd – YEAR (VI SEM.)

5G Communication (6EC4-05)

Time: 3 Hr

Max. Marks: 70

Part- A (20 Marks)

Answer should be given up to 25 words only. (All questions are compulsory)

(10x2=20)

A.	What is 5G Communication?
B.	Write data rates of 3G, 4G and 5G communication.
C.	What is network slicing in 5G communication?
D.	Write the band names of 5G and mention frequency range for these bands.
E.	What are eMBB and URLLC in context of 5G communication?
F.	What is need of multi-operator D2D communication?
G.	What are millimeter bands?
H.	What are the advantages of beam forming?
I.	Write the names of different network slicing layers.
J.	What is vehicular communication?

Part- B (50 Marks)

Attempt five questions. (Analytical/Problems/Descriptive/Analytical/Problem Solving/Design Question solving questions)

(5x10=50)

1. Explain the requirements of 5G communication in detail.
Or
1. Explain spectrum access modes and sharing in 5G communication.
2. Discuss about channel model requirements of 5G.

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Or

2. Explain different propagation scenario of 5G communication.

3. Explain extension of 4G D2D standardization to 5G.

Or

3. Explain multi-hop and multi operator D2D communication in detail.

4. Explain the concept of beam forming in detail.

Or

4. Explain massive MIMO concept of 5G in detail.

5. What is network slicing? Explain in detail.

Or

5. Write short note on- A) E2E network slicing B) SDN network slicing.

STUDENT PERFORMANCE REPORT

ROLL NO.	NAME	I-MID	II-MID	AVG	ASSIGNMENT	OUT OF MARKS 50
21ETCEC001	Abbas Hakimuddin Fakhruddin	22	22	22	15	37
21ETCEC002	Abhishek Kalal	28	26	27	18	45
21ETCEC003	Abhishek Rajwaniya	28	28	28	16	44
21ETCEC004	Alfez Umar Sheikh	29	25	27	15	42
21ETCEC005	Dhawal Purohit	28	25	27	16	43
21ETCEC006	Himanshi Soni	29	29	29	18	47
21ETCEC007	Jalaj Dashora	25	25	25	19	44
21ETCEC008	Jatin Tailor	27	28	28	16	44
21ETCEC009	Manav Kumawat	30	30	30	19	49

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

21ETCEC010	Mohit Gour	26	24	25	19	44
21ETCEC013	Rachit Dutt	28	24	26	18	44
21ETCEC014	Sanidhya Sharma	25	24	25	15	40
21ETCEC016	Shoaib Khan Pathan	25	28	27	18	45
21ETCEC017	Snehil Sharma	24	27	26	17	43
21ETCEC018	Sumit Israni	25	25	25	15	40
21ETCEC019	Yuvraj Nagda	27	25	26	15	41
21ETCEC300	Sahil Bhoi	23	23	23	18	41
22ETCEC200	Khushwant Singh Sarangdevot	29	27	27	16	43

Signature of Faculty:

Signature of HOD

RESULT ANALYSIS

S.NO.	RTU ROLL NUMBER	NAME OF STUDENT	END TERM MARKS	SESSIONAL MARKS	TOTAL
			70	30	100
		Set Target Level	60%	75%	
1	21ETCEC001	Abbas Hakimuddin Fakhruddin	A	22	22
2	21ETCEC002	Abhishek Kalal	31	27	58
3	21ETCEC003	Abhishek Rajwaniya	48	28	76
4	21ETCEC004	Alfez Umar Sheikh	48	27	75
5	21ETCEC005	Dhawal Purohit	43	27	70
6	21ETCEC006	Himanshi Soni	48	29	77
7	21ETCEC007	Jalaj Dashora	35	25	60
8	21ETCEC008	Jatin Tailor	46	28	74
9	21ETCEC009	Manav Kumawat	57	30	87
10	21ETCEC010	Mohit Gour	45	25	70
11	21ETCEC013	Rachit Dutt	53	26	79

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

12	21ETCEC014	Sanidhya Sharma	36	25	61
13	21ETCEC016	Shoaib Khan Pathan	50	27	77
14	21ETCEC017	Snehil Sharma	34	26	60
15	21ETCEC018	Sumit Israni	42	25	67
16	21ETCEC019	Yuvraj Nagda	37	26	63
17	21ETCEC300	Sahil Bhoi	50	23	73
18	22ETCEC200	Khushwant Singh Sarangdevot	43	27	70

TOTAL	PASS	FAIL	ABSENT	PASS %
18	16	2	1	88.88

Indirect Assessment:

Overall Teacher Self Assessment (at the completion of course) in terms of course objective and outcomes

Course Objectives:

The objective of a course on 5G communication is to provide participants with a comprehensive understanding of the principles, technologies, and applications associated with the fifth generation of wireless communication. Specifically, the course aims to:

- 1. Understand 5G Fundamentals:** Grasp the basic concepts and architectural framework of 5G networks, including key differences from previous generations (e.g., 4G).
- 2. Explore Key Technologies:** Examine the core technologies that enable 5G, such as millimeter wave (mmWave), massive MIMO, beamforming, and network slicing.
- 3. Analyze Use Cases and Applications:** Identify and evaluate the diverse applications of 5G across various sectors, including IoT, autonomous vehicles, smart cities, and enhanced mobile broadband.
- 4. Discuss Network Design and Management:** Learn about the design principles and management strategies required to implement and optimize 5G networks.

Course Outcomes:

Students will be able to recall key concepts and terminology related to 5G communication, including definitions of important technologies (e.g., massive MIMO, network slicing).

Students will be able to explain the fundamental principles of 5G communication and the differences between 5G and previous generations (e.g., 4G).

Students will be able to apply 5G technologies to propose solutions for specific communication challenges in real-world contexts.

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

Students will be able to evaluate different 5G applications and assess their potential impacts on various industries, considering benefits and challenges.

Students will be able to assess the effectiveness of proposed 5G solutions in addressing specific needs or problems in various contexts.

Students will be able to propose innovative ideas for future developments in 5G technology, considering trends and emerging challenges.

Methodology to identify bright student

Considered a range of criteria, including academic performance, creativity, critical thinking, problem-solving skills, and enthusiasm for learning. Bright students often excel in multiple areas. Observed how students perform in the classroom. In terms of active participation, engagement in discussions, leadership, and the ability to grasp complex concepts.

Efforts to keep students engaged

1. Active Learning:
 - Incorporate active learning strategies, such as group discussions, problem-solving activities, and hands-on projects. Active participation keeps students engaged and encourages critical thinking.
2. Varied Teaching Methods:
 - Use a variety of teaching methods, including lectures, group work, multimedia presentations, and interactive activities to cater to different learning preferences.
3. Technology Integration:
 - Leverage technology, such as online platforms, educational apps, and interactive software, to make lessons more engaging and interactive.

Some extra learning for bright students

1. <https://www.akademika.no/gsm-lte-advanced-pro-and-5g-introduction-mobile-networks-and-mobile-broadband/9781119346937r120?v=16439228>
2. <https://www.youtube.com/watch?v=YYVoCpqsPwmQ>
3. <https://www.thefastmode.com/expert-opinion/14287-what-are-the-technology-requirements-for-5g>

Methodology to identify weak student

Considered a range of criteria, including classroom observation, formative assessment, summative assessment, assignment review etc. Weak students are struggling students with sensitivity and a desire to support their learning. Some measures, such as additional tutoring, personalized assignments, or alternative assessment methods, to help students succeed.

Targeted interventions for weak student

1. Additional Resources

Offer supplementary learning materials, such as textbooks, online resources, or multimedia content, to provide alternative explanations and reinforce key concepts.

2. Remedial classes

Establish a tutoring program where students can receive extra help from teachers.

Techno India NJR Institute of Technology

(Approved by AICTE, New Delhi and Affiliated to Rajasthan Technical University Kota (Raj.))

3. Flipped classroom

Students are assigned pre-class learning materials, often in the form of videos, readings, or online modules, to cover the foundational concepts before coming to class.

Some additional resources or links for student to improve their understanding for topic

1. <https://nptel.ac.in/courses/117104484>
2. <http://archive.nptel.ac.in/courses/108/105/108105179/>