DEPARTMENT OF ELECTRICAL ENGINEERING

National University of Sciences and Technology (NUST)

1. Course Information	
Course Number and Title:	EE-356 Wireless Communications
Credits:	(3+0)
Instructor(s)-in-charge:	Associate Prof. Dr. Abdul Wakeel
Course type:	Lecture
Required or Elective:	Elective
Course pre-requisites	
Degree and Semester	
Month and Year	

2. Course Schedule	
Lecture:	3 hrs/week, Meets twice weekly
Lab:	
Discussion:	1 hrs/week
Office Hours :	3 hrs/week by instructor

3. Course Assessment		
Exam:	1 MID Term and 1 Final Examination	
Home work:	3-6 Assignments	
Lab reports:	-	
Design reports:	1x Semester Project	
Quizzes:	3-6 Quizzes	
Grading:	Quizzes:	10%
	Assignments:	10%
	1 MID Term Exam	30%
	Final Exam:	45%
	Semester Project	5%

4. Course book and Related Course Material	
Textbooks:	**Theodor S. Rappaport: Wireless Communications** Principles and Practice, 2nd Edition, Printice Hall.
Reference Books:	**Andrea Goldsmith: Wireless Communications** **David Tse and Pramod Viswanath: Fundamentals of wireless communications, Cambridge.**

5. Catalog Descriptions

This course provides a comprehensive introduction to the principles and practices of wireless communication systems. It focuses on radio wave propagation, wireless channel characterization, large-scale and small-scale fading, and cellular system design concepts. The course also covers multiple access techniques, spread spectrum communication, MIMO systems, and capacity enhancement methods. In addition, students are introduced to modern topics in wireless communication technologies such as, massive MIMO, millimeter-wave communication, and emerging trends including cognitive radio. The course emphasizes analytical understanding and system-level insights essential for designing and evaluating contemporary wireless communication systems.

6. Course Objectives

 Understand the fundamental concepts and challenges of wireless communication systems and radio wave propagation.

 Analyze large-scale and small-scale fading phenomena and their impact on wireless channel performance.

 Apply multiple access and spread spectrum techniques in the context of wireless system operation.

 Describe MIMO and diversity techniques used to enhance reliability and capacity in modern wireless systems.

 Identify and explain key technologies and trends in modern wireless communications**.**

Topics covered in the Course and Level of Coverage

Topics	Chapters	CLO	Weeks
Introduction to Wireless Communications • Evolution of wireless systems • Applications and challenges • Wireless vs wired communication	Chapter 2	1	1
Electromagnetic Spectrum & Propagation Mechanisms • Electromagnetic spectrum • Reflection, diffraction, scattering • Free-space propagation model	Chapter 4	1	2
Large-Scale Path Loss Models • Path loss concepts • Log-distance model • Okumura and Hata models.	Chapter 4	2	3

Shadowing and Large-Scale Fading • Log-normal shadowing • Measurement-based modeling • Impact on system design	Chapter 4	2	5
Small-Scale Fading Fundamentals • Multipath propagation • Delay spread • Coherence bandwidth and coherence time	Chapter 5	2	6
Statistical Models for Small-Scale Fading • Rayleigh, Rician, Nakagami fading • Doppler effects • Fade statistics	Chapter 5	2	7
Channel estimation • Purpose of Channel Estimation • Channel Estimation Techniques • Least Squares (LS) and Minimum Mean Square Error (MMSE).	Materials to be provided	3	8
Mid Term			
Channel equalization • Need for Channel Equalization • Types of Equalizer: Linear equalizer (ZF, MMSE), Non-linear equalizer (DFE), and Adaptive equalizers (LMS and RLS)	Chapter 7	3	10
Optimal receiver structure • Match Filter receiver/ Corelator receiver • ML receiver • MAP Receiver	Materials to be provided	3	11
Multiple Access Techniques • Multiplexing: FDM, TDM and CDM • Multiple access: FDMA, TDMA, CDMA, OFDM • Comparison and applications	Chapter 9	3	12-13
Spread Spectrum Techniques • DSSS • FHSS • Processing gain and interference suppression	Chapter 9	3	13
MIMO and Diversity Techniques • Diversity concepts	Chapter 10 Andrea Goldsmith	4	14

• SIMO, MISO, MIMO systems • Spatial multiplexing • Capacity benefits of MIMO			

5G Wireless Communication Systems
 	
• Key technologies:
  ○ Massive MIMO
  ○ Beamforming
  ○ mmWave communication
	Materials to be provided	4	15

Modern Trends in Wireless Communications • Cognitive radio • Software-defined radio (SDR)	Materials to be provided	4	16
FINAL TERM EXAM			

7. **Course Outcomes and their Relation to Program Outcomes (Mapping CLO to PLO)**

Course Learning Outcome (CLOs)		**PLOs**	**Learning Level**
CLO 1	Explain fundamental concepts of wireless communication and radio propagation mechanisms	1	C2
CLO 2	Analyze large-scale and small-scale fading effects in wireless channels	2	C3
CLO 3	.Apply multiple access, Channel Estimation, channel equalization and spread spectrum techniques in wireless systems,	2	C3
CLO 4	Explain MIMO principles and diversity techniques for performance enhancementand emerging trends in modern wireless communications	12	C3

8. Mapping of CLOs to Program Learning Outcomes

PLOs / CLOs	**CLO** 1	**CLO** 2	**CLO** 3	**CLO** 4	**CLO** 5
PLO:1 (Engineering Knowledge**)**	**C2**				
PLO:2 (Problem Analysis**)**		**C3**	**C4**		
PLO:3 (Design/ Development of Solutions**)**					
PLO:4 (Investigation**)**					
PLO:5 (Modern Tool Usage**)**					
PLO:6 (The Engineer and Society**)**					
PLO:7 (Environment and Sustainability**)**					
PLO:8 (ProfessionalEthics)					
PLO:9 (Individual and Team Work**)**					

PLO:10 (Communication**)**					
PLO:11 (Project Management**)**					
PLO:12 (Lifelong Learning**)**				**C3**	

1. Program Learning Outcomes	
PLO 1	**Engineering Knowledge**
	An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PLO 2	**Problem Analysis**
	An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PLO 3	**Design/Development of Solutions**
	An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PLO 4	**Investigation**
	An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.
PLO 5	**Modern Tool Usage**
	An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.
PLO 6	**The Engineer and Society**
	An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.
PLO 7	**Environment and Sustainability**
	An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
PLO 8	**Professional Ethics**
	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PLO 9	**Individual and Teamwork**
	An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.
PLO 10	**Communication**
	An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PLO 11	**Project Management**
	An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.
PLO 12	**Lifelong Learning**
	Lifelong Learning: An ability to recognize the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.