Savitribai Phule Pune University. Pune

Maharashtra, India

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern)

ME- Electronics and Telecommunication Engineering

(Communication Networks)

(With effect from Academic Year 2025-26)

Contents

Abbreviations

PEO Programme Educational Objectives

PO Programme Outcomes

WK Knowledge Attitude

Master of Engineering in Electronics & Telecommunication (Communication Networks) - 2025 Pattern

Preface by Board of Studies

Dear Students and Faculty Members,

We, the members of the Board of Studies of Electronics & Telecommunication engineering, are happy to present the syllabus for the Master of Engineering in **Communication Network** program, effective from the Academic Year 2025–26 (2025 Pattern).

Communication Network is a critical and rapidly advancing field that forms the backbone of our connected world. It encompasses the design, analysis, and implementation of wired and wireless communication systems, protocols, and network architectures that enable reliable and efficient data exchange across the globe.

This curriculum is thoughtfully designed to provide students with a strong theoretical foundation and practical expertise in areas such as network protocols, wireless communications, Internet of Things (IoT), network security, and emerging technologies like 5G and beyond. It aims to prepare students to meet the growing demands of the communication industry and contribute to innovations that shape the future of connectivity. We are confident that this program will empower students to excel in both academic and professional arenas, equipped with the knowledge and skills required to thrive in the dynamic landscape of communication technologies.

The curriculum revision is mainly focused on knowledge component, skill-based activities, experiential learning and project-based activities. The revised syllabus falls in line with the objectives of Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. Learners are now getting sufficient time for self-learning either through online courses or additional projects for enhancing their knowledge and skill sets. We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Dr. Suresh Shirbahadurkar

Chairman

Board of Studies - Electronics & Telecommunication Engineering

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Dr. Urmila Patil	Dr. D. Y. Patil Institute of Technology, Pimpri, Pune

Savitribai Phule Pune University

Curriculum Structure Semester- I

Master of Engineering (2025 Pattern) – Electronics & Telecommunication Engineering (Communication Networks)

*Comprehensive Continuous Evaluation

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			Theory	Practical	CCE*	End-Sem	Term-Work	Practical	Oral	Total	Theory	Practical	Total
PCC-501-CMN	Program Core Course	Advance Modeling and Simulation of Communication network	4	-	50	50	-	-	-	100	4	-	4
PCC -502-CMN	Program Core Course	High Speed Communication Networks	4	-	50	50	-	-	-	100	4	-	4
PCC- 503-CMN	Program Core Course	Network and Cyber Security	4	-	50	50	-	-	-	100	4	-	4
PCC -504- CMN	Program Core Course	VLSI Chip Design & Fabrication	4	-	50	50	-	-	-	100	4	-	4
PCC-505- CMN	Program Core Course	Laboratory Practice-I	-	4	-	-	25	-	25	50	-	2	2
PEC-521- CMN	Program Elective Course	Elective I	3	-	50	50	-	-	-	100	3	-	3
PEC -522- CMN	Program Elective Course	Skilled Based laboratory -I	-	2	-	-	25	-	25	50	-	1	1
Total			**19**	**6**	**250**	**250**	**50**	**-**	**50**	**600**	**19**	**3**	**22**

Elective I Courses:

PEC-521A- CMN	Block chain
PEC-521B -CMN	Coding and Modulation Techniques
PEC-521C- CMN	Detection and Estimation Theory
PEC-521D- CMN	Neural Networks in Communication

Savitribai Phule Pune University

Curriculum Structure Semester- II

Master of Engineering (2025 Pattern) – Electronics & Telecommunication Engineering (Communication Networks)

Level 6.0

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			Theory	Practical	CCE*	End-Sem	Term-Work	Practical	Oral	Total	Theory	Practical	Total
PCC -551- CMN	Program Core Course	Broadband Wireless Technologies	4	-	50	50	-	-	-	100	4	-	4
PCC -552- CMN	Program Core Course	5G LTE Cellular Networks	4	-	50	50	-	-	-	100	4	-	4
PCC -553- CMN	Program Core Course	Embedded Technology of IOT	4	-	50	50	-	-	-	100	4	-	4
PCC -554- CMN	Program Core Course	Laboratory Practice-II	-	4	-	-	25	-	25	50	2	-	2
PEC-561- CMN	Program Elective Course	Elective-II	3	-	50	50	-	-	-	100	3	-	3
PEC-562- CMN	Program Elective Course	Elective -III	3	-	50	50	-	-	-	100	3		3
SEM -571- CMN	Seminar	Seminar –I	-	4	-	-	25	-	25	50	2	-	2
Total			18	8	250	250	50	-	50	600	18	4	22

*Comprehensive Continuous Evaluation

Elective II Courses:

PEC-561A- CMN	Machine Learning
PEC-561B- CMN	Spread Spectrum & CDMA System
PEC-561C- CMN	Optical Networks
PEC-561D- CMN	RF MEMS

Elective III Courses:

PEC-562A-CMN	Cloud Architecture Protocols
PEC-562B- CMN	SDR and Cognitive Radio
PEC-562C- CMN	Traffic Analysis and QoS
PEC-562D- CMN	Modern Communication Receiver Design & Technology

Savitribai Phule Pune University
Curriculum Structure Semester - III

Master of Engineering (2025 Pattern) – Electronics & Telecommunication Engineering (Communication Networks)

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			Theory	Practical	CCE*	End-Sem	Term-Work	Practical	Oral	Total	Theory	Practical	Total
RM -601 – CMN	Research Methodology	Research Methodology	5	-	50	50	-	-	-	100	5	-	5
OJT-602- CMN	OJT/Internship	On Job Training /Internship	-	10	-	-	100	-	-	100	-	5	5
SEM-603- CMN	Seminar	Seminar -II	-	6	-	-	25	-	25	50	-	3	3
RPR-604- CMN	Research Project	Research Project -_I	-	18	-	-	25	-	25	50	-	9	9
		Total	**05**	**34**	**50**	**50**	**150**	**-**	**50**	**300**	**05**	**17**	**22**

Curriculum Structure Semester- IV

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			Theory	Practical	CCE*	End-Sem	Term-Work	Practical	Oral/Presentation	Total	Theory	Practical	Total
SEM -651- CMN	Seminar	Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-652- CMN	Research Project	Research Project	-	36	-	-	150	-	50	200	-	18	18
Total			**-**	**44**	**-**	**-**	**200**	**-**	**100**	**300**	**-**	**22**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

Master of Engineering (2025 Pattern)
Electronics & Telecommunication Engineering
(Communication Networks)

Semester I

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-501- CMN - Advance Modeling and Simulation of Communication network		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE :** 50 Marks **End-Semester:** 50 Marks

Prerequisite Courses:

1. Basic understanding of analog and digital modulation.
2. Fundamentals of probability, random variables, and basic distributions, random processes, especially Poisson and Gaussian models.
3. Knowledge of time-domain and frequency-domain analysis ,convolution ,filtering
4. System behaviour modelling.
5. Overview of network layers, protocols, routing, and queuing.
6. Familiarity with MATLAB, Python, or any simulation-oriented language.

Course Objectives: The course aims to:

1. Categorize Simulation Methods of communication networks
2. Describe random signal generation and processes.
3. Develop Monte Carlo algorithms and Traffic Modeling
4. Design different channel models and their simulation
5. Develop skills to design and validate network models

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Analyze random processes and apply the knowledge to improve the performance of communication network. .
- **CO2:** Construct Monte Carlo algorithm and Design Traffic Modeling.
- **CO3:** Design different channel models and Time varying systems.
- **CO4**: Analyze different Simulation Techniques
- **CO5**: Design the different simulation Techniques

Course Contents

Unit I - : Simulation Methodology:- (10 Hours)

Introduction, Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass Equivalent, Low-pass equivalent models for OFDM/NR signals, Simulation of multicarrier and MIMO systems in 5G, Time-varying and nonlinear system modelling, Visualization and post- Processing using Python.

Unit II - Random Signal Generation & Processing - (10 Hours)

Uniform random number generation, mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, testing of random number generators. (Chi-square, KS tests).

Unit III - Monte Carlo Simulation & Network and Traffic Modelling :- (10 Hours)

Fundamental concepts, Application to communication systems, Monte Carlo integration, Semi analytic techniques for 5G channel modelling, Case study: Performance estimation of a wireless system. Queuing theory (M/M/1, M/G/1), SDN/NFV concepts, Poissonian and Non-Poissonian modeling of network traffic; Traffic models such as Poisson, Self-similar,

Unit IV - Models & Simulation Techniques- (10 Hours)

Types, Memory-less non-linearities, non-linearities with memory, Modelling and simulation of Time varying systems: Random process models, Tapped delay line model, Modelling and simulation of waveform channels, Discrete memory-less channel models, Markov model for discrete channels with memory, Tail extrapolation, pdf estimators,

Unit V - Advance Simulation Networks - (10 Hours)

Importance of sampling methods Digital Twin simulation frameworks for IoT and Industry 4.0, AI-enhanced simulation: Reinforcement Learning for adaptive systems. Bursty IoT traffic, Simulation of network slices and MEC in 5G using Mininet + NS-3.

Leaning Resources

Textbooks:

1. William. H. Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, principles of Communication Systems Simulation, Pearson Education (Singapore) Pvt. Ltd, 2004.
2. M.C. Jeruchim, P. Balaban and K. Sam Shanmugam, Simulation of Communication Systems: Modeling, Methodology and Techniques, Plenum Press, New York,

Reference Books:

1. Averill. M. Law and W. David Kelton, Simulation Modeling and Analysis, McGraw Hill Inc., 2000.
2. Geoffrey Gorden, System Simulation, Prentice Hall of India, 2nd Edition, 1992.
3. Jerry Banks and John S. Carson, Discrete Event System Simulation, Prentice Hall of India, 1984

SWAYAM/MOOC/YouTube Links

1. https://www.youtube.com/watch?v=VjWoTof6Iko
2. https://onlinecourses.swayam2.ac.in/cec20_hs17/preview
3. https://onlinecourses.nptel.ac.in/ noc23_ee136/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-502-CMN - High Speed Communication Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 04 Hours/Week	04	**Termwork :** 25 Marks **Oral :** 25 Marks

Prerequisite Courses:

1. Basic understanding of wireless communication (if studying 4G/5G)
2. Knowledge of QoS (Quality of Service) principles
3. Familiarity with MPLS, ATM, SONET/SDH (in traditional high-speed networks)
4. Basics of optical networks (WDM, DWDM)

Course Objectives: The course aims to:

1. Differentiate high speed networking technologies, architectures and protocols.
2. Describe random signal generation and processes.
3. Describe the concept of queuing Models and congestion control.
4. Categorize the TCP, ATM congestion and traffic management
5. Design Integrated Services Architecture, Audio and video media transport in networks.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Compose the concepts of high-speed networks and Routing protocols.
- **CO2:** Describe queuing Models and effect of congestion in Packet Switching Networks.
- **CO3:** Compare TCP and ATM congestion control protocols.
- **CO4:** Describe integrated and differentiated services, Audio and video media transport in wired & wireless networks.
- **CO5:** Describe and analyze quantum information theory concepts.

Course Contents

Unit I - : High Speed Networks:- (10 Hours)

Fundamentals of high-speed network architectures and protocols, Link Layer addressing, Inter networking, Multimedia Communications, Quality of services, Resource Allocation and traffic control, Dynamic Routing protocols. High Speed Networks: Frame Relay Networks–Asynchronous transfer mode–ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL. High Speed LAN‟s: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LAN‟s: applications, requirements – Architecture of 802.11.

Unit II - Congestion and Traffic Management - (10 Hours)

Queuing Analysis–queuing Models–Single Server Queues–Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control.

Unit III - TCP Congestion Control - (10 Hours)

TCP Flow Control–TCP Congestion Control–Retransmission–Timer Management – Exponential RTO back off – KARN‟s Algorithm – Window Management – Performance of TCP over ATM .ATM Congestion Control: Traffic and Congestion control in ATM–Requirements–Attributes Traffic Management Framework, Traffic control – ABR traffic Management - ABR rate control, RM cell formats ABR Capacity allocations – GFR traffic management.

Unit IV - Wireless optical technologies - (10 Hours)

Wireless and Optical technologies - Introduction to Wireless Optical Communication, Free Space Optical Communication, Visible Light Communication (VLC) and Li-Fi, Underwater Wireless Optical Communication, Hybrid Wireless Optical Systems.

Unit V – Quantum Communications - (10 Hours)

Quantum Information Theory, Quantum entropy & mutual information, Quantum channel capacity Holevo's bound, quantum error correction, Quantum Networking, Quantum repeaters & entanglement swapping Quantum teleportation for communication Quantum internet architecture

Learning Resources

Textbooks:

1. W. Stallings, *High-Speed Networks and Internets: Performance and Quality of Service*, 2nd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002.
2. W. Stallings, *Data and Computer Communications*, 10th ed. Boston, MA, USA: Pearson, 2013.
3. J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach*, 7th ed. Boston, MA, USA: Pearson, 2017.

Reference Books:

1. William Stallings, "High Speed Networks and Internet", Communication Networks", Jean Harcourt Asia, Pvt. Ltd., II Edition, 2001.
2. Irvan Pepelnjk, Jim Guichard and Jeff Apcar, "MPLS and VPN architecture", Cisco Press, Volume 1 and 2, 2003.
3. Tom Sheldon, "Encyclopedia of Networking and telecommunications" TMH, 2001

SWAYAM/MOOC/YouTube Links

1. https://www.youtube.com/watch?v=1Xj5RT-RMzc&t=343s
2. https://onlinecourses.swayam2.ac.in/ noc24_cs19/preview
3. https://onlinecourses.nptel.ac.in/noc20_ee61/preview

Laboratory Experiments:

1. Write an article on the latest development in the ATM congestion control.
2. Discuss in detail all the versions of the Architecture of 802.11.as applied to different radio access techniques.
3. Write a note on various queuing models for traffic congestion control highlighting their advantages, disadvantages and applications.
4. Comment on the various Integrated Services Architecture leading to QoS support with proper justification.
5. Design any one high speed communication network to give atleast on parameter related to QoS.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-503-CMN- Network and Cyber security		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Course:

1. Knowledge of Computer Networks Basics
2. Knowledge of Basic Programming Skills
3. Introduction to Cryptography
4. Basic Cybersecurity Concepts

Course Objectives: The course aims to:

1. Discriminate network security concept and different security algorithms.
2. Categorize security protocols and models.
3. Analyze the performance of Network security applications.
4. Comply the needs and issues related to social networking and cyber security
5. Analyze the next generation networks

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Design different cryptography algorithms.
- **CO2:** Apply standards and laws of security related to different protocols and models.
- **CO3:** Develop security application by considering authentication Processes.
- **CO4:** Develop solutions for network and cyber security issues.
- **CO5:** Design secure solutions for next-generation networks (5G/6G, IoT, CPS) considering evolving cyber threats.

Course Contents

Unit I – Introduction to Networking: - (10 Hours)

Overview of Networking Concepts, Overview of Network Security and Operations, Information Security Concepts, Security Threats and Vulnerabilities, Cryptography, Conventional encryption, cipher-block, location of encryption devices, key distribution. Public key cryptography, RSA algorithm, diffie-hellman algorithms, message authentication, secure hash functions, HMAC, digital signatures, key management. Secrete Key Cryptography, DES, IDEA, AES.

Unit II – Networking Technologies and Protocols - (10 Hours)

Secure Software Design, Network Security Concepts, Access Control and Intrusion Detection, Security Technologies and Protocols, Security Architecture and Models, Operating System Security, Security Management and Practices, Laws and Standards. Intrusion prevention systems (IPS), and unified threat Management (UTM).

Unit III - Network Security and applications - (10 Hours)

Network Security applications: Authentication applications email Security, PGP, SMIME IP Security, authentication on header, encapsulating security payload, combining security associations, key management. Web Security Requirements, SSL and TSL, SET. Usage of security tokens and biometrics in two-factor authentication systems.

Unit IV – Introduction of Cyber Security - (10 Hours)

Cybersecurity, cyber-physical systems, Cyber-attacks, need of cybersecurity for wired and wireless networks, Cyber security for Smart Grids, Botnets and Cyber security, Cyber security for VoIP, Cyber Physical Systems and their security, Cyber security for online shopping, Incident Handling with Cyber security, Cyber security for Bluetooth Data Communication, Social Networking and Cyber security, Analysis of attack vectors in IoT devices and their corresponding defences, NIST.

Unit IV – Advanced Security Mechanisms and Emerging Trends- (10 Hours)

Advanced Cryptographic Techniques, Block chain and Distributed Ledger Security, Zero Trust Architecture (ZTA), Security in Cloud and Edge Computing, AI and Machine Learning for Cybersecurity, Emerging Security Challenges in Next-Gen Networks

Learning Resources

Textbooks:

1 William Stallings, “Cryptography and Network Security”, 3rd edition, Pearson Education

2. Jochen Schiller, “Mobile Communications”, Addison Wesley, 2000.

3. C. Siva Ram Murthy and B. S. Manoj, “Ad Hoc Wireless Networks: Architectures and Protocols”, Prentice Hall.

4. Ramjee Prasad and Luis Munoz, “WLANs and WPANs towards 4G wireless”, Artech House, 2003. 5. W. Stallings, *High-Speed Networks and Internets: Performance and Quality of Service*, 2nd ed. Upper Saddle River, NJ, USA: Prentice Hall, 2002.

Reference Books:

1 Evangelos Kranakis, “ Primality and Cryptography”, John Wiley & Sons

2. Rainer A. Ruppel, “ Analysis and Design of Stream Ciphers”, Springer Verlag

3. Douglas A. Stinson, “Cryptography, Theory and Practice”, 2nd edition, Chapman & Hall, CRC Press Company, Washington.

SWAYAM/MOOC/Youtube Links

- https://www.youtube.com/playlist?list=PLbszJxGNQ27lVbc3QupQGnwvNL7otsFmO
- https://onlinecourses.swayam2.ac.in/ noc25_ee54/preview
- onlinecourses.swayam2.ac.in/cec20_cs15/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-504-CMN - VLSI Chip design & Fabrication		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE :** 50 Marks **End-Semester:** 50 Marks

Prerequisite Courses: Digital Electronics, VLSI Design

Course Objectives: The course aims to:

1. To understand Verilog and its use to the design various applications.
2. To analyze HDL design flow and EDA tools.
3. To analyze different aspects of testing and fault models.
4. To understand the insights of chip design such as epitaxy and lithography.
5. To understand the insights of chip design such as ion implantation and metallization.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Analyze and implement basic Verilog coding.
- **CO2:** Understand the IC design flow and EDA tools
- **CO3:** Understand the AISC timing analysis and different fault models.
- **CO4:** Understand the major steps in the fabrication process of VLSI circuits
- **CO5:** Apply implantation process for VLSI devices and discuss the metallization.

Course Contents

Unit I - Design with HDL - (10 Hours)

Basics of Verilog: Typical HDL-flow, why Verilog HDL, trends in HDLs. Gate-Level Modelling: Modelling using basic Verilog gate primitives, description of and/or and buffer/not type gates, rise, fall and turn-off delays, min, max, and typical delays. Behavioral Modelling: Structured procedures, initial and always, blocking and non- blocking statements, delay control, generate statement, event control, conditional statements, Multiway branching, loops, sequential and parallel blocks.

Unit II - ASIC Design Part I - (10 Hours)

Types of ASIC and Comparisons, ASIC Design Flow, Logic Synthesis, Simulation, EDA Tools, ASIC Physical Design : Architecture Design, Physical Design, CAD Tools, System partitioning, Partitioning Strategies, Floor planning, Placement, Routing

Unit III - ASIC Design Part II - (10 Hours)

ASIC Timing Analysis: Static timing analysis, Timing constraints, Delay estimation, ASIC Verification and Testing: Different Chip Test Methods, Fault Models, Scan Test, Partial Test, Digital scan standards, BIST architecture, BILBO, Boundary Scan, Self-Test, JTAG, ATPG.

Unit IV- Chip Design - (10 Hours)

Crystal Growth and Wafer Preparation: Introduction, Electronic-Grade Silicon, Czochralski Crystal Growing. Epitaxy: Introduction, Vapour-Phase Epitaxy. Lithography: Introduction, Optical Lithography, Electron Lithography, X-ray Lithography, Ion Lithography. Reactive Plasma, Etching: Introduction, Plasma Properties, Feature-Size Control and Anisotropic Etch Mechanisms, Reactive Plasma-Etching Techniques and Equipment.

Unit V- Chip Fabrication - (10 Hours)

Ion Implantation: Introduction, Range Theory, Implantation Equipment, Annealing, Shallow Junctions, High-Energy Implantation.

Metallization: Introduction, Metallization Applications, Metallization Choices, Physical Vapor Deposition, Patterning, Metallization problems.

Learning Resources

Textbooks:

1. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Pearson Education, Second Edition.
2. S.M. Sze, VLSI Technology, McGraw-Hill, 2017, 2nd Edition (Indian).

Reference Books:

1. Smith Michael, “Application Specific Integrated Circuits” Pearson Education
2. S.K. Gandhi, “VLSI Fabrication Principles”, John Willey &Sons.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-505-CMN - Laboratory Practice-I		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	02	**TW:** 25 Marks **Oral:** 25 Marks

Course Objectives: The course aims to:

1. Provide hands-on training in the Communication Network domain.
2. Understand various computing architectures and their limitations.
3. Understand the concept of real-time systems

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Design & simulate Communication Network System for given application.
- **CO2:** Design & analyze systems for real-time applications.
- **CO3:** Design & implement real-world Network applications.

Guidelines:	**Lab Practical**

1. Laboratory-I Experiments based on program core courses.
2. Use available software/hardware

Part A: Advance Modelling Simulation and Communication Network (Any 2)	
1	Write the MATLAB code for estimating the performance of the following communication system using Monte Carlo Simulation a. AWGN Channel b. Binary Phase Shift Keying c. Binary Frequency Shift Keying
2	For uniform Random number use Monte Carlo integration method as an approximated integration technique. Integrate f(x) on {0,1} interval for the following integral function a. F(x) = x b. F(x) = x2 c. F(x) = cos(πx)
3	A simulation of memory channel using Markov model is demonstrated and system error probability is computed. Assume errors can be produced in either state where the probability of error in good state will be less than error probability of bad state. Specifically we define conditional error probability as Pr{Eg}=0.0005 and Pr{Eb}=0.1000. Markov chain is defined by transition matrix A= 0.98 0.02 0.5 0.95

Part B: High Speed Communication Networks (Any 2)	
1	Write the MATLAB code for estimating the performance of following communication system using Monte Carlo Simulation a. AWGN Channel b. Binary Phase Shift Keying c. Binary

	Frequency Shift Keying
2	For uniform Random number use Monte Carlo integration method as an approximate integration technique. Integrate f(x) on {0,1} interval for the following integral function a. F(x) = x b. F(x) = x2 c. F(x) = cos(πx)
3	A simulation of memory channel using Markov model is demonstrated and system error probability is computed. Assume errors can be produced in either state where the probability of error in good state will be less than error probability of bad state. Specifically, we define conditional error probability as Pr{Eg}=0.0005 and Pr{Eb}=0.1000. Markov chain is defined by transition matrix A= 0.98 0.02 0.5 0.95

Part C: Network and Cyber Security	
1	Write a program that reads n and e from a file and text from another file and writes encrypted text to a third file. File names will command line parameters. View each group of four characters as a 32-bit integer. Assume that characters in plain text are keyboard characters with ASCII values less than 128. Thus, the 32-bit integer will have a leading bit of 0. Since n must have a leading bit of 1 from above, the number will be from 0 to n – 1 and hence valid for the algorithm. The values of n and e can be assumed to be less than 232. Make sure that the format of your output file is such that your program can be run with n and d as input and reproduce the original input file
2	Show that the Computational Diffie-Hellman problem has a random self-reduction. Let G be a group of prime order q and let g be a generator of G. Define the function FDH(gx, gy) = gxy. Suppose there is an algorithm A that computes FDH(X, Y) in time Ton fraction of the inputs (A outputs ? on all other inputs). Show that there is an algorithm B that computes FDH on all inputs in expected time T/€.

Part D: VLSI Chip design and fabrication (Any 2)	
1	Write Verilog code and testbench to simulate, synthesis for the 4-bit counter [Synchronous & Asynchronous counter].
2	Write Verilog code and testbench to simulate, synthesis for 4/8-bit Magnitude Comparator
3	Write Verilog code and testbench to simulate, synthesis for counter with given input clock and check whether it works as clock divider performing division of clock by 2, 4, 8 and 16.
4	Write Verilog code and testbench to simulate, synthesis Mealy and Moore Sequence Detector to detect Sequence. ------11101-----.
5	Verify the functionality of the code Model in Verilog for a full adder and add functionality to perform logical operations of XOR, XNOR, AND, OR gates. Write test bench with appropriate input patterns to verify the modelled behavior.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-521A - CMN – Block chain		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory :03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :

1. Computer Networks,
2. Data Structures and Algorithms,
3. Distributed Systems

Course Objectives: The course aims to:

1. Understand the fundamental concepts, architecture and cryptographic principles underlying blockchain and distributed ledger technologies.
2. Explore various consensus mechanisms to achieve secure and reliable agreement in decentralized systems.
3. Design and develop smart contracts, decentralized applications (DApps) .
4. Evaluate the application of blockchain frameworks in enterprise environments, decentralized finance (DeFi).
5. Explore advanced trends and research directions for integrating blockchain with IoT, AI and Cloud technologies.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1: A**nalyze the evolution, architecture, and cryptographic foundations of blockchain systems.
- **CO2:**Design and evaluate smart contracts and decentralized applications (DApps),
- **CO3:** Apply enterprise blockchain frameworks to evaluate cross-chain interoperability solutions.
- **CO4:** Assess decentralized finance (DeFi) applications and challenges in blockchain adoption.
- **CO5:** Investigate emerging blockchain research trends, integration with IoT, AI, and Clo technologies.

Course Contents

Unit I - Blockchain Foundations & Cryptography- (9 Hours)

Evolution of blockchain: Bitcoin to Web3, Blockchain architecture: Blocks, chains, nodes, P2P network, Permissioned vs. permissionless blockchains, Distributed Ledger Technologies (DLT), Cryptographic principles: Hashing, Merkle Trees, Digital Signatures, Zero-Knowledge Proofs (zkSNARKs, zkSTARKs), Consensus mechanisms: Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Practical Byzantine Fault Tolerance (PBFT), Directed Acyclic Graphs (DAG)

Unit II - Smart Contracts & Decentralized Applications (DApps)- (9 Hours)

Smart contract fundamentals and design principles, Economic and legal aspects of smart contracts, Oracles and hybrid contracts: Conceptual overview, Security considerations: Common vulnerabilities, Mitigation strategies, Gas costs and optimization concepts.

Unit III - Enterprise Blockchain Frameworks & Cross-Chain Interoperability - (9 Hours)

Hyperledger Fabric, Corda, Quorum — architecture and use-cases, Cross-chain interoperability: Polkadot, Cosmos — concepts and industry relevance, Case studies and real-world examples.

Unit IV- Decentralized Finance (DeFi), NFTs & Regulations - (9 Hours)

DeFi ecosystem, NFTs, DAOs, CBDCs — trends and conceptual frameworks, Regulatory frameworks: GDPR, KYC and AML, compliance challenges, Sustainability and green blockchain initiatives.

Unit V- Advanced Trends-IoT, AI, Cloud Integration - (9 Hours)

Blockchain for IoT: Secure device identity, data integrity, Blockchain for AI: Data provenance, AI model trustworthiness, Blockchain for Cloud: case study of Decentralized storage, edge computing integration, Privacy-enhancing techniques: Mixers, ring signatures, confidential transactions.

Learning Resources

Text Books:

1. Imran Bashir, *Mastering Blockchain*, 4th Edition, Packt Publishing, 2023.
2. Daniel Drescher, *Blockchain Basics: A Non-Technical Introduction in 25 Steps*, 1st Edition, Apress, 2017.
3. Andreas M. Antonopoulos, Gavin Wood, *Mastering Ethereum: Building Smart Contracts and DApps,* 1st Edition, O'Reilly Media, 2018.
4. Ritesh Modi, *Solidity Programming Essentials,* 2nd Edition, Packt Publishing, 2022.
5. Nitin Gaur, Luc Desrosiers, Venkatraman Ramakrishna, Petr Novotny, Anthony O'Dowd, *Hands-On Blockchain with Hyperledger: Building Decentralized Applications with Hyperledger Fabric and Composer,* 1st Edition, Packt Publishing, *2018.*
6. Nakul Shah, *Blockchain for Business with Hyperledger Fabric,* 1st Edition, Packt Publishing, 2018.
7. Arshdeep Bahga, Vijay Madisetti, *Blockchain Applications: A Hands-On Approach, 1st Edition, VPT, 2017.*

Reference Books:

1. Roberto Infante, Building Ethereum DApps, 1st Edition, Packt Publishing, 2019.
2. Kevin Solorio, Randall Kanna, David H. Hoover, Hands-On Smart Contract Development with Solidity and Ethereum: From Fundamentals to Deployment, 1st Edition, O'Reilly Media, 2019.
3. Debajani Mohanty, Corda in Action, 1st Edition, Manning Publications, 2021.

SWAYAM/ MOOC / eBOOKS

1. https://onlinecourses.nptel.ac.in/noc22_cs44/preview
2. https://onlinecourses.nptel.ac.in/noc19_cs63/preview
3. https://onlinecourses.nptel.ac.in/noc20_cs01/preview
4. https://onlinecourses.swayam2.ac.in/aic21_ge01/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-521B-CMN - Coding and Modulation Techniques (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Perquisite Courses:

1. Knowledge of Signal representation, modulation basics, Bit Error Rate (BER), SNR.
2. Understand the Time/frequency domain analysis Fourier and Laplace Transforms
3. Understand the Vector spaces, matrices, eigenvalues (for coding theory)
4. Knowledge Entropy, redundancy, channel capacity

Course Objectives: The course aims to:

1. Calculate the theoretical analysis of information.
2. Differentiate different source and channel coding techniques.
3. Analyze effective utilization of spectrum considering different digital modulation Technique.
4. Develop knowledge of error detection and correction codes.
5. Enable students to analyse trade-offs among bandwidth efficiency, power efficiency, bit error rate (BER), and system complexity.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1** : Develop information theoretical analysis and design a data compression scheme using suitable source coding technique
- **CO2:** Analyze different channel coding techniques.
- **CO3:** Describe digital modulation, spread spectrum and multiple access techniques.
- **CO4:** Assess transceivers considering different parameters like channel capacity, interference, Spectrum sharing and antenna weights.
- **CO5:** Apply space-time coding and space-frequency coding concepts to improve reliability and diversity in MIMO-OFDM systems.

Course Contents

Unit I - : Introduction to modulation Techniques - (09 Hours)

Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan‟s Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word-Length, Shannon-Fano Coding, Shannon‟s First Theorem,

Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon‟s First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary Symmetric Channel, Hamming Distance, Shannon‟s Second (Fundamental) Theorem, Converse of Shannon‟s Theorems

Unit II - Coding Techniques - (09 Hours)

The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, and Kerdock Codes. Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming‟s Sphere – Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes. Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed-Muller Codes, Perfect Codes and Uniformly Packed Codes: Lloyd‟s Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems. Galois Rings over Z4, Cyclic Codes over Z4, Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes, . Adaptive Modulation and Coding.

Unit III – Modulation Techniques - (09Hours)

Advanced Digital Modulation and Demodulation Techniques, QPSK, Continuous Phase PSK (CPPSK), GMSK, QAM, Trellis Coded Modulation (TCM) Clock and Carrier Recovery Schemes. Frequency hopping multiple access (FHMA) principle and functional block diagram, DSSS, Code division multiple access, Mathematical representation, Effect of multipath propagation on CDMA. CDMA systems, Multi-user detection. Dynamic spectrum access and modulation adaptation based on spectrum sensing**. Compatibility with** multi-band, multi-mode **communication**

Unit IV – OFDM (09 Hours)

Orthogonal Frequency Division Multiplexing (OFDM), Principle, Implementation of Transceivers, Frequency selective channels, channel estimation, Inter-carrier interference, multicarrier code division multiple access. Multi-antenna systems, smart antennas, capacity increase, receiver structures, algorithms for adaptation of antenna weights. Multiple input and multiple output systems, channel state information, capacity of non-fading channels.

Unit V – Advance Trends in Coding and Modulation Networks (09

Adaptive and Cognitive Radio Modulation Schemes, Massive MIMO and Advanced Antenna Techniques, Non-Orthogonal Multiple Access (NOMA), Millimetre Wave (mm Wave) and Terahertz Communication Modulation, Space-Time Coding and Space-Frequency Coding, Machine Learning-Aided Modulation and Detection, Future Communication Paradigms.

Learning Resources

Textbooks:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R., 1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed),

Singapore, Pearson Education.
4. Neeraj Pandey, Intellectual Property Rights, 1st Edition, PHI
5. Shrivastava, Shenoy & Sharma, Quantitative Techniques for Managerial Decisions, Wiley.

Reference Books :

1. Goode W J &Hatt P K, Methods in Social Research, McGraw Hill.
2. Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH)

SWAYAM/MOOC/Youtube Links

1. https://www.youtube.com/watch?v=wn71QBApCRg
2. https://nptel.ac.in/courses/117105148
3. https://onlinecourses.swayam2.ac.in/nou24_ec09/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-521- CMN - Detection and Estimation Theory (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE :** 50 Marks **End-Semester:** 50 Marks

Prerequisite Courses:

1. Knowledge of Probability & Random Variables Understand the Time/frequency domain analysis.
2. Understanding of Fourier and Laplace Transforms.
3. Understanding of Random Processes.
4. Knowledge of Signals and Systems.

Course Objectives: The course aims to:

1. Describe the main concepts and algorithms of detection and estimation theory.
2. Categorize the random processes and estimation of continuous waveform.
3. Calculate the signal parameter estimation.
4. Differentiate different types of optimum filters.
5. Students with the ability to model, simulate, and evaluate detection/estimation algorithms using modern tools such as MATLAB or Python.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Describe the basics of statistical decision theory used for random signal Detection and estimation.
- **CO2:** Calculate signal parameters by using Bayer's, LMS, MMSE estimators. Analyze different channel coding techniques.
- **CO3:** Analyze signal estimation using optimum filters.
- **CO4:** Design and implement advanced signal detection and estimation schemes for real-world applications such as RADAR, SONAR, communication systems, and Cognitive radio.
- **CO5:** Evaluate the performance of detection and estimation techniques under fading and multipath channel conditions.

Course Contents

Unit I - : Detection and Estimation Theory:- (09 Hours)

Introduction: Signals and Systems: System theory, stochastic process and their representation, Gauss – Markov models, likelihood and efficiency. Detection theory: Hypothesis testing, Decision criterion, multiple measurements, multiple and composite hypothesis system, CFAR detection. Detection of signals in noise: detection of known signals in white noise, co- relation receiver, Maximum SNR criterion estimation theory, composite hypotheses, general Gaussian problem, performance bounds and approximations.

Unit II - Representations of Random Processes - (09 Hours)

Introduction, orthogonal representations, random process characterization, homogenous integral equations and Eigen-functions, periodic processes, spectral decomposition, and vector random processes Estimation of Continuous Waveforms: Introduction, derivation of estimator equations, a lower bound on the mean-square estimation error, multidimensional waveform estimation, non-random waveform estimation, Bayesian Detection and Estimation, Machine Learning-Inspired Detection.

Unit III – Detection of Signals - (09 Hours)

Detection of Signals – Estimation of Signal Parameters: Estimation theory: Estimation of parameters, random and non-random, Bayer's estimates properties of estimators, linear mean square estimation. Estimation of waveform: Linear MMSE estimation of waveform, estimation of stationary process, Weiner filters, estimation of non- stationary process, detection and estimation in white Gaussian noise, detection and estimation in non-white Gaussian noise, signals with unwanted parameters, multiple channels and multiple parameters.

Unit IV – Linear Estimation (09 Hours)

Properties of optimum processors, realizable linear filters, Kalman- Bucy filters, fundamental role of optimum linear filters. Weiner filters, estimation of non- stationary process, Kalman filters. Relation between Weiner filters and Kalman filters, non-linear estimation. Application to RADAR signal processing, estimation of range detection of object, it‟s size etc. Linear prediction and optimum linear filters: Forward and backward linear prediction, properties of linear prediction error filters, AR lattice and ARMA lattice ladder filters, Weiner filters for filtering and prediction.

Unit V – Advanced Signal Detection and Estimation Techniques (09 Hours)

Adaptive Filtering and Estimation, Nonlinear and Bayesian Estimation Methods, Extended and Unscented Kalman Filters, Detection in Fading and Multipath Channels, Advanced Applications.

Learning Resources

Textbooks:

1. Harry L. Van Trees, "Detection, Estimation, and Modulation Theory," Part I, John Wiley &Sons, USA, 2001 .
2. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan, "Introduction to Statistical Signal Processing with Applications," Pearson Education (Asia) Pte. Ltd. /Prentice Hall of India, 2003.
3. Steven M. Kay, "Fundamentals of Statistical Signal Processing," Volume I: "Estimation Theory", Prentice Hall, USA, 1998

Reference Books:

1. M. Kay, "Fundamentals of Statistical Signal Processing", Volume II: "Detection Theory," Prentice Hall, USA, 1998.
2. K Sam Shanmugam, Arthur M Breipohl, "Random Signals: Detection, Estimation and Data Analysis"

John Wiley & Sons, 1998

SWAYAM/MOOC/Youtube Links

1. https://www.youtube.com/watch?v=CUmLqQvKLMI
2. https://nptel.ac.in/courses/117103018.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-521D- CMN - Neural Networks in Communications (Elective-I)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Probability & Random Variables Understand the Time/frequency domain analysis.
2. Fourier and Laplace Transforms.
3. Random Processes.
4. Signals and Systems.

Course Objectives: The course aims to:

1. Describe the different types of neural networks and Neuro-dynamic programming.
2. Develop applications of neural networks in telecommunication.
3. Describe the concept of channel equalization and traffic density determination.
4. Provide knowledge of Graph Neural Networks (GNNs) for analyzing, learning, and
5. Optimizing wireless network topologies.
6. Develop understanding of self-organizing maps, recurrent networks, and graph neural Networks for communication applications.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Describe the concepts of neural networks, and Neuro-dynamic programming.
- **CO2:** Design neural network-based applications in telecommunication.
- **CO3:** Differentiate channel equalization and traffic density determination
- **CO4:** Utilize Graph Neural Networks (GNNs) for representing, learning, and optimizing complex network topologies.
- **CO5:** Implement self-organizing maps for traffic density determination and clustering on networks.

Course Contents

Unit I - : Introduction to neural networks - (09Hours)

Introduction to artificial neural networks, learning rules, perceptron networks, Feed forward networks, Feedback networks, Radial basis function networks, Associative memory networks, self-organizing feature map, Adaptive resonance theory , Deep Learning for Channel Estimation and Equalization, End-to-end learning of modulation schemes using auto encoders , learned constellations vs QAM/PSK, Deep symbol de-mapping using DNNs.

Unit II –- Probabilistic neural networks (09Hours)

Probabilistic neural networks, neocognitron, Optical neural networks, simulated annealing, Support vector machines, Neuro-dynamic programming, NNs for MIMO detection, Learned iterative detection algorithms, RNN/LSTM for sequence-based signal detection.

Unit III - Applications in Telecommunications: - (09Hours)

Efficient design of RF and wireless circuits, Neural networks for switching, ATM traffic control using neural networks, and neural model for adaptive congestion control in ATM networks. Federated Learning in Wireless Communication Distributed learning at edge devices (IoT, mobile phones), Privacy-preserving learning over wireless networks, Applications in collaborative spectrum sensing

Unit IV – Introduction to GNNs- (09 Hours)

Neural network channel equalization, Static and Dynamic Channel assignment using simulated annealing, Traffic density determination using self-organizing feature map. Graph Neural Networks (GNNs) in Network Topologies**,** Resource allocation in mesh networks, Topology-aware routing using GNNs, Learning over dynamic wireless graphs.

Unit V - Self-Organizing Feature Maps in Communications- (09 Hours)

Kohonen Self-Organizing Maps (SOM) – architecture and learning rules, Applications in traffic density estimation, clustering of network nodes, and mobility prediction, Resource allocation and load balancing using SOM, Case study: Traffic prediction in cellular networks using SOM.

Learning Resources

Textbooks:

1. S N Sivanandam, S Sumathi, S N Deepa, “Introduction to Neural Networks Using Matlab 6.0”,Tata McGraw Hill Publication.
2. Fredric Ham and IvicaKostanic, “Principles of Neuro-computing for science and Engineering”, Tata McGraw Hill Publication.

Reference Books:

1. Simon Haykin, “Neural Networks: Comprehensive foundation”, Prentice Hall Publication.
2. Ben Yuhas and Nerwan Ansari, “Neural Networks in Telecommunications”, Kluwer Academic publishers

SWAYAM/MOOC/Youtube Links

1. https://www.youtube.com/watch?v=CUmLqQvKLMI
2. https://onlinecourses.nptel.ac.in/noc21_ma74/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-522- CMN - Skilled Based Laboratory –I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 02 Hours/Week	01	Term work : 25 Marks Oral : 25 Marks

Prerequisite Courses: Programme Elective Course

Course Objectives: The course aims to:

1. Provide hands-on experience with tools, equipment, and software relevant to the subject area.
2. Develop practical skills that complement theoretical knowledge.
3. Enhance problem-solving, analytical, and experimental abilities.
4. Foster creativity, innovation, and critical thinking through practical applications.
5. Train students to work independently as well as in teams for collaborative learning.
6. Promote professional skills such as technical documentation, presentation, and reporting.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Describe the concepts of neural networks, and Neuro-dynamic programming.
- **CO2:** Design neural network-based applications in telecommunication.
- **CO3:** Differentiate channel equalization and traffic density determination
- **CO4:** Utilize Graph Neural Networks (GNNs) for representing, learning, and optimizing complex network topologies.
- **CO5:** Implement self-organizing maps for traffic density determination and clustering in networks.

List of Assignments

Select practical assignments from Part A and Mini- Project from Part B.

Part A – Practical assignments

1. Blockchain (Any Two)

1. Write a program to simulate a blockchain with multiple blocks using hashing and a simple Proof-of-Work mechanism.
2. Design and simulate a simple smart contract using Solidity on Remix IDE and test it on an Ethereum test network.
3. Simulate a consensus mechanism using Python or an online tool and demonstrate how nodes agree on the next block even in the presence of faulty nodes.

2. Coding And Modulation Techniques

1. Discuss the Reed-Solomon codes with respect to architecture and implementation highlighting the superiority for wireless communication systems.

2 Develop the design steps for RADAR signal Detection and Estimation by various prediction techniques and filters .Comment on the same by simulating the design using MATLAB

3. Detection and Estimation Theory

Develop the design steps for RADAR signal detection and estimation by various prediction Techniques and filters. Comment on the same by simulating the design using MATLAB.

1. Highlight the estimation parameters for detection of random and non-random signals.
2. Write a note on application of Markov models in estimation process. Design at least one of them.

4. Neural Networks in Communications

1. Consider the Back propagation algorithm operating on neurons which use the transfer function log sigmoid instead of the usual sigmoid function. That is assume that the output of single neuron is $\sigma = \log\sigma(w\ (T)\ x)$. Remember $(\sigma(x))' = \sigma(x).(1- \sigma(x))$ Given the weight update rules for output layer weights and for hidden layer weights.

2. The chart below shows a set of two-dimensional input samples from two classes.

(a) It looks like there exists a perfect classification function for this problem that is linearly separable, and therefore a single perceptron should be able to learn this classification task perfectly. Let us study the learning process, starting with a random perceptron with weights w0= 0.2, w1= 1, and w2= -1, where of course w0is the weight for the constant offset i0= 1. For the inputs, just estimate their coordinates from the chart. Now add the perceptron's initial line of division to the chart. How many samples are misclassified? Then pick an arbitrary misclassified sample and describe the computation of the weight update (you can choose $\eta = 1$ or any other value; if you like you can experiment a bit to find a value that leads to efficient learning). Illustrate the perceptron's

new line of division in the same chart or a different one and give the number of misclassified samples. Repeat this process four more times so that you have a total of six lines (or fewer if your perceptron achieves perfect classification earlier). You can do the computations and/or graphs either by hand or by writing a computer program. If you write a program, please attach a printout, and let the program run until the perceptron achieves perfect classification (after how many steps?).

(b)If your perceptron did not reach perfect classification, determine a set of eights that would achieve perfect classification, and draw the separating line for those weights. (c) Now let us assume that less information was available about the samples that are to be classified. Let us say that we only know the value for i1for each sample, which means that our perceptron has only two weights to classify the input as best as possible, i.e., it has weights w0and w1, where w0is once again the weight for the constant offset i0= 1. Draw a diagram that visualizes this one-dimensional classification task and determine weights for a perceptron that does the task as best as possible (minimum error, i.e., minimum proportion of misclassified samples). Where does it separate the input space, and what is its error?

Part B - Mini Project

- **Blockchain**: To design and implement a blockchain-based voting system where votes are securely stored, tamper-proof, and transparently counted using Ethereum smart contracts.
- **Coding and Modulation Techniques:** To Design and Implement an OFDM system with convolutional coding and interleaving. Compare the BER performance with and without coding under Rayleigh fading conditions.
- **Detection and Estimation Theory:** Implement a matched filter detector and an energy detector for digital communication signals. Evaluate probability of detection (Pd) and probability of false alarm (Pfa) under varying SNR conditions.
- **Neural Network in Communication**: Design and train a neural network to automatically classify modulation schemes (e.g., BPSK, QPSK, 16-QAM) from noisy received signals. Compare accuracy with traditional feature-based methods.

Learning Resources

Textbooks:

1. Imran Bashir, Mastering Blockchain, 4th Edition, Packt Publishing, 2023.
2. Harry L. Van Trees, “Detection, Estimation, and Modulation Theory,” Part I, John Wiley &Sons, USA, 2001 .
3. S N Sivanandam, S Sumathi, S N Deepa, “Introduction to Neural Networks Using Matlab 6.0”,Tata McGraw Hill Publication.
4. Fredric Ham and IvicaKostanic, “Principles of Neuro-computing for science and Engineering”, Tata McGraw Hill Publication

Savitribai Phule Pune University, Pune

Maharashtra, India

Master of Engineering (2025 Pattern)
Electronics & Telecommunication Engineering
(Communication Networks)

Semester II

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PCC-551- CMN - Broadband Wireless Technologies		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Fundamentals of Communication Systems Analog & Digital communication, Modulation techniques (AM, FM, QAM, OFDM), Time and frequency domain analysis.
2. Knowledge of Networking Basics such as OSI and TCP/IP models, LAN, WAN, MAN. IP addressing, routing, and switching.
3. Overview in Wireless and Mobile Communication ,Cellular architecture, handoff, frequency
4. Basics of LTE, 3G, and 4G.

Course Objectives: The course aims to:

1. Analyze the basics of OFDM and MIMO technology.
2. Categorize UWB and MAC Protocol.
3. Differentiate types of wireless networks and routing protocols.
4. Describe the Architectures for EPON and WiMAX.
5. To know emerging trends in the field.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Analyze different parameters of MIMO system and types of OFDM systems.
- **CO2:** Discriminate types of UWB and MAC protocols.
- **CO3:** Describe different routing protocols and QoSin wireless systems.
- **CO4:** Describe architectures for EPON and WiMAX , their design & operation issues.
- **CO5 :** Analyze emerging trends in Broadband Wireless Technologies

Course Contents

Unit I - : OFDM & Block Based Transmissions:- (10 Hours)

Block based transmissions, OFDM multiplexing systems, Single carrier cyclic prefix systems, orthogonal FDMA, interleaved FDMA, single carrier FDMA, CP based CDMA, receiver design. MIMO Antenna Systems: MIMO system model, channel capacity, diversity and spatial multiplexing gain, SIMO & MISO systems, space-time coding, MIMO transceiver design, SVD based Eigen bean forming, MIMO for frequency selective fading channels, cyclic delay diversity.

Unit II - UWB and Medium Access Control- (10 Hours)

Time hopping UWB, Direct sequence UWB, Multiband, other types UWB, Slotted ALOHA MAC, Carrier sense multiple access with collision avoidance MAC, polling MAC, Reservation MAC, Energy efficient MAC, Multichannel MAC, Directional Antenna MAC, Multihop saturated Throughput of IEEE 802.11 MAC, Multiple Access Control.

Unit III - Wireless Broadband Networks and wimax networks :- (10 Hours)

Multihop Wireless Broadband Networks, Radio Resource Management and QOS: MultihopWireless Broadband networks: Mesh networks, Importance of Routing Protocols, Routing Metrics, Classification of Routing Protocols, MANET routing protocols, Packet scheduling, Admission Control, Traffic Models, QoS in wireless systems, Out\age probability for vbideo services in a multirate DS-CDMA system. WiMAX and Optical Access Networks: Point–multipoint WiMAX networks, Mesh mode,Mobility in WiMAX networks, Data link layer Protocols, Multi – point control Protocols, Dynamic BW allocation algorithm (DBA)

Unit IV - Ethernet Passive Optical Networks - (10Hours)

EPON – WiMAX, Hybrid WOBAN, Point – Point FTTx, Broadband Access Networks Integrated Architectures for EPON and WiMAX, Design & operation Issues, WOBAN- a network for future, connectivity, routing, fault tolerance & self-healing, fiber topology vs. transmission scheme, Architectural/deployment/operational/cost considerations, open fiber access, transmission technologies, broadband networks & network requirements, scalable broadband access networks, next generation access & backhaul

Unit V - Emerging Trends and Applications - (10Hours)

Cognitive radio and dynamic spectrum access, Ultra-Reliable Low-Latency Communication (URLLC),Machine learning for broadband wireless optimization,6G Vision: Terahertz communication, Reconfigurable Intelligent Surfaces (RIS), Applications: IoT, smart cities, vehicular networks, Industry 4.0, AR/VR.

Learning Resources

Textbooks

1. David Tung Choug Wong, Peng Yong Kong, Ying Chang Liang, Lee Chaing Chua, Jon W. Mark, Wireless Broadband Networks, Wiley Publication

2. Abdallah Shami, Martin Maier, Chadi Assi: Biswanath Mukharjee- series Editor, Broadband Access Networks Technologies Deployments, Springer

Reference Books

1. Regis J. “Bud” Bates, Broadband Telecommunications Handbook, Mc GRAW – Hill
2. R. A. González and M. I. Gallego, Broadband Networks: Strategies and Technologies, 1st ed. Hoboken, NJ, USA: Wiley, 2005.

3. W. Stallings, Data and Computer Communications, 10th ed. Boston, MA, USA: Pearson, 2013.

SWAYAM/MOOC /Youtube Links

1.https://www.youtube.com/watch?v=RXsmD4N_WzA
2. https://nptel.ac.in/courses/117104074
3. https://nptel.ac.in/courses/106105081

Savitribai Phule Pune University Master of Engineering (2025 Course) – E&TC Engineering (Communication Networks)		
PCC-552- CMN - 5G LTE Cellular Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Basics of Digital Communications.
2. Knowledge of Wireless Communication.
3. Overview of Signals and Systems.
4. Understand concepts of Probability and Random Processes.
5. Knowledge of Networking Basics.

Course Objectives: The course aims to:

1. Design different cryptography algorithms.
2. Categorize security protocols and models.
3. Analyze the performance of Network security applications.
4. To know emerging trends in the field.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1** : Analyze the architecture and working principles of LTE and 5G cellular networks.
- **CO2:** Evaluate the performance of 5G enabling technologies such as massive MIMO, mm Wave, and beam forming.
- **CO3**: Develop solutions for real-time communication challenges using network slicing, SDN, and edge computing.
- **CO4**: Design and simulate LTE and 5G-based applications for use cases like IoT, eMBB, URLLC, and V2X.
- **CO5 :** Analyze emerging trends in 5G LTE Cellular Networks.

Course Contents

Unit I - : LTE and Pre-5G Systems:- (10 Hours)

Evolution from 2G to 4G: Key milestones and limitations,LTE Architecture: E-UTRAN, EPC, Interfaces (S1, X2),LTE Protocol Stack: PDCP, RLC, MAC, PHY Layers,LTE Advanced Features: Carrier Aggregation,Coordinated Multi-Point (CoMP),Enhanced MIMO (up to 8x8),Relay Nodes and HetNets,VoLTE and IMS Integration,Handover mechanisms and performance optimization Broadband Wireless Technologies.

Unit II - 5G NR Architecture and Technologies - (10 Hours)

5G Vision, ITU IMT-2020 Requirements,3GPP 5G Phases (NSA vs SA Architecture),5G NR Physical Layer: OFDM Numerology Beam forming and Massive MIMO,Dynamic TDD and Mini Slots, Spectrum for 5G: Sub-6 GHz, mm Wave, and unlicensed bands Network Slicing and Virtualization (NFV, SDN),RAN Evolution: Centralized RAN (C-RAN), Cloud RAN, Dual Connectivity (EN-DC) and Multi-RATInternetworking.

Unit III - Intelligent 5G Core and Emerging Technologies:- (10 Hours)

5G Core Network (5GC) Components: AMF, SMF, UPF, PCF, Service-Based Architecture (SBA) and APIs Edge Computing (MEC) in 5G,Private 5G Networks and Industrial Use Cases Open RAN (O-RAN): Architecture, RIC, and Vendor Neutrality AI/ML Applications in 5G:Resource Allocation, Mobility Management, Anomaly Detection, Security in 5G: Threat Models, Zero Trust, Authentication.

Unit IV - Applications, Deployment & Future Trends (10 Hours)

5G Use Case, MBB, URLLC, mMTC, Smart Cities, V2X, AR/VR, Telemedicine, Smart Manufacturing, 5G in India: Spectrum Auctions, TRAI, and DoT Policies, 5G Trials and Test beds, National and Global Initiatives, Energy Efficiency and Green Communications, 6G Vision, Terahertz Communication, Intelligent Surfaces, Quantum Communication, Integration with Satellite Networks, Research Challenges and Opportunities in B5G/6G.

Unit V- 5G Industry Trends & Technologies (10 Hours)

Private 5G Networks & Network Slicing, AI-Driven Network Automation & Management, Edge Computing (MEC) Near the Radio Edge, Cybersecurity & Trust in 5G, Quantum Communication, and Integration with Satellite Networks, Research Challenges and Opportunities in B5G/6G.

Learning Resources

Textbooks

1. *E. Dahlman, S. Parkvall, and J. Sköld,* 5G NR: The Next Generation Wireless Access Technology*,* 2nd ed. Cambridge, MA, USA: Academic Press, 2020.
2. *J. Rodriguez,* Fundamentals of 5G Mobile Networks*. Hoboken, NJ, USA: Wiley, 2015.*

Reference Books

1. A. Osseiran, J. F. Monserrat, and P. Marsch, Eds., *5G Mobile and Wireless Communication Technology*. Cambridge, U.K.: Cambridge Univ. Press, 2016.
2. A. Ghosh, J. Zhang, J. G. Andrews, and R. Muhamed, *LTE for 4G Mobile Broadband: Air Interface Technologies and Performance*. Cambridge, U.K.: Cambridge Univ. Press, 2010.

SWAYAM/MOOC /NPTEL

1. https://www.youtube.com/watch?v=EEna0xWUP8Y&utm_
2. https://onlinecourses.nptel.ac.in/noc24_ee152/preview?utm_source
3. https://nptel.ac.in/courses/106106167

Savitribai Phule Pune University Master of Engineering (2025 Course) –Electronics and Telecommunication (Communication Networks)		
PCC-553-CMN - Embedded Technology of IoT		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	CCE: 50 Marks EndSem : 50 Marks

Prerequisite Courses:

1. Embedded System
2. Analog circuits

Course Objectives: The course aims -

1. To give insight into various platforms needed for Embedded Technologies and IoT.
2. To expose students to the usage of protocol standardization in Embedded Technologies and Its selection to various applications.
3. To Understand the fundamental of sensors and actuators along with the basic concepts of an IoT and how to design IoT based applications .

Course Outcomes: On completion of the course, the learner will be able to:

- **CO1:** Understand various Embedded platforms and IoT platforms.
- **CO2:** Comprehend the operation of different buses and protocols.
- **CO3:** Interpret IoT architecture design aspects and it analyze concepts.
- **CO4:** Develop design skills in industrial IoT.
- **CO5:** Provide suitable solution for specific applications and illustrate the technologies of IoT using suitable case studies.

Course Contents

Unit I - ARM, Raspberry Pi Microcontroller - (10 Hours)

Basics of Raspberry Pi **(**RPi) board, Features and architecture, pin configurations, Installing OS on RPi, connecting to network, Programming languages with examples, Various interfaces e.g. I2C, UART, SPI, CAN. Node MCU ESP8266 Pin configuration, Station, AP, ST-AP modes, NodeMCU as web server, posting sensor data to gateway.

Unit II - Buses and Protocols- (10 Hours)

CAN Bus: Features and applications, CAN Frame, sequence of transmitting and receiving data on CAN Bus. Ethernet and USB Bus: Features and applications. Protocols: PHY/MAC Layer (3GPP MTC, IEEE 802.11, IEEE 802.15), Bluetooth Low Energy, Zigbee Smart Energy, Network Layer-IPv4, IPv6, 6LoWPAN, Transport Layer (TCP, MPTCP, UDP) Session Layer HTTP, CoAP, XMPP, AMQP, MQTT

Unit III - IoT Fundamentals- (10 Hours)

IoT Architecture and Design Concepts: IoT – An architectural overview, Design Principles and capabilities, M2M & IOT Technology Fundamentals- End Devices and gateways, Local and wide area networking, Challenges Associated with IoT, Cloud Platforms for IoT. Sensors: Different types of sensors and Actuators, Working, Networking Basics, RFID Principals and components, Wireless Sensor Networks, Physical Design of an IoT, Logical design of IoT Communication Models, Communication API's, Concept of IoE, Difference between IoT and IoE.

Unit IV- Industrial IoT- (10 Hours)

Introduction, Key Industrial IOT (IIoT) technologies, Catalysts, and precursors of IIoT, Innovation and the IIoT, Applications of IIoT Examples: Healthcare, Oil and Gas Industry, Logistics and the Industrial Internet, Retail applications, IoT innovations and design methodologies.

Unit V- IoT Applications- (10 Hours)

Applications: Smart Environment: Forest Fire Detection, Air Pollution, Smart Cities: Parking, Structural Health, Noise Urban maps, Smart Metering: Smart Grid, Tank level, Photovoltaic Installations, Health: Fall Detection, Medical Fridges, Sportsmen Care, Patients Surveillance.

Learning Resources

Textbooks:

1. Olivier Hersent, David Boswarthick, and Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2 nd Edition, Wiley Publications.
2. Arshdeep Bahga and Vijay Madisetti , "Internet of Things: A Hands-On Approach", Orient Blackswan Private Limited - New Delhi; First Edition (1 January 2015).
3. Simon Monk , "Programming Raspberry Pi", McGraw Hill TAB; 2nd edition (16 November 2015).

Reference Books:

1. Andrew Sloss, Dominic Symes, Chris Wright, "ARM System Developer's Guide – Designing and Optimizing System Software", ELSEVIER
2. Dr. Ovidiu Vermesan, Dr. Peter Friess, "Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems", River Publishers Series.
3. Rajesh Singh, "Internet of Things with Raspberry Pi and Arduino", CRC Press 2020.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PCC-554- CMN Laboratory Practice-II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical : 04 Hours/Week	02	Term work : 25 Marks Oral: 25 Marks

Group A : Broad Band Wireless Technologies (Any Two)

1. Study a specific case study on the deployment of any advanced broadband wireless technology and illustrate the details of its implementation. Also, describe its productivity gain, future benefits of technology and the resultant economic growth.

2. Perform a study of new communication services and infer possible scenarios for applying open wireless broadband platforms to new value-added scenarios such as broadcasting services, regional services, and disaster recovery.

3. Analyze the governance for open wireless broadband platforms: laws, systems, rules, assignment of radio frequencies, and propose the necessary strategies and policies that could be adopted.

4. Give details of validation of mobile communications technology including Proposal, validation of IP mobile communications protocol technology and study of network design schemes for open wireless platforms.

5. Perform study of authentication techniques for realizing MVNOs on wireless networks and ways to integrate them with open standard authentication techniques on the internet.

6. Analyze the validation of non-preemptive handover technology between foreign wireless networks, Validation of seamless handover technology between wireless networks, and study the development of standardized handover technologies for foreign wireless networks

Group B: 5G Cellular Networks (Any Two)

1. Design of 5G NR Frame Structure, Configure and simulate different subcarrier spacing.
2. Simulation of Massive MIMO in 5G, Analyze spectral efficiency and array gain.
3. Simulate NLOS/LOS channels for 28 GHz, 60 GHz bands mm Wave Channel Modeling.
4. Performance Evaluation of 5G NR Link-Level with BER/SNR analysis under various fading conditions.

Group C : Embedded and IOT Technology (Any Two)

1. IoT based stepper motor/ DC motor control using Raspberry-Pi
2. To interface sensors and actuators with Arduino/Raspberry-pi
3. To use MQTT/ CoAP protocol and send sensor data to cloud using Raspberry-Pi/ ESP8266.
4. To prepare IoT based small project implementation on the topics based on small problem statements of the fields like smart home (Home Automation) etc. This project can be built on any IoT simulation platform like Tinkercad, Cooja etc.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & telecommunication Engineering (Communication Networks)		
PEC-561A-CMN- Machine Learning (Elective II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Engineering Mathematics (Linear Algebra, Probability & Statistics, Calculus),
2. Digital signal processing ,
3. Data Structures and Algorithms

Course Objectives: The course aims to:

1. Introduce fundamental Machine Learning concepts and their applications in real-world problems.
2. Implement regression and classification models to solve engineering problems
3. Apply clustering and dimensionality reduction techniques to unlabelled data.
4. Optimize datasets through pre-processing and feature selection for Machine Learning pipelines.
5. Combine models and validate performance for robust predictions.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1**:Compare Machine Learning paradigms for real time applications
- **CO2**: Design regression models for predictive tasks and classification models (SVM, decision trees) for signal/label prediction.
- **CO3**: Develop clustering models (K-Means, DBSCAN) and PCA-based solutions for defect detection or customer segmentation.
- **CO4**: Construct feature engineering pipelines (scaling, encoding, and selection) to improve model performance in VLSI/telecom datasets.
- **CO5**: Implement ensemble techniques like Random Forest, XGBoost and statistical tests like t-test to enhance accuracy in IC testing or power grid stability.

Course Contents

Unit I - Introduction to Machine Learning - (9 Hours)

Introduction, Definition and motivation, History and evolution of Machine learning, type: Supervised, Unsupervised, Semi-supervised, Reinforcement, Machine Learning Models: Geometric, Probabilistic, Logical, and Parametric. Non-parametric, Applications of Machine Learning in Signal processing, speech recognition, image processing, Wireless communications,

Unit II - Supervised Machine Learning - (9 Hours)

Introduction to Supervised Learning, Types of Supervised Problems, Regression Models: Linear Regression, Types of Linear Regression, cost function, gradient descent of linear regression, Evaluation Metrics for Linear Regression, Classification Models: Logistic Naive Bayes algorithm KNN algorithm Support Vector Machine (SVM).

Unit III - Unsupervised Machine Learning - (9 Hours)

Introduction, Types of Unsupervised Learning: Clustering, Association Rule Learning, Dimensionality Reduction, K-means Clustering algorithm, Evaluation: Elbow method, Silhouette score, Density-Based Methods, Dimensionality Reduction Techniques, Principal Component Analysis (PCA).

Unit IV- Feature Engineering- (9 Hours)

Importance of feature engineering in Machine Learning pipeline, Handling missing values, outliers, encoding: Label, One-Hot, Ordinal, Target Scaling: Min-Max, Standardization, Normalization, Feature selection: Filter (Chi-square), Wrapper (RFE), Embedded (Lasso)

Unit V- Ensemble Learning and Model Evaluation- (9 Hours)

Introduction to Ensembles, Need of Ensemble Learning , Basic Ensemble Learning Techniques: Voting (Hard/Soft), Advanced Ensemble Learning Techniques: Bagging (Random Forest), Boosting (AdaBoost, XGBoost), Stacking, Cross-validation: Hold-out, K-Fold, LOOCV, Model comparison using t-test, McNemar's test, Hyperparameter tuning (Grid Search, Random Search)

Learning Resources

Textbooks:

1. Ethem Alpaydin, "Introduction to Machine Learning", Publisher: The MIT Press,2014
2. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, Edition 2012

Reference Books:

1. Ian H Witten, Eibe Frank, Mark A Hall, "Data Mining, Practical Machine Learning Tools and Techniques", Elsevier, 3rd Edition
2. Jiawei Han, Micheline Kamber, and Jian Pie, "Data Mining: Concepts and Techniques", Elsevier Publishers Third Edition, ISBN: 9780123814791, 9780123814807
3. Shalev-Shwartz, Shai, and Shai Ben-David, "Understanding machine learning: From theory to algorithms", Cambridge university press, 2014
4. McKinney, "Python for Data Analysis O' Reilly media, ISBN : 978-1-449- 31979-3

SWAYAM/MOOC/YouTube Videos:

1. Introduction to Machine Learning(IIT kharagpur): https://nptel.ac.in/courses/106105152
2. Introduction to Machine Learning (IIT Madras): https://onlinecourses.nptel.ac.in/noc22_cs29/prevew
3. Machine Learning A-Z™: AI, Python & R + ChatGPT Bonus [2025]: https://www.udemy.com/course/machinelearning/
4. Machine Learning and Deep Learning A-Z: Hands-On Python: https://www.udemy.com/course/machine-learning-and-deep-learning-a-z-hands-on-python/

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering		
PEC-561B-CMN - Spread Spectrum and CDMA Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Understanding of modulation/demodulation, bit error rate, channel coding, etc. Knowledge of basic statistics (mean, median, variance, standard deviation, probability concepts)
2. Basics of AM, FM, noise analysis, signal transmission.
3. Continuous- and discrete-time Fourier transforms, filtering, convolution, sampling theory,
4. Familiarity with modulation schemes (BPSK, QPSK, QAM).

Course Objectives: The objectives of this course are to

1. Describe Binary Shift Register Sequences and synchronization techniques for Spread Spectrum Systems.
2. Calculate performance of Spread Spectrum Systems.
3. Describe Code Division Multiple Access Digital Cellular Systems
4. Describe the concepts of WCDMA.
5. Implementation and applications of spread spectrum and CDMA in modern wireless Communication systems

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Discriminate Binary Shift Register Sequences and synchronization techniques forSpread Spectrum Systems.
- **CO 2:** Compare performance of Spread Spectrum Systems using different coding techniques.
- **CO 3:** Discriminate CDMA and WCDMA cellular systems.
- **CO4:** Design spreading codes and analyze their correlation properties for multiple-access communication.
- **CO5:** Apply concepts of spread spectrum and CDMA in modern wireless systems such as 3G, 4G, and emerging 5G networks.

Course Contents

Unit I - : Binary Shift Register Sequences for Spread Spectrum Systems (09 Hours)

Binary Shift Register Sequences for Spread Spectrum Systems: Definitions, mathematical background and sequence generator fundamentals, Maximal length sequences, Gold codes, and nonlinear code generators Initial Synchronization of the Receiver Spreading Code: Problem definition and the optimum synchronizer, Serial search synchronization techniques, generalized analysis of average synchronization time, Synchronization using a matched filter Synchronization by estimating the received spreading code, Tracking loop pull-in.

Unit II - Performance of Spread Spectrum Systems - (09 Hours)

Performance of Spread Spectrum Systems in Jamming Environments, with forward Error Correction: Spread spectrum communication system model, Performance of spread spectrum systems without coding, Elementary block coding concepts, Elementary convolutional coding concepts , Results for specific error correction codes, Interleaving , Coding bounds, Introduction to Fading Channels, Statistical model of fading, Characterization of the mobile radio channel , Requirement for diversity in fading channels ,Adaptive Power Control & Resource Allocation

Unit III - Code Division Multiple Access Digital Cellular Systems - (09 Hours)

Cellular radio concept, CDMA digital cellular systems, Specific examples of CDMA digital cellular systems, North American DS-CDM digital cellular system (IS-95), Cooper and Nettleton DPSK-FHMA system , Bell Labs multilevel FSK frequency hop system, SFH900 system, GSM-SFH digital cellular system , Hybrid SFH TDMA/CDMA system for PCS applications, Multi-Carrier CDMA

Unit IV - :Introduction to physical and Logical Channels :- (09 Hours)

Diversity and the RAKE receiver, Physical and logical channels in IS-95; Medium access in cdma2000 and its extensions, Physical and logical channels in WCDMA; Medium access in WCDMA; Packet access, Radio resource management: Power control and soft handoff, Radio resource management in IS-95, cdma2000 and WCDMA; HSDPA, Network planning for CDMA - IS-95 and WCDMA systems, miscellaneous topics in spread spectrum - GPS (positioning), jamming, and military systems. Orthogonal Frequency and Code Division Multiplexing (OFCDM)

Unit V- Spread Spectrum in 4G/5G (09 Hours)

OFDMA vs CDMA – key differences and coexistence Hybrid CDMA/OFDMA schemes in LTE
5G applications: Massive Machine-Type Communication (mMTC), URLLC with code-domain NOMA (Non-Orthogonal Multiple Access)GPS/GNSS positioning systems (use of spread spectrum) Secure military communication (anti-jamming and low probability of intercept) IoT networks leveraging spread spectrum techniques (e.g., LoRa)

Learning Resources

Text Books

1. R. L. Peterson, R. E. Ziemer, and D. E.Borth, Introduction to Spread Spectrum Communications, Prentice Hall, 1995. (ISBN 0-02-431623-7).
2. Vijay K. Garg, Wireless Network Evolution: 2G to 3G, Prentice Hall, 2002, ISBN: 0-13-028077-13.
3. J. S. Lee and L. E. Miller, CDMA Systems Engineering Handbook, Artech House, 1998. (ISBN 0-89006-990-5)4.

Reference Books

1. J. Viterbi, CDMA: Principles of Spread Spectrum Communication, Addison-Wesley, 1995.5.
2. R. C. Dixon, Spread Spectrum Systems with Commercial Applications, 3rd ed., John Wiley & Sons, 1994.6.
3. T. S. Rappaport, Wireless Communications: Principles and Practice (2nd Edition),Prentice Hall, 2001.7.
4. H. Holma and A. Toskala, WCDMA for UMTS, John Wiley and Sons, 2000

SWAYAM/

1. https://www.youtube.com/watch?v=mrfXVSLP6D0&t=3s
2. https://nptel.ac.in/courses/117105136
3. https://onlinecourses.nptel.ac.in/noc25_ee109/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-561C-CMN Optical Networks (Elective-II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Understanding of **Basic Communication Systems**, Analog and digital communication Signal modulation/ demodulation, Frequency, phase, and amplitude modulation.
2. Knowledge of fibre Optics Basics, Total internal reflection, Numerical aperture, Attenuation, Dispersion, Types of optical fibres (single-mode, multimode).
3. Understanding of Basic Networking Concepts, OSI model, switching, routing, IP ,Addressing And multiplexing.

Course objectives: The objectives of this course are to

1. Describe switching techniques, components and physical properties of optical networks.
2. Describe transmission system parameters and protocols applied in optical internets.
3. Differentiate architectures of SONET, SDH and Optical Transport Networks.
4. Compose network topologies and protection schemes of Optical Networks.
5. Understand network designing

Course outcomes
Having successful completion of this course, student will be able to

- **CO1**: Compare switching techniques, components and physical properties of optical networks.
- **CO2**: Assess transmission system parameters and protocols applied in optical internets.
- **CO3**: Compare architectures of SONET, SDH and Optical Transport Networks.
- **CO4**; Describe network topologies and protection schemes of Optical Networks.
- **CO5**: Analyze different network management functions.

Course Contents

Unit I - : Introduction to Telecommunications Networks:- (09 Hours)

Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks: Multiplexing Techniques, Second generation Optical Networks, Optical Packet Switching, Transmission Basics: Wavelength, frequencies, and channel spacing, Wavelength standards, Optical power and loss, Network Evolution, Nonlinear Effects: Self-phase Modulation, Cross-phase Modulation, Four Wave mixing, Solitons Components: Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters. Advanced Modulation & Transmission Techniques.

Unit II - Transmission System Engineering:- (09 Hours)

Transmission System Engineering: System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Wavelength Stabilization, Overall Design Considerations. Optical Internets: Migration to IP optical networking, IP and Optical backbone, IP Routing table, MPLS and optical cross connect table, Protocol stack Alternatives, Internetworking SS7 and Legacy Transport, Internet transport network protocol stack

Unit III - Optical Transport Networks:- (09 Hours)

SONET, SDH and Optical Transport Networks (OTNs): SONET and SDH: SONET multiplexing hierarchy, Frame structure, Functional Component, problem detection, concatenation. Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-of-band control signalling, Importance of Multiplexing and multiplexing hierarchies, SONET multiplexing hierarchies, SDH multiplexing hierarchies, New Optical Transport, OTN layered Model, Generic Framing Procedure (GFP)

Unit IV - WDM, Network topologies, MPLS and Optical Networks **(09 Hours)**

WDM, Network topologies, MPLS and Optical Networks: WDM: WDM operation, Dense Wavelength Division Multiplexing (DWDM), Erbium-doped Fiber (EDF), WDM amplifiers, Add-Drop Multiplexers, Wavelength Continuity Property, Higher dispersion for DWDM, Tunable DWDM Lasers. Network topologies and protection schemes: Robust networks, Line and path protection switching, Types of topology, Point to point topology, bi-directional line-switched ring (BLSR), meshed topology, Passive optical networks, Metro optical networks MPLS and Optical Networks: IS label switching, Forwarding equivalence class (FEC), Types of MPLS nodes, Label distribution and binding, label swapping and traffic forwarding, MPLS support of Virtual Private Networks (VPN), MPLS traffic engineering, Multi-protocol Lambda switching (MPIS) Reference B, Wavelength-Division Multiplexing (WDM) Enhancements

Unit V - Network Design and Management (09 Hours)

Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers, crosstalk, dispersion; Wavelength stabilization ; Overall design considerations; Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety, Service interface

Learning Resources

Textbooks

1. Optical Networks – Practical Perspective, 3 rd Edition, Rajiv Ramaswami and Kumar Sivarajan, Morgan - Kaufmann Publishers.
2. Optical Networks, Third Generation Transport Systems, Uyless Black, Pearson Edition

Reference Books

1. R. Ramaswami, K. N. Sivarajan, and G. H. Sasaki, *Optical Networks: A Practical Perspective*, 3rd ed., San Francisco, CA, USA: Morgan Kaufmann, 2009.
2. G. P. Agrawal, *Fiber-Optic Communication Systems*, 4th ed. Hoboken, NJ, USA: Wiley, 2010.
3. H. R. Stuart, *Optical Networks*, 1st ed. New York, NY, USA: McGraw-Hill, 2002.
4. C. R. Agarwal, *Fiber Optic Communication*, 2nd ed. New Delhi, India: Wheeler Publishing, 2011.
5. B. Mukherjee, *Optical WDM Networks*, 1st ed. New York, NY, USA: Springer, 2006.

SWAYAM/MOOC/YouTube

1. https://www.youtube.com/watch?v=4W7hieXDAmc&t=5s
2. https://nptel.ac.in/courses/115101007
3. https://nptel.ac.in/courses/108102096

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-561D-CMN - RF MEMS (Elective-II)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Understanding of Electrical & RF Circuit Fundamentals.
2. Knowledge of Technology MEMS.
3. Understanding of MEMS fabrication

Course objectives

The objectives of this course are to

1. Describe mechanical and electromagnetic properties of MEMS structures.
2. Categorize switching operations of MEMS inductors and capacitors.
3. Describe micromechanical filters and MEMS phase shifters.
4. Design RF MEMS Microstrip antennas.

Course outcomes

Having successful completion of this course, student will be able to

- **CO1**. Describe mechanical and electromagnetic properties of MEMS structures
- **CO2** Compare switching operations of MEMS inductors and Capacitors.
- **CO3** Design micromechanical filters and MEMS phase shifters.
- **CO4** Construct RF MEMS Microstrip antennas

Course Contents

Unit I - :Introduction to MEMS and RF MEMS :- (09Hours)

General overview of MEMS and RF MEMS. MEMS materials and Fabrication techniques. Analysis of the fundamental mechanical and electromagnetic properties of MEMS structures. RF MEMS relays and switches. Switch parameters. Actuation mechanism. Bistable relays and micro actuators. 3D MEMS Fabrication, MEMS for Communication & RF.

Unit II - Dynamics of switching operations (09 Hours)

Dynamics of switching operations. MEMS inductors and Capacitors. Micromachined inductor. Effect of inductor layout. Modelling and design issues of planar inductor. Gap tuning and area tuning capacitors. Dielectric tenable capacitors. Micromachined RF filters.

Unit III - Mechanical filters (09 Hours)

Modelling of mechanical filters. Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures. MEMS phase shifters. Types. Limitations. Switched delay lines

Unit IV -Micromachined transmission lines (09 Hours)

Micromachined transmission lines. Coplanar lines. Micromachined directional coupler and mixer. Micromachined antennas. Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas. One Detailed application of RF MEMS, BioMEMS, Quantum MEMS Sensors.

Unit V - RF MEMS Emerging Applications (09 Hours)

MEMS integration with microwave circuits (LNA, mixers, VCOs),Ka-band and mm-wave applications (5G, automotive radar, MEMS-enabled software-defined radios (SDR),Space and defence communication systems, IoT and wearable RF systems, Reliability issues and packaging challenges in practical RF MEMS deployment.

Learning Resources

Textbooks

1. Gabriel M Rebeiz, “RF MEMS – Theory, Design and Technology”.
2. Vijay varadan, Zoelzer, “RF MEMS and their Application”.

Reference Books

1. Hector J.de.los Santos, “RF MEMS circuit Design for Wireless Communication”.
2. V.K.Varadhan & Jose, “RF MEMS and their Application”.
3. Stephen Lveyszyn, “Advanced RF MEMS”

SWAYAM/MOOC/YouTube

1. https://www.youtube.com/watch?v=xOD_jcF66FY&t=16s
2. https://onlinecourses.nptel.ac.in/noc19_ee57/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-562 A-CMN Cloud Architecture Protocols (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :

Computer Networks, Operating Systems

Course Objectives: The course aims to:

1. Define core cloud architecture principles using standardized models (NIST, SPI).
2. Analyze network protocol mechanics, including encapsulation systems and data center topologies.
3. Evaluate security frameworks using cryptographic protocols and identity management algebras.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1:** Classify cloud service/deployment models using NIST taxonomies and deconstruct virtualization architectures.
- **CO2:** Analyze encapsulation protocols and data center fabrics using routing algebras and congestion control formalisms.
- **CO3:** Analyze the components of a virtualized data center and review the performance of Data archiving solutions.
- **CO4:** Implement /identity cryptographic protocols via state-machine models and Zero Trust policy algebras.
- **CO5:** Quantify system resilience using queuing theory, failure distributions and resource optimization heuristics

Course Contents

Unit I - Cloud Ontology & Architectural Frameworks - (9 Hours)

Foundational Models: NIST essential characteristics, SPI service model taxonomy, resource abstraction layers. Deployment Topologies: Public, Private and Hybrid structural patterns, community cloud governance frameworks. Virtualization Theory: Hypervisor architectures (Bare-metal/Hosted), container isolation formalisms, docker basics and architecture.

Unit II - Network Virtualization & Protocol Architectures - (9 Hours)

Encapsulation Systems: VXLAN/Geneve header structures, NVGRE protocol mechanics, virtual switching paradigms. Data Center Fabrics: BGP-EVPN control plane theory, Clos topology mathematics, spine-leaf routing algebras. Transport Layer Theory: TCP congestion control formalisms, QoS traffic shaping models, packet scheduling algorithms.

Unit III - Storage Networks - (9 Hours)

Storage network design considerations: NAS and FC SANs, hybrid storage networking technologies (iSCSI, FCIP, FCoE), design for storage virtualization in cloud computing, host system design considerations. Replications in NAS and SAN environments. Data archiving solutions, analysing compliance and archiving design considerations.

Unit IV- Security Protocols & Cryptographic Frameworks - (9 Hours)

Identity Systems: SAML 2.0 assertion flows, OAuth 2.0 grant type formalisms, RBAC/ABAC policy algebras. Cryptographic Systems: TLS 1.3 handshake state machine, AES-GCM mode operations, PKI trust hierarchies. Network Security Models: Zero Trust formal architectures, IPsec/IKEv2 tunnelling protocols, firewall policy verification.

Unit V- Scalability & Reliability Theory - (9 Hours)

Elasticity Frameworks: Autoscaling hysteresis models, M/M/c queueing systems, horizontal scaling proofs. Failure Engineering: Weibull failure distributions, RTO/RPO calculus, chaos engineering principles. Cost Governance Ontologies: TCO analytical frameworks, bin packing optimization, cloud governance taxonomies.

Learning Resources

Text Books:

1. T. Erl et al, Cloud Computing: Concepts, Technology & Architecture. Upper Saddle River, NJ: Prentice Hall, 2013.
2. D. Dutt, Cloud Native Data Center Networking. Sebastopol, CA: O'Reilly Media, 2019.
3. B. Beyer et al., Site Reliability Engineering: How Google Runs Production Systems. Sebastopol, CA: O'Reilly Media, 2016.
4. C. Wu and R. Buyya, Cloud Data Centers and Cost Modeling: A Complete Guide To Planning, Designing and Building a Cloud Data Center. Cambridge, MA: Morgan Kaufmann, 2015.

Reference Books:

1. R. Mather et al., Cloud Security: A Comprehensive Guide to Secure Cloud Computing. Hoboken, NJ: Wiley, 2010.
2. P. Mell and T. Grance, The NIST Definition of Cloud Computing, NIST SP 800-145.
3. Azodolmolky, Cloud Networking: Understanding Cloud-Based Data Center Networks. Waltham, MA: Morgan Kaufmann, 2014

SWAYAM/ MOOC / eBOOKS

1. Cloud computing By Prof. Soumya Kanti Ghosh, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_cs14/preview
2. Advanced Computer Networks, By Prof. Neminath Hubballi, Prof. Sameer G Kulkarni IIT Indore, IIT Gandhi nagar https://onlinecourses.nptel.ac.in/noc25_cs02/preview
3. Cloud Computing and Distributed Systems By Prof. Rajiv Misra IIT Patna https://onlinecourses.nptel.ac.in/noc21_cs15/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-562B- CMN - Software Defined and Cognitive Radio(Elective –III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Data Communication and Computer Networks
2. Computer Network Protocols
3. Mathematics for Computer Science
4. Probability and Statistics

Course objectives

The objectives of this course are to

1. Explain the fundamentals, evolution, and architectures of Software Defined Radio (SDR) And
   Cognitive Radio (CR) systems.
2. Analyze the spectrum sensing, allocation, and management techniques required for Reliable end-to-end CR communication.
3. Illustrate** the key components and standards of Software Communication Architecture (SCA) and its role in CR system design.
4. Design reconfigurable RF/baseband modules and algorithms for efficient signal Processing in SDR/CR platforms.
5. Apply adaptive antenna techniques and AI/ML-based strategies for intelligent Spectrum optimization and resource management.

Course outcomes

Having successful completion of this course, student will be able to

- **CO1:** Describe the fundamentals, evolution, and architectures of Cognitive Radio (CR) and Software Defined Radio (SDR).
- **CO2:** Apply spectrum sensing and management techniques to enable end-to-end CR communication.
- **CO3:** Evaluate the role of Software Communication Architecture (SCA), standards, and middleware (e.g., CORBA, JTRS) in CR implementations.
- **CO4:** Design radio frequency (RF) and baseband modules for reconfigurable SDR/CRplatforms.
- **CO5:** Develop adaptive antenna systems and apply AI/ML techniques for intelligent spectrum allocation and optimization

Course Contents

Unit I- Fundamentals and Evolution of Cognitive Radio Systems (09 Hours)

Cognitive radio concepts & history, Benefits of Cognitive radio, Cognitive radio Forum. Low-Cost Cognitive radio Platform, Requirements and system architecture, Convergence between military

and commercial systems, The Future of Software Defined Radio.

Unit II- : Cognitive Radio Architecture and Communication Frameworks:- (09Hours)

Ideal Cognitive radio architecture, Cognitive radio based End-to-End Communication, Worldwide frequency band plans, Cognitive Radio System Models and Protocol Stack, Spectrum Awareness & Sensing Models.

Unit III - Monte Carlo Simulation & Network and Traffic Modelling (09Hours)

Aim and requirements of the SCA, Architecture Overview, Functional View, Networking Overview, Core Framework, Real Time Operating Systems (RTOS), Common Object Request Broker Architecture (CORBA), SCA and JTRS compliance.

Unit IV - Radio Frequency and Baseband Design in SDR (09Hours)

Radio Frequency design, Baseband Signal Processing, Radios with intelligence, Cognitive signal processing principles, Reconfigurable hardware platforms (FPGA/DSP-based radios), Software-driven modulation/demodulation techniques.

Unit V - Smart Antennas and Adaptive Techniques for Cognitive Radios (09Hours)

Smart antennas, Adaptive techniques, phased array antennas, Applying Cognitive radio principles to antenna systems, Smart antenna architectures, Role of AI/ML in adaptive spectrum management.

Learning Resources

Textbooks

1. Reed, Software Radio, Pearson Education, 2002
2. Kwang– Cheng Chen and Ramjee Prasad, Cognitive Radio Networks, Wiley Pub.
3. Dillinger, Madani, Alonistioti (Eds.): Software Defined Radio, Architectures, Systems and Functions, Wiley 2003
4. Paul Burns , Software Defined Radio for 3G, 2002.

Reference Books

1. Tafazolli (Ed.): Technologies for the Wireless Future, Wiley 2005.
2. Bard, Kovarik: Software Defined Radio, the Software Communications Architecture, Wiley 2007.

SWAYAM/MOOC/Youtube links

1. https://www.youtube.com/watch?v=XDkOhlztMLs
2. https://nptel.ac.in/courses/108107107

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-562C -CMN - Traffic Analysis and QoS (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses:

1. Analog and Digital Communication Systems
2. Signals and Systems
3. Digital Signal Processing (DSP)
4. Microprocessors and Embedded Systems

Course Objectives: The course aims to:

1. Explain the concepts, standards, and architectures of network management systems for traffic monitoring and performance evaluation.Describe concepts and terminology associated with TMN.
2. Understand the principles, architecture, and terminology of Telecommunication Management Network (TMN) and broadband network management frameworks.
3. Analyze the characteristics of high-speed networks, traffic modeling techniques, and protocols that support Quality of Service (QoS).
4. Illustrate the role of QoS models, performance metrics, and optimization methods in IP-based and broadband networks.
5. Examine queuing mechanisms, congestion control, and traffic management strategies to ensure efficient network operation.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1** : Analyze and apply different network management standards, models, and tools (SNMP, NMS, MIB) for traffic monitoring and performance evaluation.
- **CO2**: Explain the architecture, standards, and applications of Telecommunication Management Network (TMN) and broadband network management technologies (ATM, MPLS, Optical).
- **CO3**: Evaluate high-speed network traffic characteristics using modelling techniques and self-similar traffic analysis.
- **CO4**: Apply QoS models (IntServ, DiffServ) and protocols to optimize performance in IP-based networks.
- **CO5**: Compare and implement congestion control mechanisms and traffic management strategies across data, TCP/IP, and ATM networks

Course Contents

Unit I - SNMP and Network Management: - (09 Hours)

Standards and Models of Network Management, Organization Model, Information Model,

Communication Model, Functional Model, Network Management Tools and Systems, System Utilities for Management, Network Statistics and Measurement Systems, MIB Engineering, NMS Design, and Network Management System.

Unit II - Telecommunication Management Network and Applications Management (09 Hours)

Telecommunication Management Network (TMN): Conceptual Model, Standards, Architecture, Service Architecture and Integrated View, TMN Implementation, Broadband Network Management: Network and Services, ATM Technology and Management, MPLS Network Technology and OAM Management, Optical and MAN Feeder Networks.

Unit III - High-Speed Networks and Traffic Characteristics:- (09 Hours)

High Speed Networks: High Speed LAN, Performance Modelling and Estimation: Self Similar Traffic. Characteristics of Self-Similar Traffic in high-speed networks-Impact on Network Performance.

Unit IV - Quality of Service in IP Networks - (09 Hours)

Congestion, Performance Issues and Traffic Management: QoS Concepts and Requirements, Integrated Services and Differentiated Services Models, Protocols for QoS Support (RSVP, MPLS QoS, DiffServ mechanisms), QoS Measurement and Performance Metrics.

Unit V - Congestion Control, Traffic Management, and Performance Issues - (09 Hours)

Need for Speed and QoS in modern networks, Performance Requirements and Metrics, Effects of Congestion in Networks, Congestion Control in Data Networks and the Internet, Link-Level Flow and Error Control Mechanisms, TCP Traffic and Control Traffic Characteristics, Congestion Control in ATM Networks.

Learning Resources

Textbooks

1. Network Management- Principles and Practices - Mani Subramanian, Pearson, Second Edition.
2. High-Speed Networks and Internets- Performance and QoS, William Stallings, Pearson, Second Edition

Reference Books

1. Computer Networking with Internet Protocols and Technology, William Stallings, Pearson, Second Edition.
2. Traffic Management & Traffic Engineering for the future Internet – Valadas & Ruj.

SWAYAM/MOOC/YouTube links

1. https://www.youtube.com/watch?v=BHnd02z6QqM
2. https://onlinecourses.nptel.ac.in/noc25_cs15/preview

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
PEC-562D-CMN - Modern Communication Receiver Design & Technology (Elective III)		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses

1. Analog Electronics / Electronic Devices and Circuits
2. Digital Electronics
3. Signals and Systems / Linear Systems
4. Electromagnetic Field Theory / Transmission Lines and Waveguides
5. Communication Systems
6. Microwave Engineering (or RF Circuit Design)

Course Objectives: The course aims to:

1. Design consideration of super heterodyne receiver
2. Differentiate the different types of dynamic range of communication receiver.
3. Describe the operation of mixers and frequency synthesizer.
4. Categorize the different components of IF receiver.
5. Explain the principles of demodulation and baseband design considerations in modern communication receivers

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1**: Analyze and design modern communication receiver architectures, including superheterodyne, direct conversion, and special receiver structures.
- **CO2**: Evaluate receiver performance parameters such as sensitivity, noise figure, intercept point, and dynamic range for front-end design optimization.
- **CO3**: Differentiate and apply various mixer topologies and frequency synthesizer techniques for efficient signal conversion and stability.
- **C04**: Design and select appropriate blocks for Intermediate Frequency (IF) receivers, including filters, AGC circuits, and noise suppression mechanisms.
- **CO5:** Apply suitable demodulation techniques and baseband design considerations for high-performance receiver implementations.

Course Contents

Unit I - Superheterodyne and Modern Receiver Architectures: - (09 Hours)

Superheterodyne Receiver Basics: Single, Double, Multiple, and Direct Conversions, Special Conversions and Their Implementations, Drift-Canceling Loops and the Barlow-Wadley Receiver, High Probability of Intercept (HPOI) and the Ideal Receiver, System Design Considerations for

Modern Receivers, Intermodulation Distortion Products & System Spurious Performance, Receiver System Analysis Tools (Charts, Web Analysis Tools)

Unit II - Dynamic Range and High-Performance Receiver Design - (09 Hours)

Five Types of Dynamic Range (Single-Tone, Two-Tone, etc.), Noise Figure Requirements and Sensitivity, Composite Noise Figure and Front-End Design Considerations, Third-Order Intercept Point (IP3-SFDR) and Measurement Techniques, Simulating and Measuring Composite Linear Dynamic Range for HPOI Receivers, High-Performance HF Transceiver Front-End Design, Practical Preselector Design: Automatically Switched Half-Octave Filter Banks, Switching Mechanisms and Performance Optimization

Unit III – Mixers and Frequency Synthesizers: - (09 Hours)

Mixer Topologies: Single-Balanced, Double-Balanced, and Performance Analysis, Terminating Mixers, Diplexers, AM Noise, and Phase Noise Effects, Conversion Loss, Noise Figure, and Intermodulation in Mixers, Compression Point, Desensitization Level, and Isolation, Commutative Mixers: FET and H-Mode Mixers, Integrated Circuit Mixers (Gilbert Cell, Image-Reject, Image Recovery), Frequency Synthesizers: Definitions, Leeson Noise Model, Long-Term and Short-Term Stability, Phase Noise, Jitter Concepts, Synthesizer Classifications: Brute Force, Direct/Indirect, Open Loop Systems

Unit IV Intermediate Frequency (IF) Receivers and Noise Control - (09 Hours)

Switched and Cascaded IF Filters, High-Performance IF Design in Star-10 Receiver, Logarithmic Amplifiers in ASK/Data Receivers, Variable Passband Filters and Analog Ifs, Noise Blankers: Variable Pulse, Notch Filter, Bandpass Tuning Mechanism, Automatic Gain Control (AGC): Feedback Systems, High Dynamic Range, AGC Implementation: Log Detectors, Square Law Detectors, RMS Detectors, Attack/Release Time, Hanged AGC, Audio-Derived AGC, Digital AGC, PIN Diode Attenuator for AGC

Unit V Demodulation and Advanced Design Considerations - (09 Hours)

Product Detectors and Beat Frequency Oscillators (BFO), Q Demodulation Process and Other Techniques, Star-10 Product Detector Architecture, Audio and Baseband Amplifier Design Considerations, Integration of Modern Digital Signal Processing (DSP) in Receiver Design.

Learning Resources

Textbooks:

1. Cornell Drentea, “Modern Communication Receiver Design & Technology”
2. Robert Dixon, “Radio Receiver Design”

Reference Books

1. Ulrich Rohde, Jerry Whitaker, Andrew Bateman” Communications Receivers: DPS Software Radios, and Design”, 3rd Edition.
2. Kevin McClain, Tom Vito “Radio Receiver Design” Richard A. Poisel,” Electronic Warfare Receivers

SWAYAM/MOOC /YouTube Links

1. https://www.youtube.com/playlist?list=PLm-zueI9b64QGMcfn5Ckv_8W5Z1d3vMBY
2. https://onlinecourses.swayam2.ac.in/cec20_hs17/preview
3. https://onlinecourses.nptel.ac.in/noc23_ge36/preview

Savitribai Phule Pune University Master of Engineering – E&TC Engineering (2025 Course)		
SEM-571-E&TC-CMN - Technical Seminar I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term Work** : 25 Marks **Practical** : 25 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

Course Objectives: Upon successful completion of this course, students will be able to:

1. **Deepen Technical Knowledge:** To enable students to explore a specialized topic within Computer Engineering beyond the regular curriculum, fostering in-depth understanding.
2. **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. **Enhance Communication Skills:** To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. **Prepare for Thesis/Dissertation:** To serve as a foundational step for the master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: After successful completion of the course, learner will be able to:

- **CO1: Formulate** the goals and objectives of scientific research.
- **CO2:** Search, evaluate and **analyze** information about the achievements of science and technology in the target area and beyond.
- **CO3: Interpret** data from different fields of science and technology.
- **CO4: Build** the logic of reasoning and statements.
- **CO5: Create**, design and edit text documents in accordance with the requirements of the organization or publisher.

Guidelines

7. Responsibility of the students:

The Seminar should be carried out individually by each student.

- A student should identify the area or topics in recent trends and developments in consultation with the guide
- A student should report to his/her respective guide regularly (at least once a week) and

report the progress of the seminar work.

- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

8. **Topic Selection**

- Relevance: Topics must be directly related to Computer Engineering, encompassing cur- rent research trends, emerging technologies, advanced concepts, or interdisciplinary ap- plications.
- Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
- Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
- Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
- Examples of Broad Areas: Artificial Intelligence/Machine Learning, Data Science & Big Data, Cybersecurity, Cloud Computing, Internet of Things (IoT), Computer Networks, Soft- ware Engineering, High-Performance Computing, Embedded Systems, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.

9. **Seminar Structure and Deliverables :** The technical seminar typically involves the following stages and deliverables

- Topic Proposal (2-3 weeks after topic approval):
- A concise document (1-2 pages) outlining:
- Proposed Seminar Title
- Brief Description/Abstract of the Topic
- Motivation and Relevance to Computer Engineering

- Preliminary List of Key References (at least 5-7 reputable sources)
- Tentative Scope and Outline of the Presentation
- Submission: To the faculty supervisor for approval.
- Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
- Critical Analysis: Beyond mere summarization, students are expected to critically ana- lyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
- Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

10. Seminar Report/Paper (Due 2-3 weeks before presentation):

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- Sections:
  - Abstract: A concise summary of the seminar topic and key findings.
  - Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
  - Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
  - Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
  - References: A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

11. **Oral Presentation :**

- Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
- Audience: Faculty members, peers, and potentially other interested individuals.
- Content: The presentation should effectively convey the key aspects of the seminar topic. It should not simply be a reading of the report.
- Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral de-

livery. Avoid excessive text on slides.

- Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace. Practice the presentation thoroughly.
- Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.

12. **Evaluation Criteria :** The technical seminar will be evaluated based on the following criteria:

- Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
- Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
- Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
- Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources

Text Books

1. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely
2. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma
3. "The Craft of Scientific Presentations" by Michael Alley

NPTEL Course

1. https://nptel.ac.in/courses/109/106/109106180/
2. https://www.udemy.com/course/technical-writing/
3. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University, Pune

Maharashtra, India

Master of Engineering (2025 Pattern)
Electronics & Telecommunication Engineering
(Communication Networks)

Semester III

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
RM -601 -CMN - Research Methodology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 05 Hours/Week	05	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :

1. Familiarity with project-based learning (e.g., mini projects, seminars, undergraduate theses)
2. Knowledge of basic statistics (mean, median, variance, standard deviation, probability concepts)
3. Basic skills in technical writing (reports, presentations, documentation).
4. Sound fundamentals of the core engineering/science domain

Course Objectives: The course aims to:

1. Understand the philosophy of research in general
2. Understand basic concepts of research and its methodologies
3. Learning the methodology to conduct the Literature Survey
4. Acquaint with the tools, techniques, and processes of doing research
5. Learn effective report writing skills and allied documentation
6. Become aware of the ethics in research, academic integrity and plagiarism

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1**: **Define** research and **explain** its essential characteristics with examples from engineering and science fields.
- **CO2**: Identify and **apply** different types of research (basic, applied, qualitative, quantitative, exploratory, descriptive, etc.) to specific problems.
- **CO3**: **Analyze** the outcomes of research such as publications, patents, and technological contributions, and understand their societal and industrial impacts.
- **CO4**: **Apply** ANOVA and ANCOVA techniques for effective experimental data analysis and interpretation of results.
- **CO5**: **Understand** and **apply** the basics of Intellectual Property Rights (IPR) to safeguard innovative research and prevent unethical practices.

Course Contents

Unit I - Definition and Characteristics of Research:- (12 Hours)

Basic of Research : Definition; Concept of Construct, Postulate, Proposition, Thesis, Hypothesis, Law, Principle. Philosophy and validity of research. Objective of research. Various functions that describe characteristics of research such as systematic, valid, verifiable, empirical and critical approach. Types - Pure and applied research. Descriptive and explanatory research. Qualitative and

quantitative approaches.

Engineering Research : Why? Research Questions, Engineering Ethics, conclusive proof-what constitutes, A research project-Why take on?

Case Study : Code of Ethics, IEEE Code of Ethics, ACM Software Engineering Code of Ethics and Professional Practice, Code of Ethics especially covering Engineering discipline, various aspects-environment, sustainable outcomes, employer, general public, and Nation, Engineering Disasters.

Unit II - Literature Search and Review - (12 Hours)

Literature Review, Types of review , Developing the objectives, Preparing the research design including sample Design, Sample size. Archival Literature, Why should engineers be ethical? Types of publications- Journal papers, conference papers, books, standards, patents, theses, trade magazine, newspaper article, infomercials, advertisement, Wikipedia & websites, Measures of research impact, publication cost.

Case Study : Engineering dictionary, Shodhganga, The Library of Congress, Research gate, Google Scholar, Bibliometrics, Citations, Impact Factor, h-index, I-index, plagiarism, copyright infringement

Unit III - Analysis of Variance and Covariance:- (12 Hours)

Basic principle of Analysis of Variance, ANOVA Technique, Setting up Analysis of Variance Table, shortcut method for one way ANOVA, Coding method, Two-way ANOVA, ANOVA in Latin-square design, analysis of co-variance (ANCOVA), assumptions in ANCOVA. Academic Ethics: Plagiarism, exposure on anti-plagiarism tools.

Unit IV - Technical Writing and IPR - (12 Hours)

Academic writing, sources of information, assessment of quality of journals and articles, writing scientific report, structure and component of research report, types of report – technical reports and thesis, SCOPUS Index, citations, search engines beyond google, impact factor, H-Index. IPR: What is IPR? the importance of patents, types of IPR, process of patent.

Unit V - Outcome of Research and Research Presentation:- (12 Hours)

Relevance, interest, available data, choice of data, Analysis of data, Generalization and interpretation of analysis, Preparation of the Report on conclusions reached, Testing validity of research outcomes, Suggestions and recommendations, identifying future scope.

Research presentation: Introduction, Standard terms, Standard research methods and experimental techniques, Paper title and keywords, Writing an abstract, Paper presentation and review, Conference presentations, Poster presentations, IPR, Copyright, Patents.

Case Study: Intellectual Property India- services, InPASS - Indian Patent Advanced Search System, US patent, IEEE / ACM Paper templates.

Learning Resources

Text Books:

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed),

Singapore, Pearson Education.
4. Neeraj Pandey, Intellectual Property Rights ,1st Edition, PHI
5. Shrivastava, Shenoy& Sharma, Quantitative Techniques for Managerial Decisions, Wile

Reference Books

1. Goode W J &Hatt P K, Methods in Social Research, McGraw Hill
2. Basic Computer Science and Communication Engineering – R. Rajaram (SCITECH)

SWAYAM/MOOC/Youtube links

1. https://www.youtube.com/playlist?list=PLm-zueI9b64QGMcfn5Ckv_8W5Z1d3vMBY
2. https://onlinecourses.swayam2.ac.in/cec20_hs17/preview
3. https://onlinecourses.nptel.ac.in/noc23_ge36/preview

Practical Assignments / Mini Project Problem Statements		
Sr. No.	**Title**	**Objectives**
1	Problem Identification Exercise	Identify and clearly define a real-world research problem in your engineering discipline.
2	Literature Review Report	Conduct a detailed literature survey (minimum 30 research papers) and summarize gaps in existing research.
3	Research Proposal Drafting	Prepare a structured research proposal including problem statement, objectives, scope, and methodology.
4	Hypothesis Formulation	Develop testable hypotheses based on selected research problems.
5	Design of Experiment	Design a detailed experimental plan or simulation for validating hypotheses.
6	Sampling Techniques	Select and justify a sampling method for data collection in your project.
7	Data Collection Tools Development	Design a survey questionnaire or sensor-based data collection method.
8	Statistical Data Analysis	Perform statistical analysis (ANOVA, regression, t-tests) on sample data.
9	Research Paper Writing	Draft a full research paper based on hypothetical or preliminary data.
10	Research Ethics and Plagiarism Check	Analyze ethical aspects and conduct a plagiarism check for your paper.

Mini Project statement list for Research Methodology (ANY ONE)		
Sr. No.	**Project Title**	**Description/Deliverable**
1	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.
2	Comparison of Research Methodologies	Compare qualitative vs. quantitative methods through case studies.
3	Development of Research Gap Identification Model	Create an algorithm that detects research gaps from published articles.
4	Design of a Predictive Analytics Model	Design a model that predicts the future trend of research in a selected field.
5	Big Data Analysis for Research Trends	Analyze publication data from Scopus/IEEE/Google Scholar to identify top emerging topics.
6	AI-based Systematic Literature Review Tool	Build a tool that automates screening and organizing research papers.

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
OJT-602-CMN - Internship/On Job Training (IN/OJT)		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 10 Hours/Week	05	Term Work : 100 Marks

Course objectives :

1. To put theory into practice and expand thinking and broaden the knowledge and skills acquired through course work in the field.
2. To relate to, interact with, and learn from current professionals in the field.
3. To understand and adhere to professional standards in the field.
4. To gain insight to professional communication including meetings, memos, reading, writing, public speaking, research, client interaction, input of ideas, and confidentiality.
5. To develop the initiative and motivation to be a self-starter and work independently.

Course Outcomes: Upon successful completion of this course, students will be able to:

- **CO1: Gain** practical experience within the industry in which the internship is done.
- **CO2: Acquire** knowledge of the industry in which the internship is done.
- **CO3: Apply** knowledge and skills learned to classroom work.
- **CO4: Develop** and refine oral and written communication skills.
- **CO5: Acquire** the knowledge of administration, marketing, finance and economics.

Course Description:

1. Internship/On Job Training provides students with the opportunity of hands-on experience that includes personal training, time and stress management, interactive skills, presentations, budgeting, marketing, liability and risk management, paperwork, equipment ordering, maintenance, responding to emergencies etc.
2. An internship is the phase of time for students when they are trained for their skills, they are good at, and it gives them a chance to apply their knowledge practically in industries
3. The internship can be carried out in any industry/R&D Organization/Research Institute/Institute of national repute/R&D Centre of Parent Institute.
4. The Department/college shall nominate a faculty to facilitate, guide and supervise students under internship.

Guidelines

1. **Purpose:** Internships are designed to bridge the gap between academic learning and industry practice. They aim to provide hands-on experience, expose students to the industrial environment, develop technical and soft skills (communication, teamwork, problem-solving), and help in career exploration.

2. Internship Duration and Academic Credentials

- Students can take internship work in the form of Online/Offline mode from any of the Industry / Government Organization Internship programs approved by SPPU/AICTE/UGC portals
- An intern is expected to spend 10 - 12 hours per week on Internship, Training will result in about 160-170 hours of total internship duration.
- The minimum requirement regarding Internship duration should not be below 8 weeks

3. Type of Internship

- Industry/Government Organization Internship: Working directly with a company or government body.
- Research Internship: Focused on research projects, often in collaboration with academic institutions or R&D labs.
- Innovation/Entrepreneurship: Working on developing new products, processes, or even starting a venture.
- Social Internship: Engaging in community-based projects.

4. Assessment Details (TW and Practical)

- Term work for 100 marks
- A daily log submitted by the student and a work log signed by the office HoDs where the student has interned will be considered towards the TW marking.

5. Indicative list of areas for OJT

- Trade and Agriculture
- Economy & Banking Financial Services and Insurance
- Logistics, Automotive & Capital Goods
- Fast Moving Consumer Goods & Retail
- Information Technology/Information Technology Enabled Services & Electronics
- Handcraft, Art, Design & Music
- Healthcare & Life Science
- Sports, Wellness and Physical Education
- Tourism & Hospitality
- Digitization & Emerging Technologies (Internet of Things / Artificial Intelligence / Machine Learning

  - **Faculty Supervision:** Students are usually assigned an internal faculty guide/mentor who supervises their internship activities. This faculty member acts as a teacher, mentor, and critic, and ensures the internship aligns with academic goals. External Supervision: In many cases, an external expert from the host organization also guides the student.

- **Documentation and Reporting**:
  - Joining Report: To be submitted within a specified time frame (e.g., one week from joining).

- Daily/Periodical Diary: Students are often required to maintain a daily or weekly record of their observations, work, and learning.
- Internship Report: A comprehensive report detailing the work done, learning outcomes, and achievements during the internship. This report needs to be duly signed by the company official and faculty mentor.
- Completion Certificate: Issued by the host organization upon successful completion.

6. Evaluation:

- Evaluation is typically done by the institute, often within a short period after the internship ends.
- It may involve presentations, viva-voce examinations, and assessment of the internship report and daily diary.
- Performance-based feedback from the industry mentor is usually a key component

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
SEM-603-CMN - Technical Seminar II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 06 Hours/Week	03	**Term Work** : 25 Marks **Practical** : 25 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

Course Objectives: Upon successful completion of this course, students will be able to:

1. **Deepen Technical Knowledge:** To enable students to explore a specialized topic within Computer Engineering beyond the regular curriculum, fostering in-depth understanding.
2. **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. **Enhance Communication Skills:** To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. **Prepare for Thesis/Dissertation:** To serve as a foundational step for the master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: After successful completion of the course, learner will be able to:

1. **CO1: Formulate** the goals and objectives of scientific research.
2. **CO2:** Search, evaluate and **analyze** information about the achievements of science and technology in the target area and beyond.
3. **CO3: Interpret** data from different fields of science and technology.
4. **CO4: Build** the logic of reasoning and statements.
5. **CO5: Create**, design and edit text documents in accordance with the requirements of the organization or publisher.

Guidelines

1. Responsibility of the students:

- The Seminar should be carried out individually by each student.
- A student should identify the area or topics in recent trends and developments in

consultation with the guide

- A student should report to his/her respective guide regularly (at least once a week) and report the progress of the seminar work.
- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

2. Topic Selection

- Relevance: Topics must be directly related to Computer Engineering, encompassing current research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
- Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
- Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
- Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
- Examples of Broad Areas: Artificial Intelligence/Machine Learning, Data Science & Big Data, Cybersecurity, Cloud Computing, Internet of Things (IoT), Computer Networks, Software Engineering, High-Performance Computing, Embedded Systems, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.

3. Seminar Structure and Deliverables : The technical seminar typically involves the following stages and deliverables

- Topic Proposal (2-3 weeks after topic approval):
- A concise document (1-2 pages) outlining:
- Proposed Seminar Title
- Brief Description/Abstract of the Topic
- Motivation and Relevance to Computer Engineering
- Preliminary List of Key References (at least 5-7 reputable sources)
- Tentative Scope and Outline of the Presentation
- Submission: To the faculty supervisor for approval.
- Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv,

Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.

- Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
- Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

4. Seminar Report/Paper (Due 2-3 weeks before presentation):

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- Sections:
  - Abstract: A concise summary of the seminar topic and key findings.
  - Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
  - Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
  - Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
  - References: A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

5. Oral Presentation :

- Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
- Audience: Faculty members, peers, and potentially other interested individuals.
- Content: The presentation should effectively convey the key aspects of the seminar topic.
  It should not simply be a reading of the report.
- Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral de- livery. Avoid excessive text on slides.
- Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace.
  Practice the presentation thoroughly.
- Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.

6. Evaluation Criteria : The technical seminar will be evaluated based on the following criteria:

- Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
- Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
- Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
- Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources

Text Books

1. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely
2. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma
3. "The Craft of Scientific Presentations" by Michael Alley

NPTEL Course

1. https://nptel.ac.in/courses/109/106/109106180/
2. https://www.udemy.com/course/technical-writing/
3. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University Master of Engineering (2025 Course) – Electronics & Telecommunication Engineering (Communication Networks)		
RPR-604-CMN - Research Project Stage - I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 18 Hours/Week	09	**Term Work :** 25 Marks **Oral/ Presentation :** 25 Marks

Course Description:

The master's degree culminates in a research project of the student's own design. This research project is documented by a final research report or dissertation. The student's work is guided by an academic supervisor. Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations within the discipline. The dissertation should represent the very best research and analysis a student can produce.

Course Objectives: Upon successful completion of this course, students will be able to:

1. Demonstrate an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
2. Demonstrate an ability to comply with ethical, safety, and documentation processes appropriate to their project
3. Demonstrate expert knowledge in the subject of their research project, such as through a integrated literature survey
4. Demonstrate expert knowledge in the research methods appropriate to generating reliable data for their research questions
5. Demonstrate the ability to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
6. Demonstrate an ability to relate their original data to existing literature, or to create an novel synthesis of existing materials
7. Demonstrate an ability to assemble their findings into a substantial piece of writing that presents a clear thesis and a cohesive, evidence-based argument
8. Demonstrate an ability to balance description, analysis, and synthesis within their project report
9. Demonstrate an ability to reflect on the strengths and weaknesses of their research and methodology, with constructive advice on how they might improve their efforts in future work

Course Outcomes:

After successful completion of the course, learner will be able to:

- **CO1:** Demonstrate how to search the existing literature to gather information about a specific problem or domain.
- **CO2:** Identify state-of-the-art technologies and research in the chosen domain, and highlight open problems that are relevant to societal or industrial needs.
- **CO3:** Evaluate various solution techniques to determine the most feasible solution within given constraints for the chosen dissertation problem.
- **CO4:** Apply software engineering principles related to requirements gathering and design to produce relevant documentation.
- **CO5:** Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.

Guidelines

General Guidelines

(a) The dissertation is a year-long project, conducted and evaluated in two phases. It can be carried out either in-house or within an industry as assigned by the department. The project topic and internal advisor (a faculty member from the department) are determined at the beginning of Phase I.

(b) Students are expected to complete the following activities in Phase-I:

i. Literature survey
ii. Problem Definition
iii. Motivation for study and Objectives
iv. Preliminary design / feasibility / modular approaches
v. Design of the research project

Phase 1: Informal conversations

Students are strongly encouraged to discuss possible research project ideas with the internal guide fellow students, and other research professionals. All research projects begin with open-ended conversations and scoping exercises. These should be non-committal.

Phase 2: Identify topic

The first formal step in the module involves identifying a preliminary project title and writing an abstract of no more than 200 words. This requires submitting a completed registration form. Writing an abstract for a research proposal or for completed research work is an important transferable skill. Students who do not submit a completed registration form will be assigned a project. The project title is understood to be provisional. Supervisors will be assigned to students after the project title/ abstract forms have been submitted. Supervision: A supervisor is required. The main responsibilities of the supervisor are to assist the student with project management and to advise the student on criteria for assessment. You can expect your supervisor to read and comment on a full draft of your research proposal and of your project.

It is a good idea to discuss a timeline for your project with your supervisor, and to establish a definite timetable.

Some key points in our advice to students on compliance:

1. Allow at least two weeks between submitting an ethics application and the date of your first data collection
2. Your supervisor must approve (and sign) your ethics application before you submit it at departmental level
3. After your protocols have been approved, append a copy of your ethical approval certificate to the dissertation and project proposal.

Phase 3: Project proposal

The proposal should reflect a student's best effort. At the same time, we recognize research often raises new questions. Some redefinitions of topics and titles are common later in the research process. Students should keep their supervisors up to date on these developments, and they can expect a reasonable amount of adaptation.

Phase 4: Term-1 research

Students are expected to commit substantial time during the term to their research project. Supervisions The principal form of academic input for the research project normally comes through discussions with the designated supervisor. The majority of these meetings should be face-to-face, either in person or via video- or audio-conferencing technology.

Students are expected to respect these periods of absence and plan their needs accordingly. One distinction is crucial:

(1) when staff are on leave, they are off work (i.e., not expected to maintain contact with their supervisees or to undertake their duties); however,

(2) when staff are working remotely, they are at work (i.e., expected to maintain contact and to be available for normal duties).

A student's supervisor is not the only person who may advise on projects and writing. Others include peers and subject experts.

Phase 5: Submit project report

The project report with the specific due date must be submitted to the Department.

Additional Information

1. **Research notebook :** Students are strongly advised to maintain a research notebook, either digital or paper, and to keep this up to date. A research notebook can prove useful should examiners query research methods, research integrity, or research process.

2. **Preventing data loss:** Protect yourself against loss of research material and writing by maintaining a system for secure, redundant, up-to-date back-up of research material and writing. Loss cannot be accepted as a reason for failing to meet a deadline. A copy of written notebooks can be stored by supervisors for the duration of the project. Loss of project materials through

accidents and theft have occurred in the past; these have had devastating effects on the un-prepared. All students are warned to create redundancies to protect their project from similar calamities.

3. **Extensions :** This is a long-term research project, and time management is a learning objective. Short-term extensions normally are not considered. Applications for extension must be made through the processes described in the STS Student Handbook. Personal Tutors are the first point of contact on extension requests.

4. **Word counts :** Words counted towards the total word count include the main body of the report and supporting footnotes or endnotes. The word count does not include bibliography, front matter (title page, keywords, abstract, table of contents, acknowledgments), appendix material, supplemental data packages, table and figure legends, or documentation of ethics protocols or approvals. Otherwise, University standard policy on word counts will apply.

5. **Re-using coursework from other modules :** Text and ideas in the research proposal may reappear in the dissertation if significantly developed or further elaborated; however, Universities policy on self-plagiarism prevents the same work receiving credit twice. This means rote duplication is not allowed.

6. **Citation format :** The style must be clear, explicit, and meaningful. In every instance, it must allow an examiner to locate efficiently and specifically material referred to. As a recommendation, students should use a style frequently used in the literature relevant to their research project. Most journals have style guides in their notes to contributors. Students should dis- cuss options with their supervisors, and they should keep in mind that efficient citation is one element in the criteria for assessment.

Savitribai Phule Pune University, Pune

Maharashtra, India

Master of Engineering (2025 Pattern)
Electronics & Telecommunication Engineering
(Communication Networks)

Semester IV

Savitribai Phule Pune University Master of Engineering – Electronics & Telecommunication Engineering (2025 Course) (Communication Network)		
SEM-651-CMN - Technical Seminar III		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work** : 50 Marks **Oral/Presentation** : 50 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers.

Course Objectives: Upon successful completion of this course, students will be able to:

1. **Deepen Technical Knowledge:** To enable students to explore a specialized topic within Computer Engineering beyond the regular curriculum, fostering in-depth understanding.
2. **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
3. **Enhance Communication Skills:** To cultivate effective oral and visual presentation skills, enabling students to articulate complex technical concepts clearly and concisely to a knowledgeable audience.
4. **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
5. **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
6. **Prepare for Thesis/Dissertation:** To serve as a foundational step for the master's thesis/dissertation, allowing students to explore potential research areas.

Course Outcomes: After successful completion of the course, learner will be able to:

- **CO1: Formulate** the goals and objectives of scientific research.
- **CO2:** Search, evaluate and **analyze** information about the achievements of science and technology in the target area and beyond.
- **CO3: Interpret** data from different fields of science and technology.
- **CO4: Build** the logic of reasoning and statements.
- **CO5: Create**, design and edit text documents in accordance with the requirements of the organization or publisher.

Guidelines

1. Responsibility of the students:

- The Seminar should be carried out individually by each student.
- A student should identify the area or topics in recent trends and developments in consultation

with the guide

- A student should report to his/her respective guide regularly (at least once a week) and report the progress of the seminar work.
- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.
- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing seminar presentations and the oral defense of the seminar

2. Topic Selection

- Relevance: Topics must be directly related to Computer Engineering, encompassing cur- rent research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
- Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
- Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
- Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
- Examples of Broad Areas: Artificial Intelligence/Machine Learning, Data Science & Big Data, Cybersecurity, Cloud Computing, Internet of Things (IoT), Computer Networks, Soft- ware
- Engineering, High-Performance Computing, Embedded Systems, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.

3. Seminar Structure and Deliverables : The technical seminar typically involves the following stages and deliverables

- Topic Proposal (2-3 weeks after topic approval):
- A concise document (1-2 pages) outlining:
- Proposed Seminar Title
- Brief Description/Abstract of the Topic
- Motivation and Relevance to Computer Engineering
- Preliminary List of Key References (at least 5-7 reputable sources)

- Tentative Scope and Outline of the Presentation
- Submission: To the faculty supervisor for approval.
- Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
- Critical Analysis: Beyond mere summarization, students are expected to critically ana- lyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
- Note-Taking & Organization: Maintain systematic notes and organize research material effectively.

4. Seminar Report/Paper (Due 2-3 weeks before presentation):

- A written report (typically 15-25 pages, excluding references and appendices) detailing the seminar content.
- Format: Follow a professional academic paper format (e.g., IEEE transaction style).
- Sections:
  - Abstract: A concise summary of the seminar topic and key findings.
  - Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
  - Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
  - Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
  - Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
  - Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
  - References: A comprehensive list of all cited sources properly formatted.
  - Appendices (Optional): Supplementary material if necessary.

5. Oral Presentation:

- Duration: Typically, 25-30 minutes for presentation, followed by 10-15 minutes for Q&A. (Specific timings will be announced)
- Audience: Faculty members, peers, and potentially other interested individuals.
- Content: The presentation should effectively convey the key aspects of the seminar topic. It should not simply be a reading of the report.
- Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral de- livery. Avoid excessive text on slides.
- Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace. Practice the presentation thoroughly.
- Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar

topic. Demonstrate a strong understanding and ability to defend your perspectives.

6. Evaluation Criteria : The technical seminar will be evaluated based on the following criteria:

- Topic Selection and Scope (10%): Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
- Literature Review and Research (25%): Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
- Seminar Report/Paper (30%): Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
- Oral Presentation (35%): Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources

Textbooks

1. "Engineering Communication" by Charles W. Knisely & Karin I. Knisely
2. "Technical Communication: Principles and Practice" by Meenakshi Raman & Sangeeta Sharma
3. "The Craft of Scientific Presentations" by Michael Alley

NPTEL Course

1. https://nptel.ac.in/courses/109/106/109106180/
2. https://www.udemy.com/course/technical-writing/
3. https://www.edx.org/course/writing-in-the-sciences

Savitribai Phule Pune University Master of Engineering – Electronics & Telecommunication Engineering (2025 Course) (Communication Network)		
RP-652-CMN - Research Project Stage-II ,		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 36 Hours/Week	18	**Term Work:**150 Marks **Oral/ Presentation :** 50 Marks

Course Description:

The master's degree culminates in a research project of the student's own design. This project is documented by a final research report or dissertation. The student's work is guided by a supervisor or guide. Students are expected to construct a research project that includes original research, deliberate and well considered methodological choices, and shows relevance to significant conversations within the discipline. The dissertation should represent the very best research and analysis a student can produce. Study of relevant supplementary literature, mastering useful programming languages and tools for the problem, are also expected at this stage of the project.

Course Objectives: Upon successful completion of this course, students will be able to:

1. **Demonstrate** an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
2. **Ability** to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
3. **Ability** to relate their original data to existing literature, or to create a novel synthesis of existing materials
4. **Identify** and **formulate** a problem of research interest in the chosen area of computing.

Course Outcomes: After successful completion of the course, learner will be able to:

- **CO1 : Undertake** independent research that makes an original contribution to knowledge, or produces a novel synthesis of existing materials relevant to significant conversations in the discipline
- **CO2 : Plan** their project in advance, using a proposal to describe their undertaking, describe how it will be managed, and reflect upon its value
- **CO3 : Relate** their original research to existing literature on the subject and relate their work to general themes in their relevant scholarly literature
- **CO4 : Assemble** their rationale, methods, findings, and analysis into a substantial piece of writing that presents a clear thesis and a cohesive evidence-based argument or analysis
- **CO5 : Reflect** on the strengths and weaknesses of their research and methodology, understanding how they might improve their efforts in future work

Guidelines

General Guidelines

- The student shall consolidate and complete the remaining part of the research work started in Semester III. This will consist of Selection of Technology, Installations, implementations, testing, Results, measuring performance, discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems, comparative analysis, validation of results and conclusions.
- The student shall prepare the duly certified final report of dissertation in standard format for satisfactory completion of the work by the guide concerned and head of the Department/Institute.
- The students are expected to validate their study undertaken by publishing it on standard platforms.
- The investigations and findings need to be validated appropriately at standard platforms like conference and/or peer reviewed journal.
- The student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordination/Head of the department. The continuous assessment of the progress needs to be documented unambiguously.
- Supervisor Interaction: Minimum one meeting per week.
- Logbook: Maintain a record of work progress and supervisor comments.
- Ethics: No plagiarism, false results, or unethical practices allowed.
- Backup: Keep source code, datasets, and reports backed up securely.
- Submission Format: Soft copy (PDF) + Hard copy as per institute norms.

- **Key Components:**
  - Implementation
    - Complete development/simulation/testing of the system or model.
    - Ensure correctness, efficiency, and validation of results.
  - Results & Analysis
    - Include experimental setup, datasets used, performance metrics.
    - Graphs, tables, and comparison with existing techniques.
    - Highlight key findings and their significance.
  - Conclusion and Future Work
    - Summarize outcomes, contributions, and applications.
    - Suggest extensions or improvements for future research.
  - Paper Publication
    - At least one paper (optional/encouraged) in peer-reviewed conference/journal.
    - Attach publication/proof as appendix (if available).
  - Final Report Format

    - Revised version of Stage 1 report with added implementation, results, and conclusion chapters.
    - Maintain academic writing standards and include all necessary references.
- Plagiarism Report
    - The final version must again be checked and should not exceed 15% similarity.
- Evaluation Parameters
    - Completeness and quality of implementation
    - Analysis and originality of results
    - Quality of documentation and adherence to format
    - Viv-voce performance and clarity of understanding
    - Contribution to knowledge or innovation.

Task Force for Curriculum Design and Development

Team Members for Course Design

Dr D.G Bhalke, Dr D.Y Patil Institute of Technology ,Pimpri
Dr Priti Shende, Dr D.Y Patil Institute of Technology, Pimpri
Dr. M.B.Mali, Sinhgad College of Engineering, Pune
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Mr. Sunil Gosavi, Reliance Jio, Maharashtra

Chairman

Dr. S. D. Shirbahadurkar - Board of Studies Electronics & Telecommunication Engineering,
Savitribai Phule Pune University, Pune

Dean

Dr. Pramod Patil - Dean – Science and Technology
Savitribai Phule Pune University, Pune