Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern) in

M. E. - Computer Networks

(With effect from Academic Year 2025-26)

Contents

Nomenclature

AICTE All India Council for Technical Education

CCE Comprehensive Continuous Evaluation

EndSem End Semester Examination

KAP Knowledge and Attitude Profile

PCC Programme Core Course

PEC- Programme Elective Course

PEO Programme Educational Objectives

PO Programme Outcomes

PSO Program Specific Outcomes

UGC University Grants Commission

WK Knowledge and Attitude Profile

Master of Engineering in Computer Networks - 2025 Pattern

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Computer Engineering, are very happy to present Master of Engineering in Computer Networks syllabus effective from the Academic Year 2025-26 (2025 Pattern). In an era defined by interconnectedness, the demand for experts who can design, manage, and secure complex network infrastructures has never been greater. Our program is meticulously crafted to address this need, moving beyond foundational concepts to explore cutting-edge topics that are shaping the future of technology. You will delve into areas such as advanced routing protocols, network security, software-defined networking, wireless communication, and the intricate architectures of cloud and IoT systems.

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.

We extend our sincere gratitude to the faculty members, industry experts, and academic advisers who have contributed their invaluable insights to the development of this curriculum. Their collective effort ensures that this program remains relevant, academically sound, and aligned with the evolving demands of the global technology landscape.

Dr. Nilesh Uke

Chairman - Board of Studies - Computer Engineering

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Programme Educational Objectives (PEO)

Program education objectives are broad statements that describe the career and professional accomplishments that the program is preparing post graduates students to achieve.

PEO	PEO Focus	PEO Statements
PEO1	Professional Expertise:	Graduates will successfully apply advanced knowledge in computer networks to design, develop, and implement robust and scalable network solutions in diverse professional settings.
PEO2	Problem-Solving & Innovation	Graduates will demonstrate the ability to analyze complex networking challenges, conduct research, and innovate solutions in areas such as network security, performance optimization, and emerging technologies.
PEO3	Career Advancement	Graduates will advance in their careers, taking on leadership roles in the networking and telecommunications industry, or pursuing further studies and research in related academic fields.
PEO4	Ethical Responsibility	Graduates will practice their profession with a strong sense of ethical responsibility, professionalism, and a commitment to lifelong learning, while being cognizant of the social and environmental impacts of their work.

Master of Engineering - Computer Networks (2025 Course)

Knowledge and Attitude Profile (WK)

A Knowledge and Attitude Profile (KAP), often represented as WK (Knowledge and Attitude Profile) in some contexts, is a framework or assessment tool used to evaluate an individual's knowledge and attitudes related to a specific area, topic, or domain.

WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
WK2	Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
WK5	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
WK8	Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
WK9	Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Programme Outcomes (PO)

Program Outcomes are statements that describe what students are expected to know and be able to do upon graduating from the program. These relate to the skills, knowledge, attitude and behaviour that students acquire through the program. NBA has defined the following three POs for a graduate of PG Engineering Program:-

PO1	Ability to independently carry out research/investigation and development work to solve practical problems.
PO2	Ability to write and present a substantial technical report/document.
PO3	Ability to demonstrate a degree of mastery over the area of specialization (Computer Engineering) at a level higher than the bachelor's program.

Program Specific Outcomes (PSOs)

Program Specific Outcomes (PSOs) are statements that describe the knowledge, skills, and attitudes that graduates of a academic program (Master of Engineering in Computer Networks) should be able to demonstrate at the time of their graduation.

PSO1	**Network Design and Management:** Apply advanced concepts of computer networks to design, configure, and manage secure, scalable, and high-performance communication systems.
PSO2	**Research and Innovation :** Analyze, model, and evaluate emerging networking technologies to develop innovative solutions through research and experimentation.
PSO3	**Security and Societal Applications:** Implement advanced security mechanisms and provide sustainable networking solutions addressing real-world challenges in industry and society.

Master of Engineering (2025 Pattern) – Computer Networks

Curriculum Structure - Semester I

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
PCC-501-CNT	Programme Core Course	Probability and Statistics	4	-	50	50	-	-	-	100	4	-	4
PCC-502-CNT	Programme Core Course	Advanced Computer Networks	4	-	50	50	-	-	-	100	4	-	4
PCC-503-CNT	Programme Core Course	Distributed Systems	4	-	50	50	-	-	-	100	4	-	4
PCC-504-CNT	Programme Core Course	Blockchain Technology	4	-	50	50	-	-	-	100	4	-	4
PCC-505-CNT	Programme Core Course	Computational Laboratory-I	-	4	-	-	25	-	25	50	-	2	2
PEC-521-CNT	Programme Elective Course	Elective I	3	-	50	50	-	-	-	100	3	-	3
PEC-522-CNT	Programme Elective Course	Skill 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-CNT	Cloud Computing and Networking
PEC-521B-CNT	Artificial Intelligence in Networking
PEC-521C-CNT	Software Defined Networks
PEC-521D-CNT	Communication Technology Protocols

Master of Engineering (2025 Pattern) – Computer Networks

Curriculum Structure - Semester II

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
PCC-551-CNT	Programme Core Course	Wireless and Mobile Networks	4	-	50	50	-	-	-	100	4	-	4
PCC-552-CNT	Programme Core Course	Internet of Things	4	-	50	50	-	-	-	100	4	-	4
PCC-553-CNT	Programme Core Course	Network Security	4	-	50	50	-	-	-	100	4	-	4
PCC-554-CNT	Programme Core Course	Computational Laboratory-II	-	4	-	-	25	-	25	50	2	-	2
PEC-561-CNT	Programme Elective Course	Elective –II	3	-	50	50	-	-		100	3	-	3
PEC-562-CNT	Programme Elective Course	Elective –III	3	-	50	50	-	-	-	100	3		3
SEM-581-CNT	Seminar	Technical Seminar I	-	4	-	-	25	-	25	50	2	-	2
Total			**18**	**8**	**250**	**250**	**50**	**-**	**50**	**600**	**18**	**4**	**22**

Elective II Courses		Elective III Courses	
PEC-561A-CNT	Bio-inspired Computing	PEC-562A-CNT	Federated Learning
PEC-561B-CNT	Optical Networking	PEC-562B-CNT	Real-Time Operating System
PEC-561C-CNT	Social Media Analytics	PEC-562C-CNT	Information Security
PEC-561D-CNT	Generative Adversarial Networks	PEC-562D-CNT	Next Generation Networks

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Curriculum Structure - Semester III

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
RM-601-CNT	Research Methodology	Research Methodology	4	-	50	50	-	-	-	100	4	-	4
OJT-602-CNT	OJT/ Internship	On Job Training/Internship	-	10	-	-	100	-	-	100	-	5	5
SEM-603-CNT	Seminar	Technical Seminar II	-	8	-	-	25	-	25	50	-	4	4
RPR-604-CNT	Research Project	Research Project-I	-	18	-	-	25	-	25	50	-	9	9
Total			**04**	**36**	**50**	**50**	**150**	**-**	**50**	**300**	**04**	**18**	**22**

Curriculum Structure - Semester IV

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
SEM-651-CNT	Seminar	Technical Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-652-CNT	Research Project	Research Project -II	-	36	-	-	150	-	50	200	-	18	18
		Total	**-**	**44**	**-**	**-**	**200**	**-**	**100**	**300**	**-**	**22**	**22**

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Computer Networks (2025 Pattern)

Semester I

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-501-CNT - Probability and Statistics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Discrete Mathematics

Course Objectives: The course aims to:

1. Use the fundamental properties and theorems of probability theory, sample spaces, events and random variables to model real-life phenomena and to compute and interpret probabilities of events.
2. Apply statistical methods to estimate parameters of numerical data from a representative sample of a population and interpret the results.
3. Perform matrix computations and use eigenvalues and eigen vectors to analyze the structure of a matrix.

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

- CO1: Apply matrices, Vectors for solving Linear systems
- CO2: Analyze Eigenvalues and Eigenvectors problems
- CO3. Solve examples using Inner product and dot product
- CO4: Demonstrate various PDFs with a suitable example
- CO5: Create Contingency Tables using Statistics

Course Contents

Unit I - Linear Algebra - (12 Hours)

Matrices, Vectors: Addition and Scalar Multiplication, Matrix Multiplication, Linear Systems of Equations. Gauss Elimination, Linear Independence. Rank of a Matrix. Vector Space, Solutions of Linear Systems: Existence, Uniqueness, Inverse of a Matrix. Gauss–Jordan Elimination, Vector Spaces, Inner Product Spaces. Linear Transformations

Unit II Linear Algebra: Matrix Eigenvalue Problems (12 Hours)

The Matrix Eigenvalue Problem, Determining Eigenvalues and Eigenvectors, Some Applications of Eigenvalue Problems, Symmetric, Skew-Symmetric, and Orthogonal Matrices, Eigenbases. Diagonalization. Quadratic Forms

Unit III Vector Space and Vector Calculus (12 Hours)

Vectors in 2-Space and 3-Space, Inner Product (Dot Product), Vector Product (Cross Product), Vector and Scalar Functions and Their Fields. Vector Calculus: Derivatives, Curves. Arc Length. Curvature.

Torsion, Functions of Several Variables. Optional, Gradient of a Scalar Field. Directional Derivative, Divergence of a Vector Field, Curl of a Vector Field

Unit IV Probability Theory (12 Hours)

Data Representation. Average. Spread, Experiments, Outcomes, Events, Probability, Permutations and Combinations, Random Variables. Probability Distributions, Mean and Variance of a Distribution, Binomial, Poisson, and Hypergeometric Distributions, Normal Distribution, Distributions of Several Random Variables

Unit V Mathematical Statistics (12 Hours)

Statistics: Introduction to Statistical Inference Problems; Point Estimation; Interval Estimation; Testing of Hypotheses; Two Sample Problems Involving Normal Populations, Tests for Proportions, Chi-Square Goodness of Fit Test, Contingency Tables.

Learning Resources

Text Books:

1. Stephen Boyd and Lieven Vandenberghe, Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, Cambridge University Press, 2018, ISBN 978-1-316-51896-0

2. Erwin Kreyszig, Herbert Kreyszig and Edward J. Norminton, Advanced Engineering Mathematics, 10th Edition, John Wiley & Sons, Inc, 2011, ISBN 978-0-470-45836-5

Reference Books:

1. T.T. Soong, Fundamentals of Probability and Statistics for Engineers, John Wiley & Sons Ltd, 2004, ISBN 0-470-86814-7

2. Glyn James & Phil Dyke, Advanced Modern Engineering Mathematics, Fifth Edition, Pearson Education Limited, 2018, ISBN: 978-1-292-17434-1

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-502-CNT - Advanced Computer Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Discrete Mathematics

Course Objectives: The course aims to:

1. To review the computer networking concepts
2. To impart concepts of advanced computer networking.
3. To equip students with the understanding necessary for pursuing specialized or advanced-level courses in computer networking.
4. To develop students' expertise in specific areas of networking, including the design, implementation, and maintenance of computer networks.

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

- CO1: Apply Data Communications System and its components.
- CO2: Identify the different types of network topologies and protocols.
- CO3: Enumerate the layers of the OSI model and TCP/IP. Explain the function(s) of each layer.
- CO4: Identify the different types of network devices and their functions within a network

Course Contents

Unit I- Computer Networks and the Internet-(12 Hours)

History of Computer Networking and the Internet, Networking Devices, The Network edge, The Network core, Access Networks and Physical media, ISPs and Internet Backbones. Networking Models: 5-layer TCP/IP Model, 7-Layer OSI Model, Internet Protocols and Addressing, Equal- Sized Packets Model: ATM.

Unit II- Network Routing and Its Concepts-(12 Hours)

Structure of a Router, Basic Router Configuration, Building a Routing Table, Static Routing, Dynamic Routing Distance Vector Routing Protocol (RIPv1, RIPv2, EIGRP), Link State Routing Protocols (OSPF).

Unit III- Lan Switching: Switching and Its Concepts-(12 Hours)

LAN Switching: Switching and its concepts: Structure of a Switch, Basic Switch Configuration, Virtual LANs (VLANs), VLAN Trunking Protocol (VTP), Spanning Tree Protocol (STP), Inter-VLAN Routing.

Unit IV- Wide Area Networks (WANS) (12 Hours)

Introduction to WANs, Point-to-Point Protocol (PPP) concepts, Frame Relay concepts, Dynamic Host Configuration Protocol (DHCP), Network Address Translation (NAT), IPv6.

Unit V- Advanced Network Technologies - (12 Hours)

Network Virtualization, Software-Defined Networking (SDN), Generic Multi-Protocol Label Switching (GMPLS), Introduction to Optical Networks, Signal, Propagation in Optical Fibers, Client Layers of the Optical Layer

Learning Resources

Text Books:

1. Computer Networking: A Top-Down Approach Featuring the Internet, James F. Kurose, Keith W. Ross, Fifth Edition, Pearson Education, 2012.

2. Network Fundamentals, Mark Dye, Pearson Education.

Reference Books:

1. Computer Networks: A Systems approach, Larry L. Peterson & Bruce S. Davie, Fifth edition, Elsevier, 2012.

2. Computer Networks: A Top-Down Approach, Behrouz A. Forouzan, Firoz Mosharaf, Tata McGraw Hill, 2012.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-503-CNT : Distributed Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Foundation in data structures and algorithms, Programming, Understanding of discrete mathematics, probability, and linear algebra.

Course Objectives: The course aims to:

1. To learn the principles, architecture, algorithms and programming models used in distributed systems.
2. To examine state-of-the-art distributed systems, such as Google File System.
3. To design and implement sample distributed systems.

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

- CO1 : Understand the design principles in distributed systems and the architectures for distributed systems.
- CO2 : Apply various distributed algorithms related to clock synchronization, concurrency control, deadlock detection, load balancing, voting etc.
- CO3 : Analyse fault tolerance and recovery in distributed systems and algorithms for the same.
- CO4 : Analyse the design and functioning of existing distributed systems and file systems.
- CO5 : Implement different distributed algorithms over current distributed platforms.

Course Contents

Unit I- Basic Concepts-(12 Hours)

Definition of a distributed systems, Examples, Resource sharing and the Web, Challenges, System models, Architectural and fundamental models, Networking Interprocess communication, External data representation and marshalling, Client-server and Group communication.

Definition of a distributed systems, Examples, Resource sharing and the Web, Challenges, System models, Architectural and fundamental models, Networking Interprocess communication, External data representation and marshalling, Client-server and Group communication.

Unit II- Distributed Objects and Process-(12 Hours)

Distributed objects and remote invocation, Communication between distributed objects, Remote procedure call, Events and notifications - The operating system layer, Protection, Processes and Threads, Communication and invocation, OS Architecture. Security techniques, Cryptographic algorithms, Access control, Digital signatures, Cryptography pragmatics, Needham-Schroeder, Kerberos, Securing electronics transaction, IEEE 802.11 WiFi.

Logical time and event ordering - Global state and snapshot algorithms - distributed snapshots in VMs - clock synchronization - Distributed mutual exclusion - Group based Mutual Exclusion - leader election - deadlock detection - termination detection - Distributed Databases - implementations over a simple distributed system and case studies of distributed databases and systems - Distributed file systems: scalable performance, load balancing, and availability. Examples from Dropbox, Google FS (GFS)/ Hadoop Distributed FS (HDFS), Bigtable/HBase MapReduce, RDD

Unit III- Operating System Issues:-(12 Hours)

Distributed file systems - Name services, Domain name system, Directory and discovery services, Peer to peer systems, Napster file sharing system, Peer to peer middleware routing overlays – Clocks, Events and process states Clock Synchronization - Logical clocks Global states - Distributed debugging - Distributed mutual exclusion - Elections - Multicast communication.

Consistency control: Data Centric Consistency - Client Centric Consistency - Replica Management - Consistency Protocols. Fault tolerance and recovery: basic concepts - fault models - agreement problems and its applications - commit protocols - voting protocols - check pointing and recovery. Case Studies from Apache Spark, Google Spanner, Amazon Aurora, Block Chain Systems etc.

Unit IV- Distributed Transaction Processing-(12 Hours)

Transactions - Nested transactions - Locks - Optimistic concurrency control - Timestamp ordering - Flat and nested distributed transactions - atomic commit protocols - Concurrency control in distributed transactions - Distributed deadlocks - Transaction recovery - Overview of replication, Distributed shared memory and Web services.

Transactions - Nested transactions - Locks - Optimistic concurrency control - Timestamp ordering - Flat and nested distributed transactions - atomic commit protocols - Concurrency control in distributed transactions - Distributed deadlocks - Transaction recovery - Overview of replication, Distributed shared memory and Web services.

Unit V- Distributed Algorithms-(12 Hours)

Synchronous network model - Algorithms: leader election, maximal independent set - Asynchronous system model: I/O automata, operations on automata, fairness - Asynchronous shared memory model - Mutual exclusion: model, the problem, stronger conditions, lockout-free mutual exclusion algorithms, lower bound on the number of registers - Asynchronous network model - Asynchronous network algorithms: leader election in a ring and an arbitrary network.

Learning Resources

Text Books

1. Andrew S. Tannenbaum and Maarten Van Steen, “Distributed Systems: Principles and Paradigms”, Second Edition, Pearson, 2007.

2. George Coulouris, Jean Dollimore, Tim Kindberg, and Gordon Blair, “Distributed Systems: Concepts and Design”, Fifth Edition, Addison Wesley, 2011.

3. James E. Smith, and Ravi Nair, “Virtual Machines: Versatile Platforms for Systems and Processes”, First Edition, Morgan Kaufmann, 2005.

Reference Books:

1. George Coulouris, Jean Dollimore, and Tim Kindberg, “Distributed Systems Concepts and Design”, 5th ed., Pearson Education, 2011.

2. Andrew S. Tanenbaum, Maartenvan Steen, “Distributed Systems Principles and Paradigms”, 2nd ed., Pearson Education, 2006.

3. Nancy A. Lynch, “Distributed Algorithms”, Hardcourt Asia Pvt. Ltd., Morgan Kaufmann, 2000.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-504-CNT: Blockchain Technology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To understand security threats with application of blockchain.
2. To gain knowledge of scalability with understanding operability.
3. To understand Blockchain and AI integration.
4. To analyze and explore the real-world applications of Blockchain technology.

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

- CO1: Get acquainted with the concept of Distributed ledger system and Blockchain.
- CO2: Understanding scalability challenges with interoperability
- CO3: Apply blockchain-AI integration with AI powered solutions.
- CO4: Understanding, Designing and Deploying cloud based blockchain solutions.
- CO5: Analyze real world applications of Blockchain Technology.

Course Contents

Unit I- Blockchain Security and Applications-(08 Hours)

Security in Blockchain: Understanding encryption, key management, and security challenges in blockchain networks

Blockchain in Various Industries: Studying applications of blockchain in finance, healthcare, supply chain management, and government services Decentralized Finance (DeFi) and NFTs: Learning about DeFi, liquidity pools, yield farming, and creating, minting, and trading NFTs

Unit II- Blockchain Scalability and Interoperability-(08 Hours)

Blockchain Scalability: Sharding, Layer 2 scaling solutions, Consensus mechanism optimization, Block size increases, transaction processing optimization

Blockchain Interoperability: Cross-chain bridges, interoperability protocols, Atomic swaps, Ulti-chain applications, Blockchain agnostic solutions, Use cases.

Unit III- Blockchain and Artificial Intelligence-(08 Hours)

Blockchain and AI Integration: Decentralized AI models, AI-powered smart contracts, Blockchain-based AI marketplaces, Applications of Blockchain and AI: Predictive maintenance, Supply chain optimization, Identity verification, Healthcare, Use cases.

Unit IV- Blockchain and Cloud Computing -(08 Hours)

Blockchain and Cloud Computing

Cloud-based Blockchain Solutions: Blockchain-as-a-Service (BaaS), Cloud-based node infrastructure, Scalable blockchain solutions, Challenges and Opportunities in Blockchain and cloud computing.

Unit V- Blockchain for Real World Applications-(08 Hours)

Crypto-currencies, Banking and Financial Services, Supply Chain, Healthcare, Real-Estate, Judiciary, IoT, Insurance, Government Sector, Energy and Utilities, Blockchain Integration with other Domains etc.

Learning Resources

Text Books

1. Martin Quest, —Blockchain Dynamics: A Quick Beginner's Guide on Understanding the Foundations of Bit coin and Other Crypto currencies||, Create Space Independent Publishing Platform, 15-May-2018

2. Imran Bashir, —Mastering Blockchain: Distributed Ledger Technology, Decentralization and Smart Contracts Explained||, Second Edition, Packt Publishing, 2018

3. Alex Leverington, —Ethereum Programming||, Packt Publishing, 2017

4. Elaine Shi, "Foundations of Distributed Consensus and Blockchains", http://elaineshi.com/docs/blockc book.pdf , 2020.

5. Alan T. Norman, "Blockchain Technology Explained: the Ultimate Beginner s Guide About Blockchain Wallet, Mining, Bitcoin, Ethereum, Litecoin, Zcash, Monero, Ripple, Dash, IOTA and Smart Contracts", Amazon Digital Services, 2017.

Reference Books:

1. Bikramaditya Singhal, Gautam Dhameja, Priyansu Sekhar Panda, "Beginning Blockchain a Beginner 's Guide to Building Blockchain Solutions", 2018.

2. Chris Dannen, "Introducing Ethereum and Solidity", Foundations of Crypto currency and Blockchain Programming for Beginners.

3. Ritesh Modi, Solidity Programming Essentials, Packt Publishing,2018.

4. Chandramouli Subramanian, Asha A George, Abhilash K A and Meena Karthikeyan, Blockchain Technology, Universities Press, ISBN-9789389211634.

5. Bahga, Arshdeep, and Vijay Madisetti. "Blockchain applications: a hands-on approach", VPT, 2017.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-505-CNT - Computational Laboratory-I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term Work** : 25 Marks **Oral** : 25 Marks

Prerequisite Courses : Probability and Statistics, Advanced Computer Network, Distributed systems, Blockchain technology

Course Objectives: The course aims to:

1. Provide knowledge of Probability and Statistics for solving engineering problems
2. Explain various algorithms for solving engineering problems
3. Elaborate use of various machine learning techniques for solving engineering problems
4. Describe distributed computing for solving engineering problems

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

- CO1: Apply knowledge of Probability and Statistics for solving engineering problems
- CO2: Choose appropriate routing Protocols and compare the performance
- CO3: Develop causal consistency distributed system
- CO4: Build a Cloud-based Blockchain-as-a-Service (BaaS) application

Guidelines for Laboratory work

- Computational Laboratory - I assignments are based on 4 Programme Core courses (Probability and Statistics, Advanced Computer Network, Distributed systems, Blockchain technology)
- Respective course faculty assigned will frame course objectives, course outcomes, list of assignments, mini projects, if any
- The list of sample assignments is given for preparation of assignments which will be approved by the respective heads of Department before conduction of laboratory.

List of Assignments

PART A: Advanced Computer Networks	
1	Implementation of client server programs with different networking constraints, hosts behind NAT, hosts are globally addressable, etc. .
2	To implement various Routing Protocols and compare the performance
3	To configure a new VLAN on one VTP server and distribute it through all switches on the domain

4	To implement Static NAT-PT on Cisco devices
5	Configure different application servers such as web server, DNS servers, and email server, and secure using firewall rules
PART B: Distributed Systems	
1	To Implement Group Communication in Distributed Systems
2	To Implement RPC (Remote Procedure Call) and RMI (Remote Method Invocation) and compare the performance
3	An implementation of causal consistency distributed system.
4	To implement Clock Synchronization, Consistency, Distributed Mutual Exclusion, Leader Election
PART C: Blockchain Technology	
1	Implementation of the Blockchain for a Banking System
2	Implementation of Cross chain interoperability to interact, exchange assets, and share data.
3	To build a Cloud-based Blockchain-as-a-Service (BaaS) application
Part D: Probability and Statistics	
1	Statistical estimation and Chi-Square Test using R programming: Estimate the population parameters like mean variance from sample data. Construct confidence intervals. Perform the Chi-Square test for Goodness of fit.
2	Vector calculus and probability theory using R programming: Perform the basic vector calculus operations like dot product, cross product, gradient, etc. Apply probability theory on continuous distributions and simulate random variables. Calculate gradient of probability density function.
3	Applications of linear programming and dynamic programming using R / Python: Apply the linear programming in real world resource optimization application. Use diet optimization problem. Choose a combination of two foods to meet minimum daily nutrition requirements at minimum cost. Optimize the cost or profit under constraints. Sample data:(i) Food A, Cost- 50, Protein -3, Fat-2. (ii) Food B, Cost- 30, Protein -2, Fat-4 (iii) Minimum Daily Requirements: Protein >= 8 units, Fat >= 6 units.
Mini Project (Any ONE) - based on the topic learned	

Learning Resources

Reference Books:

1. Computer Networks: A Top-Down Approach, Behrouz A. Forouzan, Firoz Mosharaf, Tata McGraw Hill, 2012.

2. George Coulouris, Jean Dollimore, and Tim Kindberg, “Distributed Systems Concepts and Design”, 5th ed., Pearson Education, 2011.

3. Bikramaditya Singhal, Gautam Dhameja, Priyansu Sekhar Panda, "Beginning Blockchain a Beginner ‘s Guide to Building Blockchain Solutions", 2018.

4. Stephen Boyd and Lieven Vandenberghe, Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, Cambridge University Press, 2018, ISBN 978-1-316-51896-0

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-521A-CNT: Cloud Computing and Networking		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Understand the role of network servers in networking.
2. Install and configure Active Directory and Manage Active Directory
3. Install and configure the DHCP service and Domain Name System (DNS) service
4. Understand and implement SSL services and certificate services
5. Gain knowledge of Routing, Network Address Translation (NAT), Routing and Remote Access Service (RRAS)

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

- CO1: Understand the relationships among the protocols.
- CO2: Understand network concepts and technologies and design a network with subnetting.
- CO3: Learn networking with Windows PowerShell and Manage Microsoft Azure with Microsoft Azure PowerShell.
- CO4: Understand how IP Security (IPSec) protects Transmission Control Protocol/ Internet Protocol (TCP/IP) and Implement IPSec.
- CO5: Analyze VPN tunneling, VPN security on Remotely access Microsoft Azure and Set up point-to-site and site-to-site connections.

Course Contents

Unit I- Overview on cloud and networking & Network Protocols-(08 Hours)

Introduction, Networks, Network Operating Systems, Network Architecture, Application Layer Protocols Transport Layer Protocols, Internet Layer Protocols, Network Interface Layer Protocols, Network Protocol Graph

Unit II- Network Concepts, Design and Network Directory Services-(08 Hours)

Network Types, IP Addressing, Active Directory Logical Structure, Active Directory Design, Active Directory Implementation, Active Directory Deployment

Unit III- Dynamic Host Service, Name Service & Networking with Windows PowerShell-(08 Hours)

Dynamic Host Configuration Protocol, Domain Name System, Windows PowerShell, Networking with PowerShell, Microsoft Azure™ PowerShell

Unit IV- Internet Data Transaction Protection and Internet Protocol Security-(08 Hours)

Secure Sockets Layer, Certificate Services, Enabling SSL, Certificates on Microsoft Azure™, TCP/IP-Related Security Issues, IP Security, Creating and Using IP Security (IPSec)

Unit V- Routing and Remote Access Service & Virtual Private Network- (08 Hours)

Routing, Network Address Translation, Routing and Remote Access Service, Virtual Private Network Architecture, VPN Tunneling, VPN Security, Remote Accessing on Microsoft Azure™, Hybrid Cloud Solution, Hybrid Cloud Technology, System Center Virtual Machine Manager applications.

Learning Resources

Text Books

1. Lee Chao, Cloud Computing Networking: Theory, Practice, and Development, CRC Press, Taylor & Francis Group, 2016, ISBN- 978-1-4822-5482-2

Reference Books:

1. Bobbi Sandber, Networking: The Complete Reference, Third Edition, McGraw-Hill, 2015, ISBN: 978-0-07 182764-5, MHID: 0-07-182764-1

2. Nelson L. S. da Fonseca and Raouf Boutaba, Cloud Services, Networking, And Management, IEEE Press, WILEY, 2015, ISBN 978-1-118-84594-3

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-521B- CNT : Artificial Intelligence in Networking		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory: 03 Hours/Week	03	CCE : 50 Marks End-Semester: 50 Marks

Prerequisite Courses, if any : Students should have prior knowledge of Mathematics, Probability and statistic ,Programming and Problem Solving

Companion Course if any: NA

Course Objectives: The course aims to:

1. Introduce the fundamentals of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) with specific applications in network and security management.
2. Explore various learning paradigms and their relevance to intelligent network operation and defense.
3. Examine modern network management architectures empowered by AI, including commercial and open-source solutions.
4. Understand and apply standard frameworks and protocols related to AI-driven network security and management.
5. Design and implement hierarchical reinforcement learning models for virtual network embedding and autonomous intent-based networking.
6. Develop deep learning solutions for Software Defined Networks (SDN), including traffic engineering and security enhancements.

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

- CO1: **Understand** and apply fundamental machine learning paradigms to address basic network and security management problems.
- CO2: **Evaluate** key international standards, tools, and real-world projects leveraging AI for enhancing network management and cybersecurity.
- CO3: **Design** and implement symbolic and hierarchical learning approaches to infer and manage network intents in autonomous systems.
- CO4: **Develop** hierarchical reinforcement learning solutions to solve the Virtual Network Embedding (VNE) problem in complex network environments
- CO5: **Apply** deep learning models to improve software-defined networking through intelligent traffic management, enhanced controller functions, and security mechanisms.

Course Contents

Unit I- Architecture of Machine Learning-Empowered Network -(08 Hours)

Introduction, Architecture of Machine Learning-Empowered Network and Security Management, Supervised Learning, Classification, Regression. Semi supervised and Unsupervised Learning: Clustering, Dimension Reduction, Semi Supervised Learning. Reinforcement Learning: Policy-Based, Value-Based. Industry Products on Network and Security Management: Network Management, Cisco DNA Center, Sophie, Juniper EX4400 Switch, Juniper SRX Series Services Gateway, Case Study: Cisco DNA Assurance: AI/ML guided IT operations (AIOps) At-a-Glance

Unit II- Standards on Network and Security Management, Network Management-(08 Hours)

Cognitive Network Management, End-to-End 5G and Beyond Software-Defined Radio Access Network, Architectural Framework for ML in Future Networks. Security Management: Securing AI, Projects on Network and Security Management: Poseidon, Network ML, Credential-Digger, Adversarial Robustness Toolbox, Proof-of-Concepts on Network and Security Management, Classification: Phishing URL Classification, Intrusion Detection, Active Learning, Concept Drift Detection, Case Study: Network control with AI/ML – Standardization progress in ITU

Unit III- Learning Network Intents for Autonomous Network Management-(08 Hours)

Motivation, The Hierarchical Representation and Learning Framework for Intention Symbols Inference: Symbolic Semantic Learning (SSL): Connectivity Intention, Deadlock Free Intention, Performance Intention. Virtual Network Embedding via Hierarchical Reinforcement Learning: Preliminaries and Notations: Virtual Network Embedding, Substrate Network and Virtual Network, The VNE Problem, Evaluation Metrics, Reinforcement Learning Hierarchical Reinforcement Learning.
White paper: Autonomous Networks for Service Providers

Unit IV- Virtual Network Embedding via Hierarchical Reinforcement Learning-(08 Hours)

Preliminaries and Notations: Virtual Network Embedding, Substrate Network and Virtual Network, The VNE Problem, Evaluation Metrics Reinforcement Learning, Hierarchical Reinforcement Learning, The Framework of VNE-HRL: Overview, The High-level Agent, State Encoder for HEA, Estimated Long-term Cumulative Reward, Short-term High-level Reward: The Low-level Agent, State Encoder for LEA, Estimated Long-term Cumulative Reward, Short-term Low-level Reward, The Training Method

Unit V- Deep Learning for Software Defined Networks- (08 Hours)

Deep Learning for Software Defined Networks
Introduction to SDN and its Key Properties, Using Deep Learning for Intelligent SDN Controllers, Traffic Engineering with Deep Reinforcement Learning, Security Enhancements Through Deep Learning. Designing Deep Learning Models for Networks: Key Requirements and Consideration, Data Collection and Preprocessing, Model Architectures and Hyperparameters, Training, Testing and Deployment Strategies,

Learning Resources

Text Books:

1. AI and Machine Learning for Network and Security Management Yulei Wu, Jingguo Ge, Tong Li ISBN: 978-1-119-83589-9

2. AI and Deep Learning for Networks By Gopee Mukhopadhyay, Educohack Press, ISBN: 9789361525032 9361525034

Reference Books:

1. Artificial Intelligence and Machine Learning for EDGE Computing, ISBN: 9780128240557, 0128240555, Academic Press

MOOC / NPTEL/YouTube Links:

1. https://nptel.ac.in/courses/106106133

2. https://nptel.ac.in/courses/106102064

3. https://nptel.ac.in/courses/106103069

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-521C-CNT: Software Defined Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. learn about what software defined networks are
2. understand the separation of the data plane and the control plane
3. learn about the use of SDN in data centers
4. learn about different applications of SDN

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

- CO1: Critically analyze and appreciate the evolution of software defined networks
- CO2: Point out the various components of SDN and their uses
- CO3: Explain the use of SDN in the current networking scenario
- CO4: Design and develop various applications of SDN

Course Contents

Unit I- Introduction to SDN -(08 Hours)

History of Software Defined Networking (SDN) – Modern Data Center – Traditional Switch Architecture – Why SDN – Evolution of SDN – How SDN Works – Centralized and Distributed Control and Date Planes

Unit II- Open Flow & SDN Controllers-(08 Hours)

Open Flow Specification – Drawbacks of Open SDN, SDN via APIs, SDN via Hypervisor Based Overlays – SDN via Opening up the Device – SDN Controllers – General Concepts

Unit III- Data Centers-(08 Hours)

Multitenant and Virtualized Multitenant Data Center – SDN Solutions for the Data Center Network – VLANs – EVPN – VxLAN – NVGRE

Unit IV- SDN Programming-(08 Hours)

Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs – Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.

Unit V- SDN Applications-(08 Hours)

Juniper SDN Framework – IETF SDN Framework – Open Daylight Controller – Floodlight Controller – Bandwidth Calendaring – Data Center Orchestration

Learning Resources

Text Books

1. Paul Göransson and Chuck Black, Software Defined Networks: A Comprehensive Approach, Morgan Kaufmann, Elsevier, 2014, ISBN: 978-0-12-416675-2
2. Thomas D. Nadeau, Ken Gray, SDN: Software Defined Networks, O'Reilly Media, 2013.

Reference Books:

1. Siamak Azodolmolky, Software Defined Networking with Open Flow||, Packet Publishing, 2013.
2. Vivek Tiwari, SDN and Open Flow for Beginners, Amazon Digital Services, Inc.,2013.
3. Fei Hu, Editor, —Network Innovation through Open Flow and SDN: Principles and Design||, CRC Press, 2014

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-521D-CNT: Communication Technology Protocols		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To introduce the fundamental concepts in the field of communication Technology
2. To be able to understand basic protocols of wireless technology
3. To able to understand protocols of Mobile & Transport layers.
4. To introduce the Wireless Application Protocol

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

- CO1: To aware the fundamental protocols in the field of Communication Technology.
- CO2: To provide understanding of wide protocols used in Communication system.
- CO3: Understand basic protocols of wireless technology
- CO4: Understand basic protocols of Mobile and Transport layers.
- CO5: To Understand applications of Wireless (WAP)Systems in various fields.

Course Contents

Unit I- Network Models -(08 Hours)

Network Models: Layered Tasks, The OSI Model, Layers in OSI Model, TCP/IP Protocol suite, Addressing. Connecting devices: Passive Hubs, Repeaters, Active Hubs, Bridges, Two Layer Switches, Routers, Three Layer Switches, Gateway, Backbone Networks.

Unit II- TCP, UDP & IP -(08 Hours)

TCP, UDP & IP: TCP Services, TCP Features, Segment, A TCP Connection, Flow Control, Error Control, Congestion Control, Process to Process Communication, User Datagram, Checksum, UDP Operation, IP Datagram, Fragmentation, Options, IP Addressing: Classful Addressing, IPV6.

Unit III- Stream Control Transmission Protocol -(08 Hours)

Stream Control Transmission Protocol: SCTP Services, SCTP Features, Packet Format, Flow Control, Error Control, Congestion Control. Electronic Mail and SNMP, Architecture, User agents, addresses, delayed delivery, Aliases, Mail transfer agent SMTP commands & responses, mail transfer phases, MIME, Mail Delivery, mail access protocols.

Unit IV- Mobile Network Layer -(08 Hours)

Mobile Network Layer: Entities and Terminology, IP Packet Delivery, Agents, Addressing, Agent Discovery, Registration, Tunneling and Encapsulating, Inefficiency in Mobile IP. Mobile Transport Layer: Classical TCP Improvements, Indirect TCP, Snooping TCP, Mobile TCP, Fast Retransmit/Fast Recovery, Transmission, Timeout Freezing, Selective Retransmission, Transaction Oriented TCP.

Unit V- Wireless Access Protocol -(08 Hours)

Wireless Access Protocol WAP (Wireless Application Protocol) architecture, Wireless Datagram, Wireless Transport layer security, wireless transaction, Wireless Session, Wireless Application Environment, WML

Learning Resources

Text Books

1. Behrouz A Forouzan, "TCP/IP Protocol Suite", TMH, 3rd Edition
2. B.A. Forouzan, "Data communication & Networking", TMH, 4th Edition.
3. Wireless Communications Principals & Practice- Theodore S. Rappaport, (P.E.)

Reference Books:

1. Mahbub Hasan & Raj Jain," High performance TCP/IP Networking", PHI -2005
2. Douglas. E.Comer, "Internetworking with TCP/IP ", Volume I PHI
3. Larry L. Perterson and Bruce S.Davie , "Computer Networks- A Systems Approach", 2011, Morgan Kaufmann 4. Jochen Schiiler, "Mobile Communications", Pearson, 2nd Edition.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-522-CNT - Skill 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 (Cloud Computing and Networking, Artificial Intelligence in Networking, Software Defined Networks, Communication Technology Protocols)

Guidelines for Skill Based Laboratory

- Skill Based Laboratory are based on the electives chosen by the students (Cloud Computing and Networking, Artificial Intelligence in Networking, Software Defined Networks, Communication Technology Protocols)
- Respective course faculty assigned will frame course objectives, course outcomes, list of assignments, mini projects and references.
- The list of assignments should be prepared and approved by the respective heads of Department before conduction of laboratory,

List of Assignments - Select practical assignments from part A and Mini- Project from part B.

- **Part A: Cloud Computing and Networking**
  - Create a virtual machine on AWS EC2. Launch EC2 instances, configure security groups, and host a basic web application
  - Setting up a virtual private cloud with public/private subnets, configure routing tables, and test connectivity.
  - Configuring Load Balancers and Auto-Scaling Groups. Deploy an application with Elastic Load Balancer and auto-scaling based on CPU usage.
- **Part A: Artificial Intelligence in Networking**
  - Write a program for network traffic classification using machine learning. Use packet-level features to classify network traffic - HTTP, FTP, VoIP.
  - Write a program for anomaly detection in network traffic using isolation forest to identify abnormal traffic patterns in a dataset.
  - Implement a chatbot to answer networking queries using AI/NLU/NLP techniques.
- **Part A: Software Defined Networks**
  - Set-up a SDN environment with Mininet and create a virtual network topology to run basic ping/traceroute tests.

- Install and modify flow rules via a SDN controller Ryu / ONOS, using OpenFlow - Flow Rule Management.
- Implement a load balancing for traffic engineering with SDN controllers using path optimization policies.

- **Part A: Communication Technology Protocols**
  - Simulate TCP and UDP Connections, compare latency and packet delivery in TCP / UDP using Wireshark.
  - Implement HTTP client-server communication and develop a basic HTTP request / response system using Python.
  - Implement MQTT-based IoT Communication and publish-subscribe using MQTT broker.

Part B : Mini Project

1. **Cloud Computing and Networking :** Multi-Tier Web Application Deployment: Deploy a 3-tier application with frontend, backend and database on AWS with load balancing in multi-tier cloud architecture.
2. **Artificial Intelligence in Networking** : AI-based Intrusion Detection System: Implement ML-based IDS to detect and alert malicious traffic. Apply AI for cybersecurity in networking.
3. **Software Defined Networks** : QoS-aware SDN Controller Application: Create a custom controller app to prioritize video streaming traffic and design the programmable traffic policies.
4. **Communication Technology Protocols** : Custom Application-Layer Protocol for Sensor Networks: Develop a lightweight protocol for transmitting sensor data efficiently, design and evaluate communication protocols.

Learning Resources

Text Books:

1. Lee Chao, Cloud Computing Networking: Theory, Practice, and Development, CRC Press, Taylor & Francis Group, 2016, ISBN- 978-1-4822-5482-2.
2. AI and Machine Learning for Network and Security Management Yulei Wu, Jingguo Ge, Tong Li ISBN: 978-1-119-83589-9.
3. Thomas D. Nadeau, Ken Gray, SDN: Software Defined Networks, O'Reilly Media, 2013.
4. Mahbub Hasan & Raj Jain," High performance TCP/IP Networking", PHI -2005.

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Computer Networks (2025 Pattern)

Semester II

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-551-CNT: Wireless and Mobile Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To study Channel planning for Wireless Systems
2. Studying the Mobile Radio Propagation
3. To study Equalization and Diversity
4. To study the Wireless Networks

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

- CO1: Understand Cellular communication concepts
- CO2: Study the mobile radio propagation
- CO3: Study the wireless network different type of MAC protocols

Course Contents

Unit I- The Cellular Concept-System Design Fundamentals-(12 Hours)

Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies- Prioritizing Handoffs, Practical Handoff Considerations, Interference and system capacity – Co channel Interference and system capacity, Channel planning for Wireless Systems, Adjacent Channel interference, Power Control for Reducing interference, Trunking and Grade of Service, Improving Coverage & Capacity in Cellular Systems- Cell Splitting, Sectoring.

Unit II- Mobile Radio Propagation: Large-Scale Path Loss-(12 Hours)

Introduction to Radio Wave Propagation, Free Space Propagation Model, Relating Power to Electric Field, The Three Basic Propagation Mechanisms, Reflection-Reflection from Dielectrics, Brewster Angle, Reflection from prefect conductors, Ground Reflection (Two-Ray) Model, Diffraction-Fresnel Zone Geometry, Knife-edge Diffraction Model, Multiple knife-edge Diffraction, Scattering, Outdoor Propagation Models- Longley-Ryce Model, Okumura Model, Hata Model, PCS Extension to Hata Model, Walfisch and Bertoni Model, Wideband PCS Microcell Model, Indoor Propagation Models-Partition losses (Same Floor), Partition losses between Floors, Log-distance path loss model, Ericsson Multiple Breakpoint Model, Attenuation Factor Model, Signal penetration into buildings, Ray Tracing and Site Specific Modeling.

Unit III- Mobile Radio Propagation-(12 Hours)

Small –Scale Fading and Multipath: Small Scale Multipath propagation-Factors influencing small scale fading, Doppler shift, Impulse Response Model of a multipath channel- Relationship between

Bandwidth and Received power, Small-Scale Multipath Measurements-Direct RF Pulse System, Spread Spectrum Sliding Correlator Channel Sounding, Frequency Domain Channels Sounding, Parameters of Mobile Multipath Channels-Time Dispersion Parameters, Coherence Bandwidth, Doppler Spread and Coherence Time, Types of Small-Scale Fading-Fading effects Due to Multipath Time Delay Spread, Flat fading, Frequency selective fading, Fading effects Due to Doppler Spread-Fast fading, slow fading, Statistical Models for multipath Fading Channels-Clarke's model for flat fading, spectral shape due to Doppler spread in Clarke's model, Simulation of Clarke and Gans Fading Model, Level crossing and fading statistics, Two-ray Rayleigh Fading Model.

Unit IV- Equalization and Diversity -(12 Hours)

Introduction, Fundamentals of Equalization, Training A Generic Adaptive Equalizer, Equalizers in a communication Receiver, Linear Equalizers, Nonlinear Equalization- Decision Feedback Equalization (DFE), Maximum Likelihood Sequence Estimation (MLSE) Equalizer, Algorithms for adaptive equalization-Zero Forcing Algorithm, Least Mean Square Algorithm, Recursive least squares algorithm. Diversity Techniques-Derivation of selection Diversity improvement, Derivation of Maximal Ratio Combining improvement, Practical Space Diversity Consideration-Selection Diversity, Feedback or Scanning Diversity, Maximal Ratio Combining, Equal Gain Combining, Polarization Diversity, Frequency Diversity, Time Diversity, RAKE Receiver.

Unit V- Wireless Networks-(12 Hours)

Wireless Networks

Introduction to wireless Networks, Advantages and disadvantages of Wireless Local Area Networks, WLAN Topologies, WLAN Standard IEEE 802.11, IEEE 802.11 Medium Access Control, Comparison of IEEE 802.11 a,b,g and n standards, IEEE 802.16 and its enhancements, Wireless PANs, Hiper Lan, WLL.

Learning Resources

Text Books

1. Wireless Communications, Principles, Practice – Theodore, S. Rappaport, 2nd Ed., 2002, PHI.
2. Wireless Communications-Andrea Goldsmith, 2005 Cambridge University Press.
3. Principles of Wireless Networks – Kaveh Pah Laven and P. Krishna Murthy, 2002, PE
4. Mobile Cellular Communication – Gottapu Sasibhushana Rao, Pearson Education, 2012.

Reference Books:

1. Wireless Digital Communications – Kamilo Feher, 1999, PHI. 2. Wireless Communication and Networking – William Stallings, 2003, PHI.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-552-CNT: Internet of Things		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To understand the concept of IoT.
2. To build IoT based Applications.
3. To analyze the performance of IoT based Systems.

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

- CO1: Summarize the concepts of network connected embedded devices.
- CO2: Design suitable network architecture and use appropriate protocols for a given IOT application.
- CO3: Identify and summarize different components required for IOT applications.
- CO4: Analyse the system through Data Analytics tools.

Course Contents

Unit I - Introduction & Basic of IoT - (12 Hours)

Definition, Characteristics, Physical and Logical Designs, challenges, Technological trends in IOT, IoT Examples, M2M

Unit II -IoT: Components, Communication and Networking - (12 Hours)

Introduction to Sensing and Networking: Sensing & actuation, Wireless Senor network, Senor nodes, Communication Protocols, M2M Communication, Networking Hardware, Networking Protocols.

Unit III - IoT System Management - (12 Hours)

Network Operator Requirements, IoT Platform Design Specification – Requirements, Process, Domain Model, Service, IoT Level, Function, Operational view, Device and Component Integration, Application development.

Unit IV - Networking and Computing- (12 Hours)

File Handling, Python Packages for IoT, IoT Physical Servers – Cloud Storage Models, Communication APIs.

Unit V - IoT Clouds and Data Analytics and Applications - (12 Hours)

RESTful Web API, Amazon Web Services for IoT, Apache Hadoop, Batch Data Analysis, Chef, Chef Case Studies, Puppet, NETCONF-YANG. Case studies: smart cities, smart home, connected vehicles, Industrial IOT.

Learning Resources

Text Books

1. Kamal, R.,"Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill,2017.
2. Simone Cirani," Internet of Things- Architectures, Protocols and Standards", WILEY,2018.
3. Alessandro Bassi," Enabling Things to Talk- Designing IoT solutions with the IoT Architectural Reference Model", Springer,2013.

Reference Books:

1. D. Patranabis, "Sensor & Transducers", Murthy Prentice Hall India Learning Private Limited, 2nd edition, 2009.
2. Jacob Fraden," Handbook of Modern Sensors", Physics, Designs, and Applications, Fifth Edition, Spinger,2016.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PCC-553-CNT: Network Security		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To understand the concept behind network security and its importance.
2. To acquire knowledge of application, transport and network layer security.
3. To understand basics of network security, computer and network security threats and basic paradigms and approaches used in network security at various layers.
4. To develop basic skills of secure network architecture and addressing network security issues, challenges and mechanisms.
5. To develop various security solutions against real life security threats.

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

- CO1: Gain knowledge on various secure mechanisms through set of protocols.
- CO2: Identify the security issues in the application, transport layer and resolve it.
- CO3: Identify the security issues in the wireless network, transport layer and resolve it.
- CO4: Gain knowledge of threats and vulnerabilities in different levels of the system.
- CO5: Knowledge about security features in various layers of networking.

Course Contents

Unit I- Introduction-(12 Hours)

Introduction, Security services, Need of Security, Key Principles of Security, Threats and Vulnerabilities, Vulnerability categories: Technical, Procedural and behavioral Types of Attacks, ITU-T X.800 Security Architecture for OSI, Security Policy and mechanisms, Operational Model of Network Security, Symmetric and Asymmetric Key Cryptography Algorithms, Data Integrity and Digital Signature Algorithms.

Unit II- Application and Transport Layer Security-(12 Hours)

SECURITY AT THE APPLICATION LAYER: S/MIME-Functionality, Messages and Certificate Processing, Domain Keys Identified Mail, Pretty Good Privacy (PGP), GNU Privacy Guard (GPG).
SECURITY AT THE TRANSPORT LAYER: SSL/TLS Architecture, Handshake Protocol, Change Cipher Spec Protocol, Alert Protocol, Record

Unit III- Wireless & Network Layer Security-(12 Hours)

WIRELESS NETWORK SECURITY: Wireless Security, Mobile Device Security, IEEE 802.11i Wireless LAN Security, WEP and WPA Protocols.

SECURITY AT THE NETWORK LAYER: IP Security Overview, IP Security Policy, Encapsulating Security Payload, internet Key Exchange, Authentication Header.

Unit IV- System Security-(12 Hours)

Authentication applications: Kerberos X.509 Authentication services: Firewalls, Types of Firewalls, Firewall design principles, Trusted System. Intruders, Intrusion detection, Viruses and related threats, Virus Countermeasures. Google Application Layer Transport Security (ALTS)

Unit V- Security in Mobile and IOT- (12 Hours)

Security Threats to SDN, FV Security Attack Surfaces, ETSI Perspective, Cloud Security: Security Issues, Risks, Data Protection: Security As A Service, Addressing Cloud Security, IOT Security, Vulnerability Patching.

Learning Resources

Text Books

1. William Stallings, “Cryptography and Network Security: Principles and Practice”, 7th Ed. Pearson, 2017.
2. William Stallings, “Network Security Essentials: Applications and Standards”, Fourth Edition, 2011.
3. Behrouz forouzan, Debdeep Mukhopadhyay, “Cryptography and Network Security”, 2nd Ed., Tata McGraw-Hill Education, 2010.
4. Chris McNab, “Network Security Assessment”, 3rd Ed., O’Reilly Media, 2004.
5. Charlie Kaufman, Radia Perlman, Mike Speciner, “Network Security: Private Communication in a Public World”, 2nd Ed., Prentice Hall PT, 2002.

Reference Books:

1. Bruce Schneier and Neils Ferguson, “Practical Cryptography”, First Edition, Wiley Dreamtech India Pvt Ltd.
2. William Stallings, “Foundations of Modern Networking: SDN, NFV, QoE, IoT, and Cloud”, Publisher: Addison-Wesley.

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

Prerequisite : Programme Core courses (Wireless and Mobile Networks, Internet of Things, Network Security)

Guidelines of Laboratory

- Computational Laboratory-I assignments are based on 3 Programme Core courses (Wireless and Mobile Networks, Internet of Things, Network Security)
- Respective course faculty assigned will frame course objectives, course outcomes, list of assignments, mini projects, if any
- The list of sample assignments is given for preparation of assignments which will be approved by the respective heads of Department before conduction of laboratory.

List of Assignments

Part A: Wireless and Mobile Networks (Any TWO)	
1	Implementation of client server programs with different networking constraints, hosts behind NAT, hosts are globally addressable, etc.
2	To implement various Routing Protocols and compare the performance
3	To configure a new VLAN on one VTP server and distribute it through all switches on the domain
4	To implement Static NAT-PT on Cisco devices
5	Configure different application servers such as web server, DNS servers, and email server, and secure using firewall rules
Part B: Internet of Things (Any TWO)	
1	Installation of IOT software such as Arduino / Raspberry Pi
2	Controlling the Light Emitting Diode (LED) with a push button and LED blink rate with the potentiometer
3	Interfacing the RGB LED with the Arduino / Raspberry Pi
4	Interfacing temperature sensors with the Arduino / Raspberry Pi
5	Interfacing of the Active Buzzer with the Arduino / Raspberry Pi
Part C: Network Security (Any TWO)	
1	Implementation of symmetric and asymmetric key cryptography algorithms
2	Implementation of security at the Application Layer
3	Detection algorithms for Viruses and related threats

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-561A-CNT : Bio-Inspired Computing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To learn how natural and biological systems influence computational field
2. To understand the strengths and weaknesses of nature-inspired algorithms
3. To learn the functionalities of various Bio-inspired optimization algorithms.

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

- CO1. Describe the natural phenomena that motivate the algorithms
- CO2. Apply nature-inspired algorithms to optimization
- CO3. Select the appropriate strategy or optimal solution based on bio-inspired algorithms.

Course Contents

Unit I- Natural Computing-(08 Hours)

From nature to natural computing, Introduction, sample idea, Philosophy of natural computing, Natural computing approaches, Conceptualization – introduction, general concept, Problem solving as a search track, Hill climbing, Simulated annealing.

Unit II- Evolutionary Computing-(08 Hours)

Evolutionary computing, Evolutionary biology, Evolutionary computing standard evolutionary algorithm, Genetic algorithm, evolutionary strategies, Evolutionary programming.

Unit III- Swarm Intelligence-(08 Hours)

Swarm intelligence-biological motivation, from natural to artificial, standard algorithm of Ant colony optimization, Ant clustering algorithm, Particle swarm optimization.

Unit IV- Biological Motivation-(08 Hours)

Biological motivation, from natural to artificial, standard algorithm of cuckoo search, bat algorithm, flower pollination, firefly algorithm, framework for self-tuning algorithms - case study of firefly algorithm. The essence of life, Examples of A Life projects- flocks, herds and schools, synthesizing emotional behavior, Scope of artificial life,

Unit V- Immune Systems-(08 Hours)

Immune system, Artificial immune systems - biological motivation, Design principles, main types of algorithms - Bone marrow, Negative selection, Clonal selection, Continuous immune network models,

Discrete immune network models, Scope of artificial immune systems, computer viruses, AIBO robot, Turtles, termites, and traffic jams, framsticks, Current trends and open problems

Learning Resources

Text Books

1. L. N. de Castro, "Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications", 2006, CRC Press, ISBN-13: 978-1584886433

2. D. Floreano and C. Mattiussi, " Bio-Inspired Artificial Intelligence: Theories, Methods, and Technologies", 2008, MIT Press, ISBN-13: 978-0262062718

Reference Books:

1. D. Simon,"Evolutionary Optimization Algorithms",2013, Wiley,ISBN: 10: 0470937416;13: 978-0470937419.

2. Russell C. Eberhart , Yuhui Shi , James Kennedy, " Swarm Intelligence: The Morgan Kaufmann Series in Evolutionary Computation",ISBN-13: 978-1558605954.

SWAYAM / MOOC / YouTube Links

1. Tao Song, Pan Zheng, Dennis Mou Ling Wong, Xun Wang, "Bio-inspired Computing Models And Algorithms", World Scintific Publishing, Singapur. 9789813143197, 9813143193, 2019. https://share.google/9UNkn48Ah7dQr0lZv

2. Anu Bajaj, Ajith Abraham, K. Reddy Madhavi, Dalia Kriksciuniene, "Bio-Inspired Computing", Proceedings, 14-15, 2023, Volume 5, 2025. https://link.springer.com/book/10.1007/978-3-031-78949-6

3. De-Shuang Huang, Yong Gan, Prashan Premaratne, Kyungsook Han, "Bio-Inspired Computing and Applications, 7th International Conference on Intelligent Computing", ICIC2011, Zhengzhou, China, August 11-14, Springer, 2011.https://link.springer.com/book/10.1007/978-3-642-24553-4

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-561B-CNT: Optical Networking		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To learn different optical networks and the mechanism to obtain the same.
2. To learn key components and technologies involved in WDM (Wavelength Division Multiplexing) networks.
3. To learn Network design, management, survivability, and control strategies.
4. To learn Applications of optical networks and their relevance to modern telecommunication systems.

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

- CO1: Understand the concept of WDM thoroughly and international telecom standards.
- CO2: Gain understanding the functions of network elements and network design.
- CO3: Wide knowledge of Optical Network applications.
- CO4: Understand the routing in optical networks.
- CO5: Implement simple optical network and understand further technological developments for future enhanced network.

Course Contents

Unit I- Introduction to Optical Networks-(08 Hours)

Telecommunications Networks Architecture, Services, Circuit Switching and Packet switching, Optical Networks, Optical Packet Switching, Transmission Basics, Components: Multiplexers and Filter Switches, Wavelength Converters

Unit II- Client layers of the optical layer-(08 Hours)

SONET/SDH: optical transport network, IP, routing and forwarding, multiprotocol label switching. WDM network elements: optical line terminals and amplifiers, optical add/drop multiplexers, OADM architectures, reconfigurable OADM, optical cross connects.

Unit III- Control and Management-(08 Hours)

Network management functions, optical layer services and interfacing, performance and fault management, configuration management, optical safety.

Unit IV- Network Survivability-(08 Hours)

Protection in SONET/SDH & client layer, optical layer protection schemes.

WDM network design: LTD and RWA problems, dimensioning wavelength routing networks, statistical dimensioning models.

Unit V- Access networks-(08 Hours)

Optical time division multiplexing, synchronization, header processing, burst switching, test beds, Introduction to PON, GPON, AON

Learning Resources

Text Books

Textbooks:

1. Gerd Keiser – Optical Fiber Communications, 5th Edition, McGraw-Hill.

Reference Books:

1. Rajiv Ramaswami, Sivarajan, Sasaki, “Optical Networks: A Practical Perspective”, MK, Elsevier, 3rd edition, 2010.
2. C. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks: Concepts Design, and Algorithms”, PHI, EEE, 2001
3. Optical WDM Networks by Biswanath Mukherjee, Springer

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-561C-CNT: Social Media Analytics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:To understand the structure, sources, and scale of social media data.

1. To understand the structure, sources, and scale of social media data.
2. To explore methods for collecting, processing, and analyzing textual and multimedia social data.
3. To study the use of machine learning and NLP techniques in sentiment and opinion mining.
4. To analyze user interactions and social networks using graph theory concepts.
5. To apply analytics techniques to real-world social media case studies for business, healthcare, disaster management, etc.

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

- CO1: Explain social media ecosystems and the characteristics of social data.
- CO2: Describe data collection mechanisms and preprocessing techniques.
- CO3: Apply theoretical models for sentiment analysis, topic modeling, and opinion mining.
- CO4: Analyze social networks and user behaviors using graph-based metrics.
- CO5: Evaluate the impact of social media analytics in various domains with ethical awareness

Course Contents

Unit I- Foundations of Social Media Analytics-(08 Hours)

Introduction to Social Media, Web platforms and world wide websites (www), types of social media data, Text, Image, Video, Metadata, Social media data characteristics, Volume, Velocity, Variety, Veracity, challenges in social media data analysis, SMA applications, marketing, politics, healthcare, disaster management, SMA architecture, ingestion, storage, analysis, visualization, data ecosystem, analytics opportunities across platforms, domain-specific applications of SMA.

Unit II- Data Acquisition and Preprocessing-(08 Hours)

Overview of social media APIs, Facebook Graph, Reddit, X-Twitter, Instagram, structure and access policies, web scraping, architecture, ethics, and methods, text preprocessing, tokenization, case folding, stopword removal, stemming, lemmatization, handling multilingual text, hashtags, mentions, emojis, metadata, data challenges, spam, bots, noise, redundancy, techniques for extracting and preparing social media data, common challenges in raw social data.

Unit III- Text Analytics and Natural Language Processing -(08 Hours)

Text representation, Bag-of-Words, TF-IDF, Word Embeddings, Sentiment Analysis, Rule-based approaches, ML-based approaches, topic modeling, Latent Dirichlet Allocation (LDA), Non-negative Matrix Factorization (NMF), Named Entity Recognition (NER), Overview of deep learning approaches, BERT, transformers, NLP techniques to sentiment and topic analysis, extracting insight from text data and evaluation.

Unit IV- Social Network and User Interaction Analysis-(08 Hours)

Introduction to graph theory, nodes, edges, degree, centrality, social graphs, user mentions, replies, retweets, network metrics, Betweenness, Closeness, PageRank, community detection: modularity, Louvain algorithm, Influence and virality analysis, Behavioral analytics: likes, shares, content engagement patterns, graph-based representation of social networks

Unit V- Applications of social media-(08 Hours)

Applications of Politics - Election sentiment, propaganda detection, Healthcare - Vaccine hesitancy, pandemic trend tracking, Disaster response - Earthquake, flood, or COVID alerting via social media, Agriculture - Farmer sentiment, feedback analytics, Visual analytics: Word clouds, sentiment timelines, conceptual network diagrams, Ethics - data privacy, fake news, bots, bias, misinformation, real-world applications of SMA, ethical and responsible use of social media data

Learning Resources

Text Books

1. Gupta, Mukul, Gupta, Deepa, Gupta, Parth Mukul, “Social Media and Web Analytics: Turning Insights into Action in a Digital World”, PHI publisher, ISBN: 9789354439605, 2024.
2. Matthew Ganis, Avinash Kohirkar, “Social Media Analytics: Techniques and Insights for Extracting Business Value Out of Social Media”, IBM Press

Reference Books:

1. Subodha Kumar, Liangfei Qiu, “Social Media Analytics and Practical Applications: The Change to the Competition Landscape”, 1st Edition, CRC Press,
2. Marshall Sponder, “Social Media Analytics”, McGraw-Hill Publisher, ISBN: 2800071768292, 2011.

SWAYAM / MOOC / YouTube Links

1. Alex Gonçalves, “Social Media Analytics Strategy Using Data To Optimize Business Performance”, Apress publisher, ISBN: 978-1-4842-3102-9.
2. https://nibmehub.com/opac-service/pdf/read/social%20media%20analytics% 20strategy%20%20usi

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-561D-CNT: Generative Adversarial Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Know GAN concepts
2. Understand GAN methods
3. Comparing Conditional and Controllable GANs

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

- CO1: Learn about GANs and their applications
- CO2: Understand the intuition behind the fundamental components of GANs
- CO3: Explore and implement multiple GAN architectures
- CO4: Build conditional GANs capable of generating examples from determined categories.

Course Contents

Unit I- Introduction to GANs-(08 Hours)

GANs and their applications, understand the intuition behind the basic components of GANs, and build your very own GAN using PyTorch.

Unit II- Deep Convolutional GAN-(08 Hours)

Build a sophisticated GAN using convolutional layers, activation functions, batch normalization, and transposed convolutions to tune your GAN architecture, build an advanced DCGAN specifically for processing images.

Unit III- Wasserstein GANs with Normalization -(08 Hours)

Reduce instances of GANs failure due to imbalances between the generator and discriminator by learning advanced techniques such as WGANs to mitigate unstable training and mode collapse with a W-Loss and an understanding of Lipschitz Continuity.

Unit IV- Conditional and Controllable GANs -(08 Hours)

Understand how to effectively control your GAN, modify the features in a generated image, and build conditional GANs capable of generating examples from determined categories.

Unit V- Generative Models-(08 Hours)

Generative Models: Maximum likelihood estimator, Naive Bayes, Linear Discriminant Analysis, Latent variables and Expectation-maximization algorithm, Bayesian learning

Learning Resources

Text Books

1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016
2. Generative adversarial networks explained By Caper Hansen. IBM Developer

Reference Books:

1. Goodfellow,I., Bengio.,Y., and Courville,A., (2016), Deep Learning, The MIT Press

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-562A-CNT - Federated Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To understand the principles and motivation behind federated learning.
2. To explore different architectures, algorithms, and challenges in federated learning.
3. To learn the role of federated learning in privacy-preserving AI and edge computing.
4. To analyze federated learning use cases in industry sectors like healthcare, IoT, and finance.
5. To discuss security threats, mitigation techniques, and ethical issues in federated learning.

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

- CO1: Describe the fundamentals, types, and advantages of federated learning.
- CO2: Analyze and compare federated learning architectures and optimization algorithms.
- CO3: Identify privacy, security, and communication challenges in federated learning.
- CO4: Apply federated learning concepts to real-world use cases and frameworks.
- CO5: Evaluate federated learning performance under non- independent identically distributed (non-IID) data and system heterogeneity.

Course Contents

Unit I- Introduction to Federated Learning -(08 Hours)

Introduction to federated learning, need for federated learning, data privacy, decentralization, edge AI. Centralized vs decentralized vs federated paradigms, clients, server, rounds, model aggregation, Benefits, privacy-preserving, bandwidth-efficient, collaborative learning, federated learning life cycle. concept of drivers of federated learning, centralized ML and federated ML paradigms.

Unit II- Federated Learning Architectures and Algorithms-(08 Hours)

Architecture of federated learning, horizontal federated learning, vertical federated learning, federated transfer learning federated learning, federated averaging, algorithm and work flow, federated SGD, advanced aggregation techniques, synchronous and asynchronous federated learning, optimization challenges with non- independent and identically distributed (non-IID) data, compression and quantization for efficient communication in federated learning, performance evaluation under various data and system conditions.

Unit III- Privacy and Security in Federated Learning-(08 Hours)

Threats in federated learning, model inversion, poisoning, membership inference
Differential Privacy (DP) and differentially private stochastic gradient descent (DP-SGD), Secure Aggregation: encryption and secure multiparty computation (SMC), homomorphic encryption and federated cryptographic techniques, a nonymity and trust in decentralized settings, privacy-preserving techniques in federated models, security vulnerabilities and defenses in federated learning systems.

Unit IV- Federated Learning Systems and Frameworks-(08 Hours)

Architecture of federated system: clients, coordinator, data flow. Open-source frameworks, TensorFlow Federated, PySyft, Flower, NVIDIA Clara. Resource constraints: computation, memory, communication. System-level challenges: stragglers, client selection, dropouts, Bench-marking and evaluation of federated system models, federated system development using tools and frameworks, system-level considerations in real-world deployment

Unit V- Applications of Federated Learning-(08 Hours)

Real-world applications of federated system, Healthcare: cross-institutional model training, Finance: fraud detection. Smart devices: predictive keyboard, face unlock. Agriculture: collaborative crop disease detection. Ethical aspects: bias, fairness, transparency. federated reinforcement learning, personalized federated system, swarm learning, ethical and legal implications of deploying federated system.

Learning Resources

Text Books

1. Heiko Ludwig, Nathalie Baracaldo, "Federated Learning: A Comprehensive Overview of Methods and Applications", Springer, 2022.

2. Jayakrushna Sahoo, Mariya Ouaissa, Akarsh K. Nair, "Federated Learning: Principles, Paradigms, and Applications", 1st Edition,9781003497196, Apple Academic Press, 2024.

Reference Books:

1. George Jeno, "Federated Learning with Python: Design and implement a federated learning system and develop applications using existing frameworks", Packt Publishing, ISBN-13978-1803247106, 2022.

2. Shelly Gupta, Puneet Garg, Jyoti Agarwal, Hardeo Kumar Thakur, Satya Prakash Yadav, "Federated Learning Based Intelligent Systems to Handle Issues and Challenges in Iovs- Part 1", ISBN: 978-981-5313-03-1 (Print), ISBN: 978-981-5313-02-4 (Online), 2024.

SWAYAM / MOOC / YouTube Links

1. George Drosatos, Pavlos S. Efraimidis, Pavlos S. Efraimidis, Avi Arampatzis, "Federated and Transfer Learning Applications", ISBN 978-3-7258-0076-6, 2024. https://www.mdpi.com/books/reprint/federated-and-transfer-learning-applications

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-562B-CNT: Real-Time Operating Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:To understand the real-time systems environment

1. Setup and demonstrate the development environment for RTOS
2. Illustrate strategies to interface memory and I/O with RTOS kernels
3. Interpret tasks used in handling multiple activities
4. impart skills necessary to develop software for embedded computer systems using a real-time operating system

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

- CO1: Create, test and debug on RTOS environment
- CO2: Implement Inter task communication mechanism.
- CO3: Compare general purpose OS with RTOS
- CO4: Demonstrate methods in storing, retrieving data in RTOS
- CO5: Analyze performance of task during multitasking.

Course Contents

Unit I- Introduction to Real Time Operating System-(08 Hours)

Introduction to real-time operating systems. Hard versus soft real-time systems and their timing constraints. Temporal parameters of real-time process: Fixed, Jittered and sporadic release times, execution time. Types of real-time tasks, Precedence constraints and data dependency among real-time tasks, other types of dependencies for real-time tasks. Functional parameters and Resource parameters of real-time process. Real-time task and task states, task and data. Approaches to real-time scheduling: clock driver, weighted round-robin, priority-driven- Fixed priority and dynamic priority algorithms –Rate Monotonic (RM), Earliest-Deadline-First (EDF), Latest-Release-Time (LRT), Least-Slack- Time-First (LST). Static and Dynamic systems, on-line and off-line scheduling, Scheduling aperiodic and sporadic real-time tasks

Unit II- Inter-Process Communication-(08 Hours)

Resources and resource access control-Assumption on resources and their usage, Enforcing mutual exclusion and critical sections, resource conflicts and blocking, Effects of resource contention and resource access control - priority inversion, priority inheritance.

Inter-process communication-semaphores, message queues, mailboxes and pipes. Other RTOS services-Timer function, events, Interrupts - enabling and disabling interrupts, saving and restoring context,

interrupt latency, shared data problem while handling interrupts. Interrupt routines in an RTOS environment.

Unit III- Scheduling Algorithms-(08 Hours)

Scheduling algorithms: FCFS, SJF, Priority, Round Robin, UNIX Multi-level feedback queue scheduling, Thread Scheduling, Multiprocessor Scheduling concept, Concurrency: Principles of Concurrency, Mutual Exclusion H/W Support, software approaches, Semaphores and Mutex, Message Passing techniques. Time Management, Timer Management, Resource Management Disable/Enable Interrupts, Lock/Unlock Semaphores, Mutex, Deadlocks, Synchronization.

Unit IV- Real-Time Communication-(08 Hours)

Network Topologies, Protocols, Clocks, A Non-Fault Tolerant, synchronization Algorithm, Impact of Faults, Fault Tolerant Synchronization in Hardware, Synchronization in Software. Fault Tolerant Techniques: Fault Types, Fault Detection, Fault and error Containment, Redundancy, Data Diversity, Reversal Checks, Malicious or Byzantine Failures, Integrated Failure Handing, Obtaining Parameter Values, Reliability Models for Hardware edundancy, Software Error models, Taking Time into Account.

Unit V- Real Time Systems-(08 Hours)

Real-time operating systems: Capabilities of commercial real-time operating systems, QNX/Neutrino, Microc/OS-II, VxWorks, Windows CE and RTLinux.

Real-time applications: Guidance and control, Signal processing, Multimedia, real-time databases. Real-Time Databases: Real-Time Vs General-Purpose Databases, Main Memory Databases, Transaction Priorities, Transaction Aborts, Concurrency Control Issues, Disk Scheduling algorithm, A Two Phase Approach To Improve Predictability, Maintain Serialization Consistency, Databases for Hard Real Time Systems.

Learning Resources

Text Books

1. Jane W. S. Liu, “Real-Time Systems”, Pearson Education, ISBN: 10: 0130996513.
2. C.M. Krishna, Kang G. Shin, “Real-Time Systems”, Tata McGraw Hill
3. Dr. Jürgen Sauermann, Melanie Thelen, “Realtime Operating Systems :Concepts and Implementation of Microkernels for Embedded Systems“, https://dsp-book.narod.ru/DSPROSES.pdf

Reference Books:

1. Colin walls, "Building a Real Time Operating System: RTOS from the Ground Up", Newness, 2020.
2. Jean J Labrosse, "Micro C/OS-II, The Real Time Kernel", CMP, 3rd, 2016.

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-562C-CNT: Information Security		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Provide knowledge of secure design including Information Security and Secure Coding
2. Explore authentication and authorization principles.
3. Explain how to design secure applications.
4. Describe risk-planning and risk management of computer and information systems

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

- CO1: Analyze and understand secure design including Information Security and Secure Coding
- CO3: Analyze and apply authentication and authorization principles.
- CO4: Design secure application.
- CO5: Implement risk-planning and risk management of computer and information systems.

Course Contents

Unit I- Information Security Basics-(08 Hours)

Introduction to Information Security – Risk Analysis – Legal Issues – Secure Design – Policy, Standards, Procedures and Guidelines – Security Organization structure

Unit II- Information Security Policy and Compliance-(08 Hours)

Authentication and Authorization principles - Securing unstructured data – Information Rights Management – Storage security – Data base security;

Unit III- Secure Application-(08 Hours)

Secure application design – Writing Secure Software – J2EE vulnerabilities; Secure Infrastructure Management: Security Operations Management – Disaster Recovery and Backups – Physical Security.

Unit IV- Information Security Risk Management-(08 Hours)

Development of concepts required for risk-based planning and risk management of computer and information systems (Risk analysis, risk perception, Communicating risk, risk mitigation); Objectives and methods for vulnerability assessment for natural disaster, technological hazards, and terrorist threats; implications for emergency response, vulnerability of critical infrastructure

Unit V- Scripting languages for information security-(08 Hours)

Java Script: Introduction to JavaScript, Basic Syntax, Control Structures, Writing Functions, Working with Arrays, The Document Object Model, Events Handling, Client-side Validation, Form Validation & RegExps, ASP, Perl CGI, & Form Methods, SSI & Cookies, Frames & Windows, mime Types, plugins, & Java

Learning Resources

Text Books

1. Information Security – The complete reference; Chapters: 1-9, 11-12, 26-28, 31, 32, and 34 Author: Mark Rhodes – Ousley; McGraw Hill, 2013, ISBN Number: 978-0-07-178436-8

Reference Books:

1. Whitman, Michael E., and Herbert J. Mattord, Principles of information security, Boston, MA: Thomson Course Technology, 2009.
2. Harold F. Tipton, Micki Krause Nozaki, Information Security Management Handbook, Volume 6, Sixth Edition, Auerbach Publications, 2016

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
PEC-562D-CNT - Next Generation Networks		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : It is desirable to have the knowledge of data networking and telecommunications principles.

Course Objectives: The course aims to:

1. Learn emerging network technologies, their features, challenges, advantages, and disadvantages.
2. What broadband data and multimedia services are carried out to users over a common multiservice infrastructure

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

- CO1: Describe the basic characteristics, structure and operation of wired and wireless networks.
- CO2. Identify appropriate architectural models, systems strategies and use cases for a range of modern network concepts.
- CO3. Implement solutions to key challenges in modern network architecture, e.g., scalability, cost effectiveness and energy efficiency.
- CO4. Evaluate the performance of queues and develop network traffic models.
- CO5. Assess the operation of medium access protocols in contemporary wireless standards for local and wide area networks, and Internet of Things, and discuss co-existence between different types of systems.

Course Contents

Unit I Introduction and NGN Networks: Perspectives and Potentials - (08 Hours)

Introduction, Challenges, The Network Evolution Towards NGN, The Telecom Environment and Corporate Responsibility: NGN Networks: Perspectives and Potentials, Some Possible Scenarios.

Unit II - NGN Requirements on Technology and Management & NGN Functional Architecture- (08 Hours)

NGN Requirements on Technology, NGN Requirements on Management, The ITU NGN Functional Architecture, The Proposed NGN Functional Architecture

Unit III NGN Customer and CTE & Network and Service Evolution towards NGN - (08 Hours)

NGN Operator, Provider, Customer and CTE; Major Evolution Steps for the Networks and Services of Today, Fixed Network Evolution, Mobile Network Evolution, Cable Network Evolution, Internet Evolution,IP Network Problems Critical to be Solved

Unit IV - NGN Key Development Areas - (08 Hours)

Terminal Area, Access Network Area, Backhaul Network Area, Core Transport Network Area, Service Creation Area, Network Control and Management Area, Service Control and Management Area, Advanced Technologies for Network and Service Management

Unit V - NGN Standardizations - (08 Hours)

ITU and GSI-NGN, ETSI and TISPAN-NGN, ATIS and NGN, CJA and NGN. TMF and NGOSS, NGMN Alliance and NGMN, and 3GPP and LTE/SAE

Learning Resources

Text Books

1. Jingming Li Salina and Pascal Salina, Next Generation Networks: Perspectives and Potentials, John Wiley & Sons Ltd, 2007, ISBN 978-0-470-51649-2.

Reference Books:

1. Steven Noble, Building Modern Networks: Create and manage cutting-edge networks and services, Packt Publishing, 2017, ISBN 978-1-78646-697-6\

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
SEM-581-CNT - Technical Seminar - I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term Work** : 25 Marks **Oral/Presentation** : 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. Technical Seminars will provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.

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

- **Deepen Technical Knowledge:** To enable students to explore a specialized topic within Computer Engineering beyond the regular curriculum, fostering in-depth understanding.
- **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
- **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.
- **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
- **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
- **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 for Seminar

- **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 in 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 diary. The 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 work towards seminar.
  - 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 for seminar presentations and the oral presentation of the seminar.
- **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.

- **Seminar Structure and Deliverable :** The technical seminar typically involves the following stages and deliverable
  - 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.
- **Seminar Report (Due 2-3 weeks before presentation):**
  - A written report (typically 20-25 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.

- **Oral Presentation :**
  - Duration: Typically 25-30 minutes for presentation, followed by 10-15 minutes for Q&A.
  - 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 delivery. 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.
- **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 Courses

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

M. E. - Computer Networks (2025 Pattern)

Semester III

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Networks		
RM-601-CNT - Research Methodology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**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. Learn the methodology to conduct the Literature Survey
4. Acquaint with the tools, techniques, and processes of doing research
5. Learn the effective report writing skills and allied documentations
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, short-cut method for oneway 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?, 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, 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/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 (2025 Course) - Computer Engineering		
OJT-602-CNT - 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 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 provide students 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

- **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.
- **Internship Duration and Academic Credentials**
  - Student can take internship work in the form of Online/Offline mode from any of the Industry / Government Organization Internship Programmes approved by SPPU/AICTE/UGC portals
  - A 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
- **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.
- **Assessment Details (Term Work)**
  - 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.
- **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 / Deep Learning / Augmented Reality / Virtual Reality etc.)
  - Humanitarian, Public Policy and Legal Services
  - Communication
  - Education
  - Sustainable Development
  - Environment
  - Commerce, Medium and Small-Scale Industries

- **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.

- **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 - Computer Engineering (2025 Course)		
SEM-603-CNT - Technical Seminar - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:**25 Marks **Oral/Presentation:** 25 Marks

Course Description:

- Research Project seminar is the first stage of work on a master's thesis. During this course, students gain experience in the field of intellectual property and research ethics. They conduct patent searches and analyze related works to study the current state of the target area.
- Work on the "Research Project seminar" is carried out on the basis of the research and training laboratories of the Institute and the Scientific Library of the Institute/University and in close cooperation with the student's supervisor.
- The aim of the "Research Project Seminar " is to prepare for the implementation of the Final Project and for master's thesis defense. It includes finding or developing methods and tools to solve a stated problem, taking into account the latest research and trends; clarification of requirements for the object under development; planning experiments and tests to prove the effectiveness of the proposed solution

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

- To provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.
- To raise student's awareness in advanced methods of research and mastering the skills to apply them.
- Teach students to find and critically analyze sources of information.
- Develop their ability to build logic of reasoning and statements based on the interpretation of data combined from various fields of science and technology, to make judgments based on incomplete data.
- Improve the student's academic writing experience.

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

- **CO1 -** Gain fundamental concepts and categories in the field of scientific research- ways of organizing and planning research
- **CO2** - Advanced information technologies allowing us to **acquire** new knowledge in various fields
- **CO3 - Learn** features of the technical and scientific style of writing texts

- **CO4 -** Evaluation criteria and methods of handling incomplete data

By the end of the course, students will be able to:

- formulate the goals and objectives of scientific research;
- search, evaluate and analyze information about the achievements of science and technology in the target area and beyond;
- interpret data from different fields of science and technology;
- to build the logic of reasoning and statements;
- write a text in a scientific or scientific and technical style, use the appropriate vocabulary;
- create, design and edit text documents in accordance with the requirements of the organization or publisher;
- plan a pilot study
  - methods of planning scientific research, taking into account the peculiarities of the professional area.
  - methods of collecting and analyzing information on the achievements of science and technology in the target area and beyond.
  - proficiency in preparing publications on the topic of research
  - experience in data integration from different fields of science and technology and building evidence-based judgments.
  - methods of planning an experiment, taking into account the peculiarities of the field of professional activity.

Responsibility of the students:

- This Seminar should be carried out individually by each student based on the research project.
- 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 in 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 for seminar presentations and the oral presentation of the seminar
- **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.
- **Seminar Structure and Deliverable :** The technical seminar typically involves the following stages and deliverable
  - 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.

- **Seminar Report (Due 2-3 weeks before presentation):**
  - A written report (typically 20-25 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.

- **Oral Presentation :**
  - Duration: Typically 25-30 minutes for presentation, followed by 10-15 minutes for Q&A.
  - 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 delivery. 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.

- **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. Kennett, B. (2014). Planning and managing scientific research. ANU Press. https://www.jstor.org/stabl (free access)
2. Sirotinina, N. (2012). History and methodology of computer science. Siberian Federal University. Tomsk: TPU Publishing House.
3. Moore, N. (2006). How to do research: a practical guide to designing and managing research projects. Facet publishing.

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
RPR-604-CNT - 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

Course Outcomes:

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

- CO 1 : Demonstrate how to search the existing literature to gather information about a specific problem or domain.
- CO 2 : Identify the state-of-the-art technologies and research in the chosen domain, and highlight open problems that are relevant to societal or industrial needs.

- CO 3 : Evaluate various solution techniques to determine the most feasible solution within given constraints for the chosen dissertation problem.
- CO 4 : Apply software engineering principles related to requirements gathering and design to produce relevant documentation.
- CO 5 : Write a dissertation report that details the research problem, objectives, literature review, and solution architecture.

Guidelines for Research Project

1. **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) Student is 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.

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 500 words. Writing an abstract for a research proposal or for completed research work is an important transferable skill.

The project title is understood to be provisional. Supervisors/guide will be assigned to students after the project title/ abstract forms have been submitted. The main responsibilities of the supervisor/guide are to assist the student with project management and to advise the student on criteria for assessment. It is a good idea to discuss a time line for your project with your supervisor/guide, and to establish a definite timetable.

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 is 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. 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.

Phase 5: Submit project report

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

Additional Information

- **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.
- **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 unprepared. All students are warned to create redundancies to protect their project from similar calamities.
- **Citation format :** The style must be clear, explicit, and meaningful. 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 discuss 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

M. E. - Computer Networks (2025 Pattern)

Semester IV

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
SEM-651-CNT- 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. Technical Seminars will provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.

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

- **Deepen Technical Knowledge:** To enable students to explore a specialized topic within Computer Engineering beyond the regular curriculum, fostering in-depth understanding.
- **Develop Research Skills:** To provide practical experience in identifying, acquiring, evaluating, and synthesizing information from various technical sources (research papers, standards, technical reports).
- **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.
- **Foster Critical Thinking:** To encourage students to critically analyze existing research, identify challenges, propose solutions, and engage in constructive discussions.
- **Promote Independent Learning:** To encourage self-directed learning and the ability to stay updated with emerging technologies and research trends.
- **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 for Seminar

- **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 in 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 diary. The 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 work towards seminar.
  - 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 for seminar presentations and the oral presentation of the seminar.
- **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.

- **Seminar Structure and Deliverable :** The technical seminar typically involves the following stages and deliverable
  - 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.
- **Seminar Report (Due 2-3 weeks before presentation):**
  - A written report (typically 20-25 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.

- **Oral Presentation :**
  - Duration: Typically 25-30 minutes for presentation, followed by 10-15 minutes for Q&A.
  - 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 delivery. 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.
- **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 Courses

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 - Computer Engineering (2025 Course)		
RPR-652-CNT - Research Project Stage-II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 36 Hours/Week	18	**Term Work:**150 Marks **Oral/ Presentation :** 50 Marks

Prerequisite : Research Project Stage-I

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

- **Demonstrate** an ability to plan a research project, such as is required in a research proposal prior to the launch of their work
- **Ability** to manage projects and to make constructive use of expertise associated with their project, while working as an independent learner
- **Ability** to relate their original data to existing literature, or to create an novel synthesis of existing materials
- **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:

1. **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
2. **CO2 : Plan** their project in advance, using a proposal to describe their undertaking, describe how it will be managed, and reflect upon its value
3. **CO3 : Relate** their original research to existing literature on the subject and relate their work to general themes in their relevant scholarly literature
4. **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
5. **CO5 : Reflect** on the strengths and weaknesses of their research and methodology, understanding how they might improve their efforts in future work

Guidelines for Research Project

- **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 concerned guide and head of the Department/Institute.
- The students are expected to validate their study undertaken by publishing it at 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**

    - Final version must again be checked and should not exceed 15% similarity.

- **Evaluation Parameters**
    - Completeness and quality of implementation
    - Anaysis and originality of results
    - Qulity 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

Programme Coordinator

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