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 Engineering

(With effect from Academic Year 2025-26)

Contents

Nomenclature

AICTE All India Council for Technical Education

CCE Comprehensive Continuous Evaluation

ESE End-Semester Examination

KAP Knowledge and Attitude Profile

OJT On Job Training

PCC Programme Core Course

PEC Programme Elective Course

PEO Programme Educational Objectives

PO Programme Outcomes

PSO Program Specific Outcomes

WK Knowledge and Attitude Profile

Master of Engineering in Computer Engineering - 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 Computer Engineering syllabus (2025 Pattern) effective from the Academic Year 2025-26. Computer Engineering is a dynamic discipline that lies at the intersection of electrical engineering and computer science. It provides the foundation for the design, development, and application of computer systems and other computing devices. This curriculum is designed to provide students with a comprehensive understanding of the fundamental principles, theories, and practices of computer engineering, while also preparing them for the ever-evolving technological landscape.

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 would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

Dr. 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 graduates to achieve.

PEO	PEO Focus	PEO Statements
PEO1	Core competence	To prepare globally competent post graduates with enhanced domain knowledge and skills attaining professional excellence and updated with modern technology to provide effective solutions for engineering and research problems.
PEO2	Breadth	To prepare the post graduates to work as a committed professionals with strong professional ethics and values, sense of responsibilities, understanding of legal, safety, health, societal, cultural and environmental issues.
PEO3	Professionalism	To prepare motivated post graduates with research attitude, lifelong learning, investigative approach, and multidisciplinary thinking to succeed in the career in industry/academia/research
PEO4	Team Building	To prepare post graduates with strong managerial and communication skills to work effectively as an individual as well as in teams.

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 Engineering) should be able to demonstrate at the time of their graduation.

PSO1	Advanced Computing Solutions: Apply advanced techniques in artificial intelligence, machine learning, cloud computing, and big data analytics to design and optimize computing solutions.
PSO2	Research & System Design: Conduct research, model complex systems, and develop efficient algorithms and architectures for high-performance and secure computing.
PSO3	Professional Readiness: Demonstrate domain expertise, industry-readiness, and the ability to adapt emerging technologies for professional, entrepreneurial, and societal applications.

Master of Engineering (2025 Pattern) – Computer Engineering

Curriculum Structure - Semester I

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	ESE	Term Work	Practical	Oral	Total	Theory	Practical	Total
PCC-501-COM	Programme Core Course	Probability and Statistics	4	-	50	50	-	-	-	100	4	-	4
PCC-502-COM	Programme Core Course	Advanced Algorithms	4	-	50	50	-	-	-	100	4	-	4
PCC-503-COM	Programme Core Course	Machine Learning	4	-	50	50	-	-	-	100	4	-	4
PCC-504-COM	Programme Core Course	Distributed Computing	4	-	50	50	-	-	-	100	4	-	4
PCC-505-COM	Programme Core Course	Computational Laboratory-I	-	4	-	-	25	-	25	50	-	2	2
PEC-521-COM	Programme Elective Course	Elective I	3	-	50	50	-	-	-	100	3	-	3
PEC-522-COM	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-COM	Data Engineering
PEC-521B-COM	Deep Learning
PEC-521C-COM	Business Intelligence
PEC-521D-COM	Internet of Things

Master of Engineering (2025 Pattern) – Computer Engineering

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-COM	Programme Core Course	Quantum Computing	4	-	50	50	-	-	-	100	4	-	4
PCC-552-COM	Programme Core Course	Cyber Security	4	-	50	50	-	-	-	100	4	-	4
PCC-553-COM	Programme Core Course	Natural Language Processing	4	-	50	50	-	-	-	100	4	-	4
PCC-554-COM	Programme Core Course	Computational Laboratory-II	-	4	-	-	25	-	25	50	2	-	2
PEC-561-COM	Programme Elective Course	Elective –II	3	-	50	50	-	-		100	3	-	3
PEC-562-COM	Programme Elective Course	Elective –III	3	-	50	50	-	-	-	100	3		3
SEM-581-COM	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-COM	Cloud and Edge Technology	PEC-562A-COM	Federated Learning
PEC-561B-COM	Generative Artificial Intelligence	PEC-562B-COM	Real-time Operating System
PEC-561C-COM	Game Theory and Applications	PEC-562C-COM	Social Network Analytics
PEC-561D-COM	Bio Inspired Computing	PEC-562D-COM	Next Generation Networks

Master of Engineering (2025 Pattern) – Computer Engineering

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-COM	Research Methodology	Research Methodology	4	-	50	50	-	-	-	100	4	-	4
OJT-602-COM	OJT/ Internship	On Job Training/Internship	-	10	-	-	100	-	-	100	-	5	5
SEM-603-COM	Seminar	Technical Seminar II	-	8	-	-	25	-	25	50	-	4	4
RPR-604-COM	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-COM	Seminar	Technical Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-652-COM	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

ME - Computer Engineering

Semester I

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PCC-501-COM - 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 Engineering		
PCC-502-COM - Advanced Algorithms		
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, Proficiency in programming, Understanding of discrete mathematics, probability, and linear algebra.

Course Objectives: The course aims to:

1. To understand different algorithm design techniques.
2. To analyze performance of different algorithmic strategies in terms of time and space.
3. To apply algorithmic strategies while solving problems.
4. To Understand Multithreaded and Distributed Algorithms.
5. To understand and apply and implement geometric algorithms and optimization algorithms.

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

- CO1.Evaluate and contrast the efficiency of polynomial time algorithms by examiningtheir performance across the worst, best, and average case scenarios.
- CO2.Utilize appropriate algorithmic techniques to address problems involving binomial coefficients, chain matrix multiplication, and longest common subsequence.
- CO3. Develop and apply problem-solving skills to address real-world business challenges and decision-making scenarios.
- CO4.Evaluate the effectiveness and accuracy of randomized algorithms, considering both their efficiency and correctness.
- CO5.Apply problem-solving techniques tailored for multi-core, distributed, or concurrent environments to effectively address complex computational challenges.

Course Contents

Unit I - Introduction to Algorithms - (12 Hours)

Review and Introduction: Role of algorithms in computing, Growth functions, Recurrences, Solving Recurrences: Substitution method, Recursive Tree method and Master method. Review of algorithmic strategies: Greedy method, Divide and Conquer method, Dynamic Programming, Branch and Bound method

Unit II - Dynamic programming and Linear Programming (12 Hours)

Dynamic programming: Control abstraction for dynamic programming, elements of dynamic programming, use of dynamic programming method to solve the problems: binomial coefficients, chain matrix multiplication, longest common subsequence.

Linear programming: Its use, problem formulation as linear programming model, simplex method, duality.

Unit III - Randomized and Distributed Algorithms - (12 Hours)

Randomized Algorithms: Reasons for using randomized algorithms, Examples: Randomized Qsort, min-cut problems, Introduction to approximation algorithms, Examples: TSP, 3-coloring problem, Parallel and Distributed Algorithms: Parallel loops, Race conditions, Problem Solving using Multithreaded Algorithms, Multithreaded matrix multiplication, Multithreaded merge sort.

Distributed Algorithms: Introduction, Distributed breadth first search, Distributed Minimum Spanning Tree. String Matching: Introduction, The Naive string-matching algorithm, The Rabin-Karp algorithm.

Unit IV - Geometric and Optimization Algorithms (12 Hours)

Geometric algorithms - Introduction, range searching, convex hulls, segment intersections, closest pairs of points. Optimization Algorithms- Introduction, Gradient Descent, Genetic Algorithms, Particle Swarm Optimization.

Unit V - Complexity Theory (12 Hours)

Classes of problems: P, NP, NP-complete, and NP-hard. Examples- Travelling salesman problem, post correspondence problem. P vs NP: The implications of solving this problem, its relevance to cryptography, and its connections to real-world applications. Reduction Techniques: Polynomial-time reductions and Cook reductions.

Case Studies of Industry Relevance/recent trends

Learning Resources

Text Books:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, “Introduction to Algorithms,” ISBN: 978-0-262-04630-5, 4th edition MIT press, 2022.
2. Parag Himanshu Dave, Himanshu Bhalchandra Dave, “Design and Analysis of Algorithms,” Pearson Education, ISBN 81-7758-595-92, 2nd edition, 2013.

Reference Books:

1. Rajeev Motwani and Prabhakar Raghavan, “Randomized Algorithms,” Cambridge University Press, ISBN: 978-0-521-61390-3, 1st edition, 2004.
2. Gilles Brassard, Paul Bratley, “Fundamentals of Algorithmics,” PHI, ISBN 978-81-203-1131-2.
3. Michael T. Goodrich, Roberto Tamassia, “Algorithm Design: Foundations, Analysis and Internet Examples,” Wiley, ISBN 978-81-265-0986-7, 1st edition 2006.
4. Dan Gusfield, “Algorithms on Strings, Trees and Sequences,” Cambridge University Press, ISBN:0-521-67035-7,1st edition 1997.
5. Horowitz and Sahani, “Fundamentals of Computer Algorithms,” University Press, ISBN: 978 817371 6126, 81 7371 61262, 2nd edition 2008.

SWAYAM / MOOC Links :

1. Design and Analysis of Algorithms, By Prof. Madhavan Mukund, Chennai Mathematical Institute https://onlinecourses.nptel.ac.in/noc19_cs47/preview

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

Prerequisite Courses : Design of Analysis & Algorithms. and Machine Learning

Course Objectives: The course aims to:

1. To understand the basic concepts, state-of-the art techniques of machine learning.
2. To apply different concepts for the machine learning problems.
3. To apply and analyze different supervised and unsupervised learning approaches as per the suitability of the problem.
4. To understand and evaluate machine learning methods to use them.
5. To design solutions of problems using different machine learning approaches.

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

- CO1: Apply different feature extraction, classification, regression, algorithms and modeling.
- CO2: Evaluate the performance of an algorithm and comparison of different learning techniques.
- CO3: Understand unsupervised methods and their applications
- CO4: Optimize the algorithms effectively
- CO5: Apply techniques using different case studies

Course Contents

Unit I - Introduction & Supervised Learning Algorithms - (12 Hours)

Introduction: Pattern Representation, Concept of Pattern Recognition, Basics of Probability, Bayes' Decision Theory, Maximum-Likelihood and Bayesian Parameter Estimation, Error Probabilities, Learning of Patterns, Modeling, Regression.

Supervised Learning Algorithms: Linear Regression, K-Nearest Neighbor, Naïve Bayes, Bayesian Networks, Bayes Classification, Bayesian Decision Theory, Losses and Risks.

Parametric Methods: Gaussian Parameter Estimation, Maximum Likelihood Estimation, Bias and Variance, Bayes' Estimator, Bayesian Estimation, Parametric Classification, Regression, Naive Bayes, Hidden Markov Models, Support Vector Machines, Decision Trees.

Unit II - Unsupervised Learning Algorithms - (12 Hours)

Kernel methods, Basic kernels, Types of Kernel, Properties of kernels, Pattern analysis using Eigen decomposition, Principal Component Analysis, Hidden Markov Models, Markov Decision Processes, Nonparametric techniques for density estimation, Parzen-window method.

Unit III - Convolutional Neural Networks- (12 Hours)

Convolutional Neural Networks: The operation, Pooling layers, fully connected layers, Convolution and Pooling as an infinitely strong prior, Variants of the basic functions, efficient algorithms, Random or Unsupervised Features, Neuroscientific Basis for Convolutional Networks. Applications.

Unit IV - Optimization methods (12 Hours)

Recurrent Neural Networks: Types of RNN, Encoder-Decoder Sequence to sequence architecture, Deep Recurrent Networks, Recursive Neural Networks, The Long Short-Term Memory and other Gated RNNs, Optimization for Long Term Dependencies, Applications

Unit V - Use Cases and Applications (12 Hours)

Advanced Machine Learning Techniques: Ensemble Learning Methods, Support Vector Machines (SVM),Dimensionality Reduction Techniques, Introduction to Deep Learning, Use Cases and Applications- Fraud detection, sentiment analysis, computer vision, medical diagnosis case studies and applications only

Learning Resources

Text Books:

1. Peter Flach, Machine Learning: The Art and Science of Algorithms that make sense of data, Cambridge University Press, 1st Edition, 2012, ISBN No.: 978-1-316-50611-0.
2. Ethem Alpaydin, Introduction to Machine Learning, PHI, 2nd edition, 2013, 978-0-262-01243-0.
3. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, 2nd Edition, Wiley, 2001.
4. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
5. Geoff Dougherty, “Pattern recognition and classification an Introduction”, Springer, 2013.
6. John Shae Taylor and NelloCristianini, “Kernel methods for pattern analysis” Cambridge university press, 2004.

Reference Books:

1. C.M. Bishop, Pattern Recognition and Machine learning, Springer, 1st Edition, 2013, ISBN No.: 978-81-322-0906-5.
2. Hastie, Tibshirani, Friedman, Introduction to statistical machine learning with applications in R, Springer, 2nd Edition, 2013, ISBN No.: 978-1-4614-7138-7.
3. Tom Mitchell, Machine Learning, McGraw Hill, 1997, 0-07-042807-7.
4. Parag Kulkarni, Reinforcement and Systemic Machine learning for Decision Making, Wiley-IEEE Press, 2012, 978-0-470-91999-6.

5. Ranjjan Shinghal, “Pattern Recognition techniques and application”, Oxford university press, 2006.

6. Theodoridis and K.Koutroumbas, “Pattern Recognition”, 4th Edition, Academic Press, 2009.

E-Books Links

1. http://www.ru.ac.bd/wpcontent/uploads/sites/25/2019/03/207_05_01_Rajchka_Using-Python-for-machinelearning-2015.pdf

2. Foundation of Machine Learning: https://cs.nyu.edu/~mohri/mlbook/

3. Dive into Deep Learning: http://d2l.ai/

4. A brief introduction to machine learning for Engineers: https://arxiv.org/pdf/1709.02840.pdf

5. Feature selection: https://dl.acm.org/doi/pdf/10.5555/944919.944968

6. Introductory Machine Learning Nodes : http://lcsl.mit.edu/courses/ml/1718/MLNotes.pdf

MOOC Courses:

1. Introduction to Machine Learning: https://nptel.ac.in/courses/106105152

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PCC-504-COM - Distributed Computing		
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 introduce the computation and communication models of distributed systems
2. To illustrate the issues of synchronization and collection of information in distributed systems
3. To describe distributed mutual exclusion and distributed deadlock detection techniques
4. To elucidate agreement protocols and fault tolerance mechanisms in distributed systems
5. To explain the cloud computing models and the underlying concepts

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 - Introduction to Distributed Computing - (12 Hours)

Introduction: Definition-Relation to Computer System Components – Motivation – Message -Passing Systems versus Shared Memory Systems – Primitives for Distributed Communication – Synchronous versus Asynchronous Executions – Design Issues and Challenges; A Model of Distributed Computations: A Distributed Program – A Model of Distributed Executions – Models of Communication Networks – Global State of a Distributed System.

Unit II - Logical Time and Global State - (12 Hours)

Logical Time: Physical Clock Synchronization: NTP – A Framework for a System of Logical Clocks – Scalar Time – Vector Time; Message Ordering and Group Communication: Message Ordering Paradigms – Asynchronous Execution with Synchronous Communication – Synchronous Program Order on Asynchronous System – Group Communication – Causal Order – Total Order; Global State and

Snapshot Recording Algorithms: Introduction – System Model and Definitions – Snapshot Algorithms for FIFO Channels.

Unit III - Distributed Mutex and Deadlock- (12 Hours)

Distributed Mutual exclusion Algorithms: Introduction – Preliminaries – Lamport's algorithm – Ricart-Agrawala's Algorithm — Token-Based Algorithms – Suzuki-Kasami's Broadcast Algorithm; Deadlock Detection in Distributed Systems: Introduction – System Model – Preliminaries – Models of Deadlocks – Chandy-Misra-Haas Algorithm for the AND model and OR Model.

Unit IV - Consensus and Recovery - (12 Hours)

Consensus and Agreement Algorithms: Problem Definition – Overview of Results – Agreement in a Failure-Free System(Synchronous and Asynchronous) – Agreement in Synchronous Systems with Failures; Checkpointing and Rollback Recovery: Introduction – Background and Definitions – Issues in Failure Recovery – Checkpoint-based Recovery – Coordinated Checkpointing Algorithm – – Algorithm for Asynchronous Checkpointing and Recovery.

Unit V - Cloud Computing- (12 Hours)

Definition of Cloud Computing – Characteristics of Cloud – Cloud Deployment Models – Cloud Service Models – Driving Factors and Challenges of Cloud – Virtualization – Load Balancing – Scalability and Elasticity – Replication – Monitoring – Cloud Services and Platforms: Compute Services – Storage Services – Application Services

Learning Resources

Text Books

1. Kshemkalyani Ajay D, Mukesh Singhal, "Distributed Computing: Principles, Algorithms and Systems", Cambridge Press, 2011.
2. Mukesh Singhal, Niranjan G Shivaratri, "Advanced Concepts in Operating systems", McGraw Hill Publishers, 1994.

Reference Books:

1. George Coulouris, Jean Dollimore, Time Kindberg, "Distributed Systems Concepts and Design", Fifth Edition, Pearson Education, 2012.
2. Pradeep L Sinha, "Distributed Operating Systems: Concepts and Design", Prentice Hall of India, 2007.
3. Tanenbaum A S, Van Steen M, "Distributed Sysems: Principles and Paradigms", Pearson Education, 2007.
4. Liu M L, "Distributed Computing: Principles and Applications", Pearson Education, 2004.
5. Nancy A Lynch, "Distributed Algorithms", Morgan Kaufman Publishers, 2003.
6. Arshdeep Bagga, Vijay Madisetti, " Cloud Computing: A Hands-On Approach", Universities Press, 2014.

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

Prerequisite Courses : Probability and Statistics, Advance Algorithms, Distributed Systems and Machine Learning

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 eigenvectors 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

Guidelines:

- Computational Laboratory-I assignments are based on 4 Programme Core courses (Probability and Statistics, Advance Algorithms, Distributed Systems and Machine Learning)
- 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: Probability and Statistics (Any TWO)

1	Statistical estimation and Chi-Square Test using R programming: Estimate the population parameters like mean variance from sample data. Construct the 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. Chose 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.
Part B: Advanced Algorithms	
1	Randomized, distributed, geometric and optimized algorithms using R / Python: Implement any two core examples of the algorithms to solve practical computational problems and analyze algorithmic efficiency. i. Apply randomized algorithm to offer fast approximation to estimate Pi using Monte Carlo algorithm. ii. Implement distributed Rabin Karp algorithm for string matching. Use hashing to find pattern matches. Use of sliding window and rolling hash makes fast for multiple matches. iii. Implement a geometric algorithm convex hull using Graham's Scan / SciPy. iv. Apply optimization algorithm to implement a genetic algorithm for function optimization to solve a complex non-linear problem efficiently.
2	Complexity Theory in practice using R / Python: Implement Travelling Salesman problem for route optimization and demonstrate the problem in n P and NP complexity class.
Part C: Machine Learning	
1	Support vector machine for multiclass classification using Python: Implement a classification model using Support vector machine algorithm for news article topic classification like science, technology, politics, sports, etc. Use sklearn dataset and/or fetch dataset using APIs.
2	Convolution Neural Network for face recognition using Python: Implement a real-world application like AI Face Recognition Entry Agent using CNN. It detects and recognizes faces in real-time environment. It should grant or denies the entry based on known faces of pre-trained databases
Part D: Distributed Computing (Any Two)	
1	Coordination Problem. Two processes, A and B, communicate by sending and receiving messages on a bidirectional channel. Neither process can fail. However, the channel can ex perience transient failures, resulting in the loss of a subset of the messages that have been sent. Devise a protocol where either of two actions α and β are possible, but (i) both processes take the same action and (ii) neither take both actions.

2	Election Problem. A set of processes P1, P2, ..., Pn must select a leader. Each process Pi has a unique identifier uid(i). Devise a protocol so that all of the processes learn the identity of the leader. Assume all processes start executing at the same time and that all communi--4 cate using broadcasts that are reliable.
3	Recurrent Neural Networks for Language Translation using Python: Implement a real-world application like English to Marathi translation using RNN Encoder-Decoder model. LSTM Encoder reads input sentences and encodes into a fixed length context vector to generate translated sentence. Define a tiny dataset for demonstration.
Mini Project (Any ONE)	
1	Matrix Eigenvalue Problems using R: Compute the eigenvalues and eigenvectors of a matrix. Apply diagonalization and check dimension reduction of eigenvector. Perform the principal component analysis (PCA) using covariance matrix of sample data.
2	Applications of decision-making problems using dynamic programming for investment allocation problem using R / Python. Consider, a company is interested to invest 50 Lakhs across 3 projectsto maximize total return. Each project has minimum and maximum investment levels. Apply dynamic programming to determine optimal allocation at multi-stage decision levels: 0, 10, 20, 30, 40, 50.
3	Recurrent Neural Networks for Language Translation using Python: Implement a real-world application like English to Marathi translation using RNN Encoder-Decoder model. LSTM Encoder reads input sentences and encodes into a fixed length context vector to generate translated sentence. Define a tiny dataset for demonstration.

Learning Resources

Reference Books:

1. Michael T. Goodrich, Roberto Tamassia, “Algorithm Design: Foundations, Analysis and Internet Examples,” Wiley, ISBN 978-81-265-0986-7, 1st edition 2006.
2. https://ps-iitd.vlabs.ac.in/List%20of%20experiments.html
3. http://www.ru.ac.bd/wpcontent/uploads/sites/25/2019/03/207_05_01_Rajchka_Using-Python-for-machine
4. Hastie, Tibshirani, Friedman, Introduction to statistical machine learning with applications in R, Springer, 2nd Edition, 2013, ISBN No.: 978-1-4614-7138-7.

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

Prerequisite Courses: Design of Analysis & Algorithms

Course Objectives: The course aims to:

1. Introduce the foundational concepts and tools used in data engineering.
2. Understand the architecture of modern data pipelines and platforms.
3. Explore data ingestion, transformation, storage, and orchestration techniques.
4. Gain insight into scalable data processing using batch and stream frameworks.
5. Enable students to design reliable, secure, and ethical data pipelines.

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

- **CO1:** Explain the core concepts, lifecycle, and goals of data engineering.
- **CO2:** Design data pipelines for data ingestion, storage, and processing.
- **CO3:** Apply data transformation and ETL principles using conceptual tools.
- **CO4:** Evaluate batch vs stream processing architectures and their use cases.
- **CO5:** Analyze challenges of scalability, security, quality, and ethics in data workflows.

Course Contents

Unit I - Introduction to Data Engineering (08 Hours)

Introduction to data engineering, role in the AI/ML lifecycle, types of data, Structured, Semi-structured, Unstructured, data engineering for data science and ML engineering, data lifecycle, ingestion, storage, processing, analysis, data formats, CSV, JSON, Avro, Parquet, ORC, overview of data engineering roles and real-world examples, scope and responsibilities in data engineering, data types handled in real-world systems.

Unit II - Query Processing & Optimization (08 Hours)

Data sources, databases, APIs, IoT, social media, Logs, batch and real-time ingestion, file systems, HDFS, object storage, S3, GCS, Azure clouds, databases, relational, PostgreSQL, NoSQL, MongoDB, Cassandra, Data lakes and data warehouses, Concepts of data lakehouse, Delta Lake, Apache Iceberg, data ingestion and architectures for various use cases, storage solutions based on data structure and scale.

Unit III - Data Transformation and ETL/ELT (08 Hours)

ETLand ELT pipelines, concepts and use cases, data cleansing, enrichment, deduplication, normalization, data validation and quality checks, data modeling: Star and Snowflake schema, conceptual tools, Apache NiFi, Airbyte, dbt, Informatica, data transformation, data handling schema evolution, concept of underpinnings of ETL and transformation pipelines, evaluate data quality, consistency, and schema design.

Unit IV- Distributed Data Processing (08 Hours)

Need for distributed processing, batch processing, Hadoop, Apache Spark – architecture and concepts, stream processing, Apache Kafka, Flink, Spark Structured Streaming, data partitioning and shuffling, fault tolerance and parallelism, AI/ML pipelines – training large models, feature engineering, batch processing systems, stream processing systems, scalable systems, real-time ML systems workflows

Unit V- Data Engineering Applications- (08 Hours)

Data engineering workflow, data orchestration, metadata management and lineage, data security, encryption, access control, anonymization, Applications: Recommendation systems, agricultural AI pipelines, Fraud detection, Predictive maintenance, use of pipelines in high-impact AI/ML applications.

Learning Resources

Text Books:

1. Joe Reis and Matt Housley, Fundamentals of Data Engineering, 1st Edition O'Reilly, July 2022, ISBN: 978-1-098-10830-4 https://freecomputerbooks.com/books/Fundamentals-of-Data-Engineering.
2. Yupo Chan, John R. Talburt, Tery M. Tally, "Data Engineering: Mining, Information and Intelligence", Springer, ISBN: 978-1-4419-0176-1.
    - https://archive.org/download/springer_10.1007-978-1-4419-0176-7/10.1007-978-1-4419-0176-7.pdf

Reference Books:

1. Martin Kleppmann,"Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems", O'Reilly Media, Inc., 2017.
2. Paul Crickard, "Data Engineering with Python", Packt, ISBN: 978-1-83921-418-9, 2020

E-Book:

1. Big Book of Data Engineering, 3rd Edition - Databricks, https://www.databricks.com/resources/ebook/book-of-data-engineering

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PEC-521B-COM: Deep Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Linear Algebra, Statistics and Probability, Advanced Machine Learning

Course Objectives: The course aims to:

1. Understand fundamental concepts of deep learning.
2. Apply deep learning algorithms to solve real-world problems.
3. Develop and evaluate deep learning models.
4. Critically analyze deep learning methodologies.

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

- CO1: Fundamentals: Demonstrate mastery of fundamental deep learning concepts.
- CO2: Application: Apply deep learning algorithms to solve practical engineering problems.
- CO3: Model Development: Design, implement, and evaluate deep learning models.
- CO4: Critical Analysis: Critically evaluate deep learning methodologies and their limitations.
- CO5: Problem Solving: Develop and implement solutions using deep learning techniques appropriate to given contexts.

Course Contents

Unit I -Foundations of Deep Learning- (08 Hours)

Introduction to Artificial Neural Networks (ANNs), Perceptrons and Multilayer Perceptrons (MLPs), Activation Functions (Sigmoid, Tanh, ReLU, Leaky ReLU), Backpropagation Algorithm, Optimization Algorithms (Gradient Descent, Stochastic Gradient Descent, Adam), Regularization Techniques (Dropout, L1/L2 Regularization), Introduction to Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) – basic concepts only.

Assessment: Homework assignments focused on implementing basic neural networks using Python libraries (e.g., TensorFlow/Keras)

Unit II - Deep Learning Architectures and Applications- (08 Hours)

Convolutional Neural Networks (CNNs): Architectures (LeNet, AlexNet, ResNet, Inception), Applications (Image Classification, Object Detection, Image Segmentation), Recurrent Neural Networks (RNNs): Architectures (Vanilla RNN, LSTM, GRU), Applications (Natural Language Processing, Time Series Analysis), Long Short-Term Memory (LSTM) Networks and Gated Recurrent Units (GRUs), Generative Adversarial Networks (GANs),

Assessment: Practical project on image classification or a simple NLP task using a chosen deep learning framework.

Unit III Deep Learning Model Development- (08 Hours)

Data Preprocessing for Deep Learning, Model Selection, Training Strategies, and Hyperparameter Tuning, Evaluation Metrics for Deep Learning Models (Accuracy, Precision, Recall, F1-Score, AUC-ROC), Model Deployment and Monitoring, Techniques for handling imbalanced datasets in deep learning, Introduction to transfer learning,

Assessment: A medium-sized project requiring the design, implementation, and evaluation of a deep learning model on a given dataset (e.g., a complex image classification problem or a text classification task).

Unit IV - Advanced Deep Learning Techniques- (08 Hours)

Autoencoders: Undercomplete Autoencoders, Regulraized Autoencoders-Sparse Autoencoders, Stochastic Encoders and Decoders, Denoising Autoencoders, Contractive Autoencoders, Applications of Autoencoders.

Ensemble Methods in Deep Learning, Autoencoders and Variational Autoencoders (VAEs), Deep Reinforcement Learning (basics), Explainable AI (XAI) and its role in DL, Ethical considerations in deep learning,

Assessment: A presentation on advanced deep learning techniques along with a critical analysis of their strengths and limitations.

Unit V - Deep Learning Applications in Computer Engineering- (08 Hours)

Deep Learning applications in Computer Vision, Natural Language Processing, and other relevant fields, Image Classification, Social N/w/ analysis, Speech Recognition, Recommender system, Case studies on the application of Deep Learning in areas such as robotics, signal processing, and healthcare,

Assessment: A final project focusing on a deep learning application that solves a specific problem in Computer Engineering (e.g., anomaly detection using sensor data, image-based defect detection).

Practical Assignments / Mini Project Problem Statements

Mini project focusing on a deep learning application that solves a specific problem in Computer Engineering (e.g., anomaly detection using sensor data, image-based defect detection). Throughout the course: Python programming, TensorFlow / Keras, PyTorch, and relevant libraries will be utilized extensively for practical implementation.

Learning Resources

Text Books

1. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

Reference Books:

1. "Hands-on Machine Learning with Scikit-Learn, Keras & TensorFlow" by Aurélien Géron
2. "Neural Networks and Deep Learning" by Michael Nielsen

3. "Deep Learning with Python" by Francois Chollet

SWAYAM / MOOC / YouTube Links

1. https://www.deeplearningbook.org/
2. https://www.youtube.com/channel/UCF9O8Vj-FEbRDA5DcDGz-Pg/videos
3. https://onlinecourses.nptel.ac.in/noc20_cs62/preview
4. https://swayam.gov.in/search_courses?searchText=deep%20learning

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

Prerequisite Courses : Linear algebra and Probability

Course Objectives: The course aims to:

1. To understand the concept of speech processing.
2. To build speech-based systems.
3. To analyze the performance of speech processing systems.

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

- CO1: Critically appraise current theory and practice in Big Data Analytics, Decision Support Systems and Business Intelligence
- CO2: Appraise the role of BI strategy in driving companies' insight.
- CO3: Apply data analysis and visualization on a sample dataset, appropriate to the level of study, and to provide recommendations on the driven insights to specialist and non-specialist audiences.
- CO4: Identify and appraise emerging trends within the field and evaluate the social and ethical aspects
- CO5: Communicate complex topics and concepts effectively using different communication means such as report writing, use of ICT and/or presentation to specialist and non-specialist audience.

Course Contents

Unit I - Business Intelligence and Information Exploitation- (08 Hours)

Why Business Intelligence? The Information Asset, Exploiting Information, Business Intelligence and Program Success, what is Business Intelligence? Actionable Knowledge Business Case, Business Intelligence Process, System Infrastructure, Information Access, Delivery, and Analysis Services, Management Issues

Unit II - Business Models (08 Hours)

Business Models and Information Flow: The Business Case, Information Processing and Information Flow, the Information Flow Model Usage in Practice Modeling Frameworks Management

Data Warehouses, Online Analytical Processing, and Metadata: The Business Case, Data Models, The Data Warehouse, The Data Mart, Online Analytical Processing, Metadata, Management Issues

Unit III - Data Quality and Information Compliance - (08 Hours)

Business Rules: Business Case, Business Rules Approach, What Is a Business Rule? What Is a Business Rule System? Sources of Business Rules, Management Issues

Data Profiling: The Business Case, Data Profiling Activities, Data Model Inference, Attribute Analysis, Relationship Analysis, Management Issues

Data Quality and Information Compliance: Business Case, More Than Just Names and Addresses, Types of Errors, Data Cleansing, Business Rule-Based Information Compliance, Management Issues

Unit IV - Information Integration- (08 Hours)

Information Integration: The Business Case, ETL: Extract, Transform, Load, Enterprise Application Integration and Web Services, Record Linkage and Consolidation, Management Issues

The Value of Parallelism: Business Case, Parallelism and Granularity, Parallel Processing Systems, Dependence, Parallelism and Business Intelligence, Management Issues

Alternate Information Contexts: Business Case, Psychographics and Demographics, Geographic Data , Web Behavior Intelligence, Management Issue

Unit V - Data Enhancement, Knowledge Discovery and Data Mining - (08 Hours)

Data Enhancement: The Business Case, Types of Data Enhancement, Incremental Enhancements, Batch Enhancements, Standardization Example: Address Standardization, Enhancement Methodologies Management Issues

Knowledge Discovery and Data Mining: The Business Case, Data Mining and the Data Warehouse, The Virtuous Cycle, Directed versus Undirected Knowledge Discovery, Six Basic Tasks of Data Mining, Data Mining Techniques, Management Issues

Using Publicly Available Data: Business Case, Management Issues, Public Data, Data Resources Semi Structured Data, The Myth of Privacy

Learning Resources

Text Books

1. Douglas K. Barry and David Loshin, Business Intelligence: The Savvy Manager's Guide, Morgan Kaufmann Publishers,2003, ISBN-13:978-1-55860-916-7

2. Ahmed Sherif, Practical Business Intelligence, Packt Publishing Ltd.,2016, ISBN 978-1-78588-543-3

Reference Books:

1. Sartaj Singh, Business Intelligence, Excel Books Private Limited, 2011

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PEC-521D-COM - Internet of Things		
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 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 - (08 Hours)

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

Unit II -IoT: Components, Communication and Networking - (08 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 - (08 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- (08 Hours)

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

Unit V - IoT Clouds and Data Analytics and Applications - (08 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 Engineering		
PEC-522-COM - 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

Guidelines for Skill Based Laboratory

- Skill Based Laboratory are based on the electives chosen by the students.
- 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 Departments before conduction of laboratory

List of Assignments

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

Part A - Data Engineering

1. Identify Data Sources in Your Daily Life and classify them as structured, semi-structured and unstructured. (Data sources: ATM logs / online orders / weather data).
2. Write a Python script to read a CSV file and insert the data into a SQLite database.
3. Build a Data Pipeline for Weather Data from a public weather API and perform extraction, transformation, and loading (ETL) operations on it using Python.

Part A - Deep Learning

1. Implement a neural network to classify digits using the MNIST dataset using Python - Keras.
2. Train DL model on a very small dataset and reduce overfitting using dropout data, represent its loss and accuracy graph using python tools.
3. Implement activation functions for CNN using MNIST dataset and compute performance.

Part A - Business Intelligence

1. Select any two BI Tools and compare their features. (BI tools: Power BI, Tableau, Google Data Studio)
2. Create a Basic BI Dashboard using Power BI to visualize a dummy sales dataset
3. Create an interactive dashboard using Power BI / Google Data Studio for Supermarket Sales and perform analysis of trends.

Part A - Internet of Things

1. Identify and describe IoT devices used in daily life for smart home communication. (IoT Devices: smart TV, smartwatch, Alexa, etc.).
2. Write a Python program to simulate temperature readings collected from sensor data and send them to a CSV file.
3. Write a Python program to simulate the smart irrigation system using IoT and Firebase. Represent the real-time view of moisture and logs. Use sensors for soil moisture, humidity and Platform: Arduino/RPi.

Part B - Mini Project

- **Data Engineering :** ETL Pipeline using Python programming: Extract weather data from an open API, clean it and load it into a CSV /r SQLite database using tools Python pandas, sqlite3, CSV file
- **Deep Learning :** Image classifier for fruits: build a CNN to classify fruits dataset using Python TensorFlow, Keras and compute model accuracy.
- **Business Intelligence :** BI Dashboard for Grocery Store Sales: Create a dashboard that shows top-selling items, monthly sales, and sales by region using Power BI/ Google Data Studio.
- **Internet of Things :** IoT-based Room Temperature Monitor: Measure temperature and humidity using sensors, send it to a serial monitor / cloud platform. Use Arduino and DHT11 sensors, construct the circuit diagram and record the output.

Learning Resources

Text Books:

1. Martin Kleppmann, Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems, O'Reilly Media, Inc., 2017.
2. Francois Chollet, Deep Learning with Python.
3. Ahmed Sherif, Practical Business Intelligence, Packt Publishing Ltd.,2016, ISBN 978-1-78588-543-3.
4. Massimo Banzi, Michael Shiloh, Getting Started with Arduino, Third Edition, Maker Media, Inc., 978-1-449-36333-8.

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Computer Engineering

Semester II

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PCC-551-COM - Quantum Computing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Being able to analyze simple quantum algorithms and argue optimality.
2. Familiarity with 1-qubit / 2-qubit gate operators and ability to design simple quantum circuits.
3. Ability to read and understand recent results as well as research papers on quantum algorithms

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

- CO1: Explain how the physics of quantum computation is different from classical computational models.
- CO2: Describe the theoretical performance improvements that quantum algorithms offer compared to classical algorithms.
- CO3: Analyze the life cycle of hybrid applications and decompose their execution on a hybrid quantum-classical computational continuum.
- CO4: Develop their own (hybrid) quantum algorithms and implement them using (real or simulated) quantum computers using quantum toolkits such as Qiskit.

Course Contents

Unit I -Introduction and The Leap from Classical to Quantum - (12 Hours)

Introduction: Cbits and Qbits, Reversible and Manipulating operations on Cbits and Qbits, Circuit diagrams, Measurement gates and state preparation, Constructing arbitrary 1- and 2-Qbit states
The Leap from Classical to Quantum: Classical Deterministic Systems, Probabilistic Systems, Quantum Systems, Assembling Systems

Unit II - Basic Quantum Theory & Architecture- (12 Hours)

Basic Quantum Theory: Quantum States, Observables, Measuring, Dynamics, Assembling Quantum Systems
Architecture: Bits and Qubits, Classical Gates, Reversible Gates, Quantum Gates

Unit III -Algorithms & Programming Languages - (12 Hours)

Algorithms: Deutsch's Algorithm, The Deutsch–Jozsa Algorithm, Simon's Periodicity Algorithm, Grover's Search Algorithm, Shor's Factoring Algorithm,
Programming Languages: Programming in a Quantum World, Quantum Assembly Programming, Toward Higher-Level Quantum Programming, Quantum Computation Before Quantum Computers

Unit IV - Theoretical Computer Science and Cryptography- (12 Hours)

Theoretical Computer Science: Deterministic and Nondeterministic Computations, Probabilistic Computations, Quantum Computations

Cryptography: Classical Cryptography, Quantum Key Exchange I: The BB84 Protocol, Quantum Key Exchange II: The B92 Protocol, Quantum Key Exchange III: The EPR Protocol, Quantum Teleportation

Unit V - Information Theory & Hardware - (12 Hours)

Information Theory: Classical Information and Shannon Entropy, Quantum Information and von Neumann Entropy, Classical and Quantum Data Compression, Error-Correcting Codes

Hardware: Quantum Hardware: Goals and Challenges, implementing a Quantum Computer I: Ion Traps, implementing a Quantum Computer II: Linear Optics, Implementing a Quantum Computer III: NMR and Superconductors, Future of Quantum Ware

Learning Resources

Text Books

1. Eleanor Rieffel and Wolfgang Polak, "Quantum Computing: A Gentle Introduction," The MIT Press, 2011, ISBN 978-0-262-01506-6

2. Quantum Computation and Quantum Information by Nielsen and Chuang (NC), Classical and Quantum Computation by Kitaev, Shen, and Vyalyi (KSV)

3. Scott Aaronson, "Quantum Computing Since Democritus," Cambridge University Press, March 2013, ISBN: 9780521199568

Reference Books:

1. N. David Mermin, "Quantum Computer Science: An Introduction," Cambridge University Press, August 2007, ISBN: 9780521876582

2. Noson S. Yanofsky and Mirco A. Mannucci, "Quantum Computing for Computer Scientists," Cambridge University Press, August 2008, ISBN: 9780521879965

3. "IBM Quantum Computing- Qiskit - ibm.com," https://www.ibm.com/quantum/qiskit

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PCC-552-COM - Cyber 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 various types of cyber-attacks and cyber-crimes
2. To learn threats and risks within context of the cyber security
3. To have an overview of the cyber laws & concepts of cyber forensics
4. To study the defensive techniques against these attacks
5. To study the data protection techniques and address the privacy issues.

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

- CO1. Analyze cyber-attacks to protect them for the entire Internet community.
- CO2. Interpret and forensically investigate security incidents
- CO3. Apply policies and procedures to manage Privacy issues
- CO4. Design and develop secure software modules
- CO5. Apply data protection techniques to solve the privacy issues.

Course Contents

Unit I- Introduction to Cyber Security -(12 Hours)

Basic Cyber Security Concepts, layers of security, Vulnerability, threat, Harmful acts, Internet Governance – Challenges and Constraints, Computer Criminals, CIA Triad, Assets and Threat, motive of attackers, active attacks, passive attacks, Software attacks, hardware attacks, Cyber Threats-Cyber Warfare, Cyber Crime, Cyber terrorism, Cyber Espionage, etc., Comprehensive Cyber Security Policy.

Unit II- Cyberspace and Cyber Forensics-(12 Hours)

Introduction to cyberspace and cyber forensics, Cyber Security Regulations, Roles of International Law. The INDIAN Cyberspace, National Cyber Security Policy. Introduction, Historical background of Cyber forensics, Digital Forensics Science, The Need for Computer Forensics, Cyber Forensics and Digital evidence, Forensics Analysis of Email, Digital Forensics Lifecycle, Forensics Investigation, Challenges in Computer Forensics

Unit III- Cyber Security for Mobile and Wireless Devices -(12 Hours)

Introduction to Cyber security for Mobile and Wireless Devices, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit card Frauds in Mobile and Wireless Computing Era, Security

Challenges Posed by Mobile Devices, Registry Settings for Mobile Devices, Authentication service Security, Attacks on Mobile/Cell Phones, Organizational security Policies and Measures in Mobile Computing Era, Laptops.

Unit IV- Cyber Security for digital Infrastructure-(12 Hours)

Cyber Security for Organizational Implications, cost of cybercrimes and IPR issues, web threats for organizations, security and privacy implications, social media marketing: security risks and perils for organizations, social computing and the associated challenges for organizations, digital Infrastructure Security, data Centre and its infrastructure, IT Security Act , ethical hacking, Hackers - Attacker, Countermeasures, Web Application Security.

Unit V- Privacy Issues and Protection - (12 Hours)

Privacy Issues, Basic Data Privacy Concepts, Data Privacy Attacks, Datalinking and profiling, privacy policies and their specifications, privacy policy languages, privacy in different domains- medical, financial, etc. Online Banking, Credit Card and UPI Security, Overview of Online Banking Security, Mobile Banking Security, Security of Debit and Credit Card, UPI Security. Cloud Computing Threats, Solutions,Vulnerabilities; Risks, Cloud Security. Case study: e-mail spoofing instances, online Gambling, Intellectual Property Crime, Financial Frauds in Cyber Domain.

Learning Resources

Text Books

1. Nina Godbole and SunitBelpure, Cyber Security Understanding Cyber Crimes,Computer Forensics and Legal Perspectives,Wiley
2. B.B.Gupta,D.P. Agrawal, Haoxiang Wang, Computerand CyberSecurity: Principles, Algorithm, Applications, and Perspectives, CRC Press, ISBN 9780815371335,2018.

Reference Books:

1. Cyber Security Essentials, James Graham, Richard Howard and Ryan Otson, CRCPress.
2. Introduction to Cyber Security, Chwan-Hwa(john) Wu,J. David Irwin, CRC Press T&FGroup.
3. Introduction to Cyber Security: Jatindra Pandey.

SWAYAM / MOOC / YouTube Links

1. Introduction to Cyber Security. http://uou.ac.in/foundation-course
2. Fundamentals of Information Security http://uou.ac.in/progdetail?pid=CEGCS-17
3. Cyber Security Techniques. http://uou.ac.in/progdetail?pid=CEGCS-17
4. Cyber Attacks and Counter Measures: User Perspective http://uou.ac.in/progdetail?pid=CEGCS-17
5. Information System. http://uou.ac.in/progdetail?pid=CEGCS-17

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PCC-553-COM - Natural Language Processing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Provide knowledge of Natural Language Processing Phases
2. Explain Tokenization, Part-of-Speech Tagging, Bag of Words (BOW), N-Grams Models
3. Describe Deep Learning Techniques for NLP
4. Use of Transformer Model in NLP

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

- CO1: Familiarize with the fundamentals of natural language processing.
- CO2: Perform text preprocessing for natural language processing.
- CO3: Apply backpropagation algorithm of artificial neural network.
- CO4: Distinguish the parts of transformer.
- CO5: Choose and propose an appropriate model in real life problem.

Course Contents

Unit I- Fundamentals of Natural Language Processing-(12 Hours)

Definition of Natural Language Processing, Phases of Natural Language Processing. Natural Language Understanding stages, syntactic analysis, semantic analysis, and discourse analysis. Natural Language Generation, content planning, sentence planning, and sentence realization. Differences between NLP, NLG, and NLU. Advanced Applications of NLP.

Unit II- Data Preprocessing for Natural Language Processing-(12 Hours)

Tokenization, Word Tokenization, Rule-based Tokenization, Dictionary-Based Tokenization, Stop Word Removal, Lemmatization and Stemming, Part-of-Speech Tagging, Bag of Words (BOW), N-Grams, Term Frequency-Inverse Document Frequency (TF-IDF), N-Gram Language Modeling, Word embedding techniques, word2vec embedding, One-Hot Encoding, Pre-Trained Embedding, Document Embedding.

Unit III- Deep Learning Techniques for Natural Language Processing -(12 Hours)

Artificial Neural Networks (ANNs) Backpropagation Algorithm, Recurrent Neural Networks (RNNs), Backpropagation through Time (BPTT), Long Short-Term Memory (LSTM), Gated Recurrent Unit (GRU)

Unit IV- Transformers- (12 Hours)

Encoders and Decoders, teacher forcing mechanism, Seq2Seq Models, Attention mechanism, Bahdanau and Luong mechanism, Introduction to Self-attention mechanism, Architecture of Transformer Model, encoder and decoder in transformer in detail, concept of cross attention, Positional embedding.

Unit V- Pre-Trained Language Models for natural language processing - (12 Hours)

Introduction to Language models, Chat Models, Embedding models, GPT (Generative Pre-Trained Transformer), Transformers XL, T5 (Text-to-Text Transfer Transformer), RoBERTa.
Application of models in Natural Language Processing.

Learning Resources

Text Books

1. Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit by Steven Bird, Ewan Klein, Edward Loper.

Reference Books:

1. Foundations of Statistical Natural Language Processing, Authors: Christopher D. Manning and Hinrich Schütze.
2. NLP at Work - The Difference that Makes the Difference By Sue Knight

SWAYAM / MOOC / YouTube Links

1. https://www.youtube.com/watch?v=CMrHM8a3hqw
2. https://www.youtube.com/playlist?list=PLKnIA16_RmvZo7fp5kkIth6nRTeQQsjfX
3. https://www.youtube.com/watch?v=zlUpTlaxAKI

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

Course Objectives: The course aims to:

1. Provide knowledge related to quantum algorithms to aware 1-qubit / 2-qubit gate operators and ability to design simple quantum circuits.
2. Explain various types of cyber-attacks and cyber-crimes, threats and risks within context of the cyber security.
3. Explain Tokenization, Part-of-Speech Tagging, Bag of Words (BOW), N-Grams Models in NLP

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

- CO1. Analyze quantum algorithms considering 1-qubit / 2-qubit gate operators and ability to design quantum circuits.
- CO2. Demonstrate various types of cyber-attacks and cyber-crimes, threats and risks within the context of application.
- CO3. Use of Tokenization, Part-of-Speech Tagging, Bag of Words (BOW), N-Grams Models in NLP

Guidelines:

- Computational Laboratory - II assignments are based on 3 Programme Core courses (Quantum Computing, Cyber Security, Natural Language Processing)
- 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 Departments before conduction of laboratory.

List of Assignments

Part A: Quantum Computing	
1	Write down the state vector (matrix representation) of two qubits, i.e. the tensor product, in the computational basis. Write down the basis vectors of the composite system

2	Write down the unitary matrix representations of the CNOT in the computational basis with qubit 1 being the control qubit. Write down the matrix in the same basis with qubit 2 being the control bit
3	How to transfer an unknown quantum state only using one entangled pair of qubits and classical information as a resource.
Part B: Cyber Security	
1	Identify assets, vulnerabilities, and threats and calculate risk levels using a formula or Python script and create a mitigation strategy report.
2	Analyze provided web applications and Identify vulnerabilities such as SQL injection or XSS and Propose mitigation strategies
3	Simulate a DDoS attack in a controlled environment, Configure mitigation tools and Document findings mitigation strategies
4	Collect logs from different sources, Parse logs using regex and Python and Analyze for anomalies.
Part C: Natural Language Processing	
1	Choose a typical masculine noun, ending in 'A', from your language. Write down its various forms along with various features and their values associated with them.
2	Refer to the following data and answer the question below:
	List 1: taller, shorter, higher, lower, smarter
	List 2: mower, teacher, sailor, caller, operator
	List 3: never, cover, finger, river Are the words ending with 'er'/'or' have some common features?
3	Calculate the probability of occurrence of each word given below. Which of these represent the correct spelling? (a) qotient (b) quotient (c) quotient

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
PEC-561A-COM - Cloud and Edge Technology		
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 concepts of Cloud and Edge Computing.
2. To build Cloud based Applications.
3. To analyze the performance of Cloud and Edge based Systems.

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

- CO1: Approach designing of parallel computation based better.
- CO2: Implement the solutions for various applications
- CO3 : Learn and use Open Source and Commercial Clouds
- CO3: Design and implement distributed applications using cloud and edge platforms
- CO4: Apply security, privacy, and compliance mechanisms for cloud and edge computing scenarios.

Course Contents

Unit I - Introduction to Cloud Computing- (08 Hours)

Introduction to Cloud Computing, Recent Trends in Computing Cloud Computing, Evolution of cloud computing.

Unit II - Cloud Computing Architecture- (08 Hours)

Cloud Computing Architecture, Service Management in Cloud Computing Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service(SaaS), Data Management in Cloud Computing, Resource Management in Cloud Computing, Cloud Implementation.

Unit III - Open Source and Commercial Clouds - (08 Hours)

Open Source and Commercial Clouds, Cloud Simulator, Research trend in Cloud Computing, Fog Computing, VM Resource Allocation, Management and Monitoring, Introduction to Edge Computing, the Cloud Computing analytics pipeline, Coordination of Cloud Services.

Unit IV - Serverless Computing- (08 Hours)

Serverless Computing and FaaS Model, Cloud-Fog-Edge enabled Analytics, Cloud Security, Case Studies and Recent Advancements

Unit V -IoT Clouds and Data Analytics and Applications - (08 Hours)

Edge Computing, edge network, Edge computing architectures, Edge Computing: Design Issues, Lightweight Container Middleware for Edge Cloud Architectures, Case Study: open source platforms like Apache Edgent.

Learning Resources

Text Books

1. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley,2011.
2. Enterprise Cloud Computing - Technology, Architecture, Applications, GautamShroff, Cambridge University Press, 2010.
3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India, 2010.
4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley- India, 2010.
5. Cloud Computing: Principles, Systems and Applications, Editors: Nikos Antonopoulos, Lee Gillam, Springer, 2012.

Reference Books:

1. Javid Taheri, Shuiguang Deng, “Edge Computing: Models, technologies and applications”, IET, 2020
2. Khaldoun Al Agha, Pauline Loygue, Guy Pujolle, “ Edge Networking”,Wiley-ISTE,2022.

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

Prerequisite Course : Artificial Intelligence

Course Objectives: The course aims to:

1. To understand the fundamentals of Generative AI models and their applications.
2. To explore various architectures like GANs, VAEs, and Transformers.
3. To apply Generative AI techniques for text, image, and audio generation.
4. To examine real-world applications and emerging trends in Generative AI

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

- CO1: Explain the evolution, types, and ethical considerations of Generative AI models.
- CO2: Analyse the architecture and working principles of Transformers, Large Language Models (LLMs), and multimodal generative models.
- CO3: Implement AI-based text, image, and audio generation techniques using state-of-the-art models.
- CO4: Utilize industry-standard frameworks (Hugging Face, OpenAI APIs, TensorFlow/Keras) to build and fine-tune generative AI models.
- CO5: Evaluate real-world applications, challenges, and emerging trends in Generative AI across different domains.

Course Contents

Unit I - Introduction to Generative AI - (08 Hours)

Introduction to AI-driven content generation, Evolution of generative models: From rule based AI to deep generative models, Types of Generative Models: Autoregressive models, Variational Autoencoders (VAEs), Generative Adversarial Networks (GANs), Diffusion Models, Ethical Considerations in Generative AI: Bias, misinformation, deepfakes, copyright issues.

Unit II - Foundation Models & Architectures- (08 Hours)

Transformers and Self-Attention Mechanism, Large Language Models (LLMs): GPT, BERT, T5, LLaMA, Pre-training vs. Fine-tuning approaches, Multimodal Generative AI: DALL·E, CLIP, Stable Diffusion

Unit III - Generative AI for Text, Image & Audio Generation- (08 Hours)

Text Generation: Autoregressive models, ChatGPT, summarization, creative writing, Image Generation: StyleGAN, Stable Diffusion, DeepDream, AI Art, Audio Generation: Text to-Speech (TTS),

AI Music Composition, Speech Synthesis, Evaluation Metrics: Perplexity, BLEU, FID score, Inception Score

Unit IV -Tools, Frameworks, and Applications - (08 Hours)

Generative AI in Software Development: GitHub Copilot, Code Llama, Frameworks & Libraries: Hugging Face, OpenAI APIs, TensorFlow/Keras for Generative AI, Fine-tuning & Custom Model Development, AI for Content Creation: Deepfake detection, AI-generated movies, virtual influencers

Unit V - Industry Use Cases & Future Trends - (08 Hours)

Generative AI in Healthcare, Finance, and Creative Industries, Synthetic Data Generation & AI for Simulations, Regulations & AI Governance: Transparency, accountability, and ethical AI, Future Trends in Generative AI: Explainable AI, Federated Learning, Edge AI.

Learning Resources

Text Books

1. Generative Deep Learning: Teaching Machines to Paint, Write, Compose, and Play – David Foster, O'Reilly Media, 2nd Edition, 2023.
2. Hands-On Generative AI with Transformers – Utkarsh Sinha, Packt Publishing, 2023.

Reference Books:

1. Deep Learning for Natural Language Processing – Palash Goyal, Sumit Pandey, Karan Jain, Apress, 2018.
2. GANs in Action: Deep Learning with Generative Adversarial Networks – Jakub Langr, Vladimir Bok, Manning Publications, 2019.
3. Building Machine Learning Powered Applications – Emmanuel Ameisen, O'Reilly Media, 2020.
4. Transformers for Natural Language Processing – Denis Rothman, Packt Publishing, 2022.

SWAYAM / MOOC / YouTube Links

1. onlinecourses.swayam2.ac.in/nou25_ma05/preview - Generative AI for Everyday Life
2. onlinecourses.swayam2.ac.in/imb25_mg46/preview - Generative AI and Large Language Models
3. www.coursera.org/learn/prompt-engineering?utm_source=chatgpt.com - Prompt Engineering for ChatGPT
4. www.youtube.com/watch?v=-v9PiM6cqLM - Generative AI Full Course 2025

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PEC-561C-COM : Game Theory and Applications		
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 game concept and visualization
2. To study user interface and various elements of game.
3. To understand game design process and & apply to develop game applications.
4. To be able to design 2D and 3D Models using tools.
5. To study AI principles to problem solving, knowledge representation, learning.

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

- CO1. Understand game logic and visualization
- CO2. Understand user interface and various elements of game.
- CO3. Understand the game design process and decision making
- CO4. Students will be able to design various face 2D and 3D game characters.
- CO5. Apply the principles of AI to problem solving, knowledge representation, learning.

Course Contents

Unit I- Fundamentals of Game Theory-(08 Hours)

Introduction to Game, Game History, Game Architecture, Game Logic, Game View for the Human Player, Game Views for AI Agents, game idea visualization and storytelling, and game documentation. Game Programming, Software Tools, Building the Game, creating a Project, Creating Build Scripts, Introduction to Unity, prototyping using Unity, Photoshop and flash.

Case study: Write a game architecture for target shooting game

Unit II- Game UI Design Elements-(08 Hours)

Introduction to User Interface, Web and Graphic User Interfaces, Visual Design Basics, Usability, Visual and Interactive elements, buttons, icons, spacing, sliders and scrollbars, typography, color schemes, text style, shapes and layers to create screens, fundamental principles of visual design, pixel precision to UI elements.

Case study: Design the UI for “candy catch game "and represent essential components

Unit III- Game Design Process-(08 Hours)

Pre-Production, Production, Post-Production, MDA Framework, Planning and Iteration: Under planning and Over planning, Iteration, Knowledge Creation: Knowledge Creation Methods, Rumination, Research, artistic methods, Brainstorming, written analysis, Debate, testing,metrics, invented methods, Organic Process, Dependencies:Dependency Stack, Cascading uncertainty, Design Backlog, Authority, Motivation:Extrinsic Rewards, meaningful work, expectations-Driven motivation, Complex Decisions: Decision Effects, Decision Effects Case Study, Values: Openness, Candor, Humility, Hunger.

Unit IV-2D & 3D Modeling for Game -(08 Hours)

Definition of Computer-based Animation, Basic Types of Animation: Real Time, Non-real-time, Definition of Modelling. Understanding 2D Splines & shape using unity, Extrude & Bevel 2D object to 3D using Unity SNAPS, Understanding Loft & terrain, Creation of 3D objects. Modelling with Polygons, using Unity. Creating and Destroying Game Objects , the scene view, building simple and complex games in 2D and 3D using Unity.

Case study: Design 2D and 3D face models.

Unit V- Game Applications -(08 Hours)

Introduction to AI, Model of Game AI, Movement, Decision Making, Strategy, Infrastructure, Game AI, The Pathfinding Graphs, Weighted Graphs, Directed Weighted Graphs, Dijkstra Algorithm, Data Structures and Interfaces, Performance of Dijkstra, Decision Making, Decision Tree, Knowledge Representation, Implementation of Nodes, Performance of Decision Trees, Balancing the Tree, Random Decision Trees.

Case study: AI in Video Games.

Learning Resources

Text Books

1. Florian Bartholomae, Marcus Wiens, “Game Theory and Applications: A Guide for Students and Researchers”, 1st edition, 2024
2. Dario Calonaci, Designing User Interfaces: Exploring User Interfaces, UI Elements, Design Prototypes and the Figma UI Design Tool, BPB Publisher, ISBN-13- 978-9389898743, 2021.

Reference Books:

1. Michael E. Mortenson , 3D Modeling, Animation, and Rendering: An Illustrated Lexicon, Color Edition, Create Space Independent Publishing Platform Publisher, ISBN:1453728481, 2010
2. Tatsuro Ichiishi, Abraham Neyman and Yair Tauman, “Game Theory and Applications “, Elsevier.

SWAYAM / MOOC / YouTube Links

1. Mike MrMike McShaffry , David Rez Graham, “Game Coding Complete”, Fourth Edition, Course Technology, a part of Cengage Learning Publisher, ISBN-13: 978-1-133-77657-4. https://ms.z-library.sk/book/2072433/3f7bf2/game-coding-complete-fourth-edition.html
2. Gabe Zechermann, Christopher Cunningham, Gamification by Design, Oreilly, ISBN: 978-1-449-39767-8, 2011. http://storage.libre.life/Gamification_by_Design.pdf

3. Jun Tanimoto, Fundamentals of Game Theory and its Applications, Volume 6, Springer, ISBN: 978-4-431-54961-1, 2015. https://link.springer.com/book/10.1007/978-4-431-54962-8

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PEC-561D-COM: 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.
- CO4: Formulate real-life projects using algorithms studied
- CO5 : Analyze the strengths and limitations of various bio-inspired algorithms for solving optimization and search problems

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 - Computer Engineering (2025 Course)		
PEC-562A-COM - 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/repri federated-and-transfer-learning-applications

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PEC-562B-COM: 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.

SWAYAM / MOOC / YouTube Links

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
PEC-562C-COM: 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 explore methods for collecting, processing, and analyzing textual and multimedia social data.
2. To study the use of machine learning and NLP techniques in sentiment and opinion mining.
3. To analyze user interactions and social networks using graph theory concepts.
4. 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 Engineering		
PEC-562D-COM - 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-COM - 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 Engineering

Semester III

Savitribai Phule Pune University Master of Engineering (2025 Course) - Computer Engineering		
RM-601-COM - 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-COM - 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-COM - Technical Seminar - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:50 Marks** **Practical: 50 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-COM - 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 Engineering

Semester IV

Savitribai Phule Pune University Master of Engineering - Computer Engineering (2025 Course)		
SEM-651-COM - 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.
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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-COM - 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

Dr. Balwant A. Sonkamble - Member, Board of Studies - Computer Engineering

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