Savitribai Phule Pune University, Pune

Maharashtra, India

Faculty of Science and Technology

Curriculum Structure and Syllabus

Master of Engineering (2025 Pattern) in

M. E. - Artificial Intelligence (AI)

(With effect from Academic Year 2025-26)

www.unipune.ac.in

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Nomenclature

CCE	Comprehensive Continuous Evaluation
ESE	End Semester Examination
L	Lecture
OR	Oral
P	Practical
PCC	Programme Core Course
PEC	Programme Elective Course
PO	Programme Outcomes
PSO	Program Specific Outcomes
TW	Term Work

Preface by Board of Studies - Computer Engineering

Dear Teachers and Students,

On behalf of the Board of Studies in Computer Engineering, we are delighted to introduce the revised syllabus for the Master of Engineering (Artificial Intelligence) program, effective from the academic year 2025–26. This comprehensive curriculum has been meticulously designed to provide students with a cutting-edge education that balances theoretical foundations with practical applications in this rapidly advancing field. As AI continues to transform industries and reshape technological landscapes worldwide, our program aims to equip students with the specialized knowledge and skills needed to become innovators and leaders in this dynamic domain. The syllabus integrates core AI principles with advanced topics such as Machine Learning, Deep Learning, Natural Language Processing, Computer Vision, and Robotics, while also emphasizing critical aspects of ethical AI development, including bias mitigation and societal impact.

We extend our sincere gratitude to our faculty members, industry experts, researchers, and students whose valuable feedback and collaboration have been instrumental in shaping this forward-looking syllabus. Their collective insights have ensured that the program remains at the forefront of AI education, addressing both current industry demands and future technological trends. We are confident that this revised syllabus will provide a stimulating and challenging academic journey, empowering our students to push the boundaries of AI research and applications while maintaining the highest ethical standards. As you embark on this exciting educational path, we encourage you to fully engage with the diverse learning opportunities this program offers and to contribute meaningfully to the ever-evolving field of artificial intelligence.

Dr. Nilesh Uke
Chairman
Board of Studies - Computer Engineering.

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Programme Educational Objectives

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

PEO	PEO Focus	PEO Statements
PEO1	Technical Expertise	To equip post graduates with advanced competencies in artificial intelligence, machine learning, and intelligent systems, enabling them to develop innovative solutions for complex challenges across interdisciplinary domains including healthcare, finance, cybersecurity, and sustainable technologies.
PEO2	Ethical & Societal Impact	To prepare postgraduates to address ethical considerations, societal needs, and environmental impacts while designing AI systems, ensuring responsible development and deployment of technologies that benefit diverse communities.
PEO3	Research & Innovation	To nurture postgraduates with strong research capabilities, fostering continuous learning and interdisciplinary collaboration to drive advancements in AI applications and contribute to academia, industry, and entrepreneurial initiatives.
PEO4	Leadership & Collaboration	To develop postgraduates who can effectively lead AI projects, communicate technical concepts to varied stakeholders, and work collaboratively in multidisciplinary teams to achieve organizational and societal goals.

Master of Engineering - Artificial Intelligence (2025 Course)

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 **Artificial Intelligence**) should be able to demonstrate at the time of their graduation.

PSO1	**Foundational AI Knowledge and Application-** Analyze and apply fundamental principles of Artificial Intelligence and Machine Learning to identify, formulate, and solve complex engineering problems. This includes a deep understanding of concepts such as search algorithms, knowledge representation, and machine learning models.
PSO2	**Advanced AI System Design and Development -** Design, develop, and evaluate advanced AI systems and solutions for various domains, utilizing modern tools and techniques. This involves proficiency in areas like Deep Learning, Natural Language Processing (NLP), and Computer Vision.
PSO3	**Research and Innovation -** Demonstrate research aptitude by identifying real-world problems, proposing innovative solutions, and conducting independent research in the field of Artificial Intelligence.

Curriculum Structure

First Year M. E. - Artificial Intelligence (2025 Pattern)

Semester I

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
PCC-501-AI	Programme Core Course	Mathematical Foundations	4	-	50	50	-	-	-	100	4	-	4
PCC-502-AI	Programme Core Course	Machine Learning	4	-	50	50	-	-	-	100	4	-	4
PCC-503-AI	Programme Core Course	AI Systems Engineering	4	-	50	50	-	-	-	100	4	-	4
PCC-504-AI	Programme Core Course	Optimization Techniques	4	-	50	50	-	-	-	100	4	-	4
PCC-505-AI	Programme Core Course	Computational Laboratory - I	-	4	-	-	25	-	25	50	-	2	2
PEC-521-AI	Programme Elective Course	Elective-I	3	-	50	50	-	-	-	100	3	-	3
PEC-522-AI	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	
MEC-521A-AI	Speech Processing
MEC-521B-AI	Natural Language Processing
MEC-521C-AI	Blockchain Technology
MEC-521D-AI	Computer Vision

Master of Engineering (2025 Pattern) – Artificial Intelligence

Semester II

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
PCC-551-AI	Programme Core Course	Deep Learning	4	-	50	50	-	-	-	100	4	-	4
PCC-552-AI	Programme Core Course	Generative AI	4	-	50	50	-	-	-	100	4	-	4
PCC-553-AI	Programme Core Course	IoT and Smart Systems	4	-	50	50	-	-	-	100	4	-	4
PCC-554-AI	Programme Core Course	Computational Laboratory - II	-	4	-	-	25	-	25	50	-	2	2
PEC-561-AI	Programme Elective Course	Elective - II	3	-	50	50	-	-	-	100	3	-	3
PEC-562-AI	Programme Elective Course	Elective - III	3	-	50	50	-	-	-	100	3	-	3
SEM-571-AI	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-AI	AI for Game development	PEC-562A-AI	Robotics and Automation
PEC-561B-AI	AI for Social Impact	PEC-562B-AI	Reinforcement Learning
PEC-561C-AI	AI for Healthcare	PEC-562C-AI	Quantum Computing
PEC-561D-AI	AI for Cyber security	PEC-562D-AI	High Performance AI systems

Master of Engineering (2025 Pattern) – Artificial Intelligence

Semester III

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
RM-631-AI	RM	Research Methodology	4	-	50	50	-	-	-	100	4	-	4
OJT-641-AI	OJT/ Internship	On Job Training/ Internship	-	10	-	-	100	-	-	100	-	5	5
SEM-632-AI	Seminar	Technical Seminar II	-	8	-	-	25	-	25	50	-	4	4
RPR-642-AI	Research Project	Research Project Stage - I	-	18	-	-	25	-	25	50	-	9	9
Total			**4**	**36**	**50**	**50**	**150**	**-**	**50**	**300**	**4**	**18**	**22**

Semester IV

Course Code	Course Type	Course Name	Teaching Scheme (Hours/ Week)		Examination Scheme and Marks						Credits		
			L	P	CCE	ESE	TW	PR	OR	Total	L	P	Total
SEM-671-AI	Seminar	Technical Seminar III	-	8	-	-	50	-	50	100	-	4	4
RPR-681-AI	Research Project	Research Project - Stage II	-	36	-	-	150	-	50	200	-	18	18
Total				**44**	**-**	**-**	**200**	**-**	**100**	**300**	**-**	**22**	**22**

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M. E. - Artificial Intelligence (2025 Pattern)

Semester I

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-501-AI - Mathematical Foundations		
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 build a strong mathematical foundation essential for understanding and designing AI and Machine learning algorithms.
2. To apply key concepts from linear algebra, probability, statistics, calculus, and graph theory in AI contexts.
3. To explore optimization techniques critical to model training and performance improvement.
4. To develop the ability to analyze, model, and interpret data-driven AI systems using mathematical reasoning.

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

- CO1: Develop mathematical rigor for cutting-edge technologies.
- CO2: Utilize mathematics as a tool to interpret the outcomes of the black box techniques.
- CO3: Develop optimization techniques for learning algorithms.
- CO4: Apply statistical techniques to model the data.

Course Contents

Unit I - Linear Algebra - (12 Hours)

Introduction to scalars, vectors, matrices, and tensors, Matrix operations: addition, multiplication, transposition, Properties of matrices: rank, inverse, determinant, Systems of linear equations and their solutions, Eigenvalues and Eigenvectors: significance in PCA and dimensionality reduction, Singular Value Decomposition (SVD) and its applications in recommender systems

Unit II Calculus and Optimization (12 Hours)

Gradient vector and its interpretation, Directional derivatives, Tangent planes and linear approximation, Critical points and saddle points, Second derivative test (Hessian), Constrained optimization using Lagrange multipliers

Unit III Probability (12 Hours)

Probability mass, density, and cumulative distribution functions, Parametric families of distributions, Expected value, variance, conditional expectation, Applications of the univariate and multivariate, Central Limit Theorem, Probabilistic inequalities, Bayes Theorem, Markov chains

Unit IV Statistics (12 Hours)

Descriptive Statistics: Mean, Median, Mode, Range, Variance, Standard Deviation, Skewness, Kurtosis, Data Visualization: Histograms, Bar plots, Pie charts, 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.

Unit V Discrete Mathematics and Graph Theory (12 Hours)

Mathematics: Sets, Relations, functions, Probability Theory: P and C, GraphTheory: Isomorphism, Planar graphs, graph coloring, Hamilton circuits and Euler cycles. Permutations and Combinations with and without repetition. Specialized techniques to solve combinatorial enumeration problems.

Learning Resources

Text Books:

1. M. P. Deisenroth, A. A. Faisal, and C. S. Ong, Mathematics for Machine Learning. Cambridge, U.K.: Cambridge University Press, 2020.
2. E. Kreyszig, K. Stroud, and G. Stephenson, Advanced engineering mathematics, Integration, vol. 9, no. 4, p. 1014, 2008.
3. W. L. Briggs, L. Cochran, B. Gillett, and E. Schulz, Multivariable Calculus, 3rd ed. Boston, MA: Pearson Education, 2018.
4. S. Boyd and L. Vandenberghe, Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares. Cambridge, U.K.: Cambridge University Press, 2018.

Reference Books:

1. C. M. Bishop, Pattern Recognition and Machine Learning. New York, NY: Springer, 2006.
2. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA: MIT Press, 2016.
3. G. James and P. Dyke, Advanced Modern Engineering Mathematics, 5th ed. Harlow, U.K.: Pearson Education Limited, 2018.
4. S. Ross, A First Course in Probability, 9th ed. Boston, MA: Pearson, 2012.

NPTEL/MOOC/Youtube Links:

1. Foundational Mathematics for AI, Coursera. [Online]. Available: https://www.coursera.org/learn/fou mathematics-for-ai.
2. Study Materials | Linear Algebra | Mathematics, MIT OpenCourseWare. [Online]. Available: https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/pages/study-materials/.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-502-AI - Machine Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Students should have prior knowledge of

- Fundamentals of Programming Languages
- Design and Analysis of Algorithms

Course Objectives: The course aims to:

1. To understand the foundational concepts, types, and goals of Machine learning, including model evaluation and generalization strategies.
2. To explore various Supervised and Unsupervised learning algorithms and their practical applications.
3. To apply feature selection, model selection, and evaluation techniques to assess algorithm performance.
4. To analyze Ensemble learning methods and optimization techniques for improving predictive models.
5. To examine evolutionary algorithms and the fundamentals of Neural Networks, including Perceptron learning and Computational learning theory

Course Outcomes: After successful completion of the course, Students will be able to:
CO1: Develop critical thinking, and problem-solving ability using Machine learning tools.
CO2: Apply Machine learning to assist in data-driven decision making.
CO3: Develop mathematical background for Machine learning frameworks.
CO4: Optimize the model with Regularization and Hyperparameter tuning

Course Contents

Unit I - Introduction to Machine Learning Concepts - (12 Hours)

Knowledge based systems, Rule based systems, Introduction to Machine Learning: Basic definitions, types of learning, Hypothesis space and inductive bias, Variance, Data pre-processing, handling data imbalance, feature extraction.

Unit II - Supervised Learning Algorithms - (12 Hours)

Linear Regression and Logistic Regression, k-Nearest Neighbors (k-NN), Decision Trees and Random Forests, Support Vector Machines (SVM), Feature selection and extraction techniques, Model selection, Evaluation metrics (Accuracy, Precision, Recall. ROC, AUC), Overfitting, underfitting and generalization, L1 and L2 errors, Regularization: L1 and L2 regularization, Model evaluation: training/test/validation, cross-validation.

Unit III - Unsupervised Learning Algorithms - (12 Hours)

Clustering: k-Means, Hierarchical Clustering, DBSCAN, Dimensionality Reduction: PCA, t-SNE, LDA, Association Rule Mining: Apriori, FP-Growth, Evaluation metrics for clustering (Silhouette Score, Davies–Bouldin index, Adjusted Rand Index.)

Unit IV - Ensemble Methods and Model Optimization (12 Hours)

Bagging, Boosting, and Stacking, AdaBoost, Gradient Boosting, XGBoost, LGBM, CatBoost, Hyperparameter tuning: Grid Search, Random Search, Bayesian Optimization.

Unit V - Foundations and Frontiers in Machine Learning - (12 Hours)

Interpretability and Explainability: Need for explainability in ML, Global vs local interpretability, Tools and techniques: LIME, SHAP, Feature importance, Trade-offs: Accuracy vs Interpretability, AutoML and Meta-Learning, Brief overview of tools: Auto-sklearn, H2O, Google AutoML, Meta-learning concepts (learning to learn).

Learning Resources

Text Books:

1. T. M. Mitchell, Machine Learning, 1st ed. New York, NY, USA: McGraw-Hill, 1997.
2. E. Alpaydin, Introduction to Machine Learning, 4th ed. Cambridge, MA, USA: MIT Press, 2020.
3. M. P. Deisenroth, A. A. Faisal, and C. S. Ong, Mathematics for Machine Learning. Cambridge, U.K.: Cambridge University Press, 2020.

Reference Books:

1. C. M. Bishop, Pattern Recognition and Machine Learning, 1st ed. New York, NY, USA: Springer, 2006.
2. K. P. Murphy, Machine Learning: A Probabilistic Perspective, 1st ed. Cambridge, MA, USA: MIT Press, 2012.
3. A. Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2019.
4. T. M. Mitchell, Machine Learning. New York, NY, USA: McGraw-Hill, 1997.
5. P. Kulkarni, Reinforcement and Systemic Machine Learning for Decision Making. Hoboken, NJ, USA: Wiley-IEEE Press, 2012.

SWAYAM / MOOC / YouTube Links

1. IBM, "IBM Machine Learning Professional Certificate," Coursera. [Online]. Available: https://www.cou certificates/ibm-machine-learning.
2. S. Sarkar, "Introduction to Machine Learning," NPTEL, IIT Kharagpur. [Online]. Available: https://onlinecourses.nptel.ac.in/noc21_cs85/preview.
3. A. Ng, "Machine Learning Specialization," Stanford Online. [Online]. Available: https://online.stanfor ymls-machine-learning-specialization.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-503-AI - AI Systems Engineering		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses, if any: Students should have prior knowledge of
Fundamentals of Programming Languages
Familiarity with version control

Course Objectives: The course aims to:

1. To understand end-to-end AI system design, from prototyping to deployment.
2. To learn and apply MLOps practices (CI/CD, monitoring, scaling) for AI systems.
3. To integrate Software engineering principles to build robust, scalable AI solutions.
4. To examine ethical, legal, and security challenges in AI deployment.

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

- CO1: Design AI systems with modular, Scalable architectures.
- CO2: Implement ML pipelines (data ingestion, preprocessing, training, serving).
- CO3: Deploy models using Docker, Kubernetes, and Serverless platforms.
- CO4: Apply MLOps tools (MLflow, Kubeflow, TFX) for lifecycle management.
- CO5: Address bias, fairness, and regulatory compliance (GDPR, AI ethics)

Course Contents

Unit I - Foundations of AI Systems Engineering- (12 Hours)

Role of systems engineering in AI, AI research vs. AI engineering, Lifecycle of AI applications: from ideation to deployment, Key components of AI systems: data, models, infrastructure, business logic, System design principles: modularity, reliability, observability, Introduction to cloud-based environments (AWS, Azure, GCP)

Unit II - DevOps for Software- (12 Hours)

DevOps Fundamental: Version control, CI/CD in software, Environment management and reproducibility, Containerization, Testing and deployment.

Unit III -MLOps Principles and Pipelines - (12 Hours)

MLOps, vs DevOps, MLOps lifecycle: Experiment tracking, reproducibility, drift detection, Tools: MLflow, Weights & Biases, DVC, Kubeflow, SageMaker, Deployment strategies: batch, online, streaming inference, Data pipelines: ingestion, preprocessing, scheduling (Airflow, Prefect).

Unit IV - AI Model Serving, Monitoring & Scaling - (12 Hours)

Model serving frameworks: TensorFlow Serving, TorchServe, Triton Inference Server, Load balancing, autoscaling, and A/B testing, Latency vs throughput: optimization techniques, Monitoring tools: Prometheus, Grafana, Open Telemetry, Logging, alerts, and rollback mechanisms

Unit V -Ethics, Security, and Reliability in AI Systems - (12 Hours)

Model explainability (SHAP, LIME), Bias and fairness in deployed systems, Adversarial attacks & securing model APIs, Data privacy, anonymization, and compliance (GDPR, HIPAA), Fault-tolerant design and recovery strategies

Learning Resources

Text Books

1. C. Huyen, Designing Machine Learning Systems. Sebastopol, CA, USA: O'Reilly Media, Inc., 2022.
2. A. Burkov, Machine Learning Engineering, vol. 1. Montreal, QC, Canada: True Positive Incorporated, 2020.

Reference Books:

1. M. Treveil and The Dataiku Team, MLOps: Continuous Delivery and Automation Pipelines in Machine Learning. Sebastopol, CA, USA: O'Reilly Media, 2020.
2. V. Lakshmanan, Data Science on the Google Cloud Platform: Implementing End-to-End Real-Time Data Pipelines: From Ingest to Machine Learning, 2nd ed. Sebastopol, CA, USA: O'Reilly Media, 2022.
3. T. Grant, H. Karau, B. Lublinsky, R. Liu, and I. Filonenko, Kubeflow for Machine Learning: From Lab to Production. Sebastopol, CA, USA: O'Reilly Media, 2020.
4. D. Sculley, G. Holt, D. Golovin, E. Davydov, T. Phillips, D. Ebner, V. Chaudhary, M. Young, J. Crespo, and D. Dennison, "Hidden Technical Debt in Machine Learning Systems," in Advances in Neural Information Processing Systems, vol. 28, 2015, pp. 2503–2511.

SWAYAM / MOOC / YouTube Links

1. Machine Learning Operations (MLOps) | https://www.coursera.org/learn/mlops-fundamentals

Savitribai Phule Pune University Master of Engineering - Data Science (2025 Pattern)		
PCC-504-AI - Optimization Techniques		
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. Develop concepts of optimization algorithms and iterative process leading to the solution.
2. Understand the optimization algorithms often used in data science.
3. Learn fundamentals and mathematics behind gradient based methods and to speed up the computation.
4. Develop idea of novel gradient free optimizers often used in AI/ML and data science.

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

- CO1: Differentiate between convex and non-convex functions
- CO2: Apply the gradient based methods for training neural network.
- CO3: Utilize advanced gradient based methods to perform faster computation.
- CO4: Ability to perform complex constrained optimization efficiently.

Course Contents

Unit I - BASICS OF OPTIMIZATION - (12 Hours)

Optimization Techniques, Optimal Problem Formulation, Convex Functions, First and Second Order Conditions for Optimizations, Convex and Non-Convex Optimization problems in Data Science.

Unit II - GRADIENT DESCENT TECHNIQUES - (12 Hours)

Mathematical background, Programming basic optimization problems and their solutions, Variants of Gradient Descent: Projected, Stochastic, Proximal, Accelerated, Coordinate Descent, Training a Neural Network.

Unit III - ADVANCED GRADIENT BASED METHODS - (12 Hours)

Advanced Gradient Descent: Projected, Stochastic, Proximal, Accelerated, Coordinate Descent, Training a Neural Network: Theory and Implementation, Newtons Method.

Unit IV - CONSTRAINED OPTIMIZATION - (12 Hours)

Kuhn-Tucker Conditions, Lagrangian Duality Theory, Penalty Function Method, Method of Multipliers, Random Search, Quadratic Programming

Unit V - GRADIENT FREE OPTIMIZATION TECHNIQUES - (12 Hours)

Genetic Algorithms: Operations, GA Operators, Real Coded-GA, Multi-objective GA, Particle Swarm Optimization, Evolutionary Strategy, Covariance Matrix Adaptation Methods, Differential Evolution Technique, Bayesian Optimization.

Learning Resources

Text Books

1. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, Cambridge, MA, USA: MIT Press, 2016.
2. K. Deb, Optimization for Engineering Design: Algorithms and Examples, 2nd ed., New Delhi, India: Prentice-Hall of India, 2012.
3. D. Roy and G. V. Rao, Stochastic Dynamics, Filtering and Optimization, Cambridge, U.K.: Cambridge University Press, 2017.
4. S. Sra, S. Nowozin, and S. J. Wright, Optimization for Machine Learning, Cambridge, MA, USA: MIT Press, 2012.

Reference Books:

1. R. K. Arora, Optimization: Algorithms and Applications, Boca Raton, FL, USA: CRC Press, 2015.
2. S. Bhandari, K. Sahay, and R. Singh, "Optimization Techniques in Modern Times and Their Applications," in Proc. IEEE Int. Conf. on Electrical, Electronics, Computers, Communication, Mechanical and Computing (IEECON), 2018, pp. 1–4, d
3. S. Sun, Z. Cao, H. Zhu, and J. Zhao, "A Survey of Optimization Methods From a Machine Learning Perspective," IEEE Trans. Cybern., vol. 50, no. 8, pp. 3668–3681, Aug. 2020,
4. H. A. Taha, Operations Research: An Introduction, 6th ed., New Delhi, India: Prentice-Hall of India, 1997.
5. R. W. Ott, Environmental Statistics and Data Analysis, Cambridge, U.K.: Cambridge University Press, 2020.

E-books:

1. "J. Xie, Optimization for Data Science, Lecture Notes, FS 23 [Online]. Available: https://n.ethz.ch/~jia
2. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, Cambridge, MA, USA: MIT Press, 2016. [Online]. Available: https://www.deeplearningbook.org/

SWAYAM / MOOC / YouTube Links

1. https://onlinecourses.nptel.ac.in/noc23_cs64/preview

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

Computational Laboratory I is companion course of theory core courses in Semester I. It is recommended that set of assignments or at least one mini-project/study project per course is to be completed. Set of problem statements are suggested. Course/ Laboratory instructors may frame suitable problem statements.

Student has to submit a report/Journal consisting of appropriate documents - Prologue, Certificate, Table of Contents, and other suitable write-up like (Introduction, Motivation, Aim and Objectives, Outcomes, Brief Theory, Requirements Analysis, Design Aspects, Algorithms, Mathematical Model, Complexity Analysis, Results, Analysis and Conclusions). Soft copy of report/journal and code is to be maintained by department/institute in digital repository.

Suitable platform/framework/language is to be used for completing mini- project/assignments.

Guidelines for Term Work Assessment

Continuous assessment of laboratory work is done based on performance of student. Each assignment/ mini-project assessment is to be done based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as mini-project assessment include- timely completion, performance, innovation, efficient codes, usability, documentation and adhering to SDLC comprehensively.

Guidelines for Practical Examination

It is recommended that practical examination should be conducted based on the understanding and knowledge of the subject as well as on the mini projects completed and the content understanding of laboratory work.

Suggested List of Laboratory Assignments

A. Mathematical Foundations

1. Linear Algebra for AI

- Implement matrix operations (addition, multiplication, transpose) and use them to perform Principal Component Analysis (PCA) on a small dataset.

2. Probability and Bayesian Inference

- Given a dataset of weather conditions and whether an event (e.g., playing tennis) occurred, implement a Naive Bayes classifier and evaluate its accuracy.

3. Eigenvalues and Eigenvectors:

- Compute eigenvalues and eigenvectors of a covariance matrix and explain their significance in feature extraction.

4. Statistics and Data Analysis:

- Calculate descriptive statistics (mean, variance, covariance) and plot a correlation matrix for a given dataset.

5. Convex Optimization:

- Study convex functions and implement the gradient descent to find the minimum of a convex quadratic function.

B. Machine Learning

1. Data Preprocessing, Supervised Learning & Model Evaluation:

A. Preprocessing:Load a real-world dataset (e.g., Titanic, UCI Heart Disease)

- Handle missing values, categorical encoding, and normalization
- Address class imbalance (e.g., SMOTE or class weighting)

B. **Supervised Learning Models:**

- Train Logistic Regression, k-NN, Decision Tree, and SVM
- Apply L1/L2 regularization and interpret results

C. **Model Evaluation:**

- Use accuracy, precision, recall, F1-score, ROC, AUC
- Perform train-test split, k-fold cross-validation
- Analyze overfitting and underfitting

D. **Feature Selection:**

- Apply filter methods (correlation), wrapper (RFE), and embedded (Lasso)

2. **Clustering**

- Apply k-Means, Hierarchical Clustering, and DBSCAN on datasets like Iris or Mall Customer Segmentation
- Evaluate using Silhouette Score, Davies-Bouldin Index, Adjusted Rand Index

3.**Dimensionality Reduction:**

- Apply PCA, t-SNE, and LDA on high-dimensional data (e.g., digit recognition)
- Visualize in 2D and interpret component contributions

4: **Ensemble Learning & Hyperparameter Tuning**

A. **Bagging and Boosting:**

- Implement Random Forest, AdaBoost, Gradient Boosting, and XGBoost

- Compare performance using cross-validation

B. Stacking:

- Build a stacked ensemble using base learners and meta-learner

C. **Hyperparameter Optimization:**

- Perform Grid Search, Random Search, and Bayesian Optimization using scikit-optimize.

C. AI Systems Engineering

1. Implement a CI/CD pipeline for streaming data:

Write a code to implement data generation function. Use Data Lake like S3 to store the generated data. Develop a model (linear regression) and deploy it using AWS (AWS provides 750 hrs of EC2 instances for free, similar stuff exists for GCP and Azure).

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-521A-AI - Speech Processing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :Students should have prior knowledge of

- Fundamentals of Mathematics and programming
- Basics of Machine Learning

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: After successful completion of this course, students will be able to:

- CO1: Analyze the structure of Speech signals using time-domain and frequency-domain techniques.
- CO2: Extract key features such as MFCCs, pitch, and formats for speech recognition and synthesis.
- CO3: Implement Automatic Speech Recognition (ASR) systems using Hidden Markov Models (HMMs)
- CO4: Develop and evaluate text-to-speech (TTS) systems using rule-based and statistical methods.
- CO5: Apply speech technologies in real-world applications such as speaker identification , speech emotion detection, and voice-enabled interfaces.

Course Contents

Unit I - Introduction to Speech Processing - (09 Hours)

Speech production mechanism, Acoustics: vowels and consonants, Digital speech Signal: sampling and quantization, Applications: ASR, TTS, speaker verification

Unit II - Speech Analysis - (09 Hours)

Speech Analysis: Features, Feature Extraction and Pattern Comparison Techniques: Speech distortion measures– mathematical and perceptual– Log Spectral Distance, Cepstral Distances, Weighted Cepstral Distances and Filtering, Likelihood Distortions, Spectral Distortion using a Warped Frequency Scale, LPC, PLP and MFCC Coefficients, Time Alignment and Normalization– Dynamic Time Warping, Multiple Time– Alignment Paths.

Unit III - Speech Modeling - (09 Hours)

Speech Modeling: Hidden Markov Models: Markov Processes, HMMs– Evaluation, Optimal State Sequence– Viterbi Search, Baum-Welch Parameter Re-estimation, Implementation issue

Unit IV - Speech Recognition- (09 Hours)

Speech Recognition: Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system – acoustics and language models – ngrams, context dependent sub-word units; Applications and present status.

Unit V - Speech Synthesis- (09 Hours)

Speech Synthesis: Text-to-Speech Synthesis: Concatenative and waveform synthesis methods, sub-word units for TTS, intelligibility and naturalness – role of prosody, Applications and present status.

Learning Resources

Text Books

1. D. Jurafsky and J. H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition. Upper Saddle River, NJ, USA: Pearson Education.

2. L. Rabiner and B.-H. Juang, Fundamentals of Speech Recognition. Upper Saddle River, NJ, USA: Pearson Education, 2003.

Reference Books:

1. J. Benesty, M. M. Sondhi, and Y. Huang, Springer Handbook of Speech Processing. Berlin, Germany: Springer-Verlag, 2007.

2. T. F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice. Upper Saddle River, NJ, USA: Pearson Education.

3. C. Becchetti and L. Prina Ricotti, Speech Recognition. New York, NY, USA: John Wiley & Sons, 1999.

4. B. Gold and N. Morgan, Speech and Audio Signal Processing: Processing and Perception of Speech and Music, Wiley India Edition, 2006.

5. F. Jelinek, Statistical Methods of Speech Recognition. Cambridge, MA, USA: MIT Press.

SWAYAM / MOOC / YouTube Links

1. Digital speech processing, IIT Kharagpur Prof. Shyamal Kumar Das Mandal nptel.ac.in/courses/117105

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-521B-AI - Natural Language Processing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Fundamental of Programming, Linear algebra and Probability

Course Objectives: The course aims to:

1. To understand the foundational concepts of NLP
2. To apply core NLP techniques
3. To implement and evaluate language models
4. To develop NLP pipelines for real-world applications

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

- CO1: Understand the fundamentals of NLP and levels, of language analysis
- CO2: Apply syntactic parsing and morphological analysis techniques.
- CO3: Analyze statistical approaches and language models used in NLP.
- CO4: Perform semantic analysis using lexical resources and logical forms.
- CO5: Explain the role of machine learning and deep learning in modern NLP applications.

Course Contents

Unit I - Foundations of NLP and Language Analysis - (09 Hours)

Introduction to NLP and NLU: Key concepts, applications, history, and challenges, NLP tasks at syntactic, semantic, and pragmatic levels, Language analysis levels: morphology, syntax, semantics, pragmatics, Representation and understanding of language, Text preprocessing: tokenization, stemming, lemmatization, stopword removal, Evaluation of NLP systems

Unit II - Syntax, Parsing, and Morphological Analysis (09 Hours)

Grammar and sentence structure: CFGs and their limitations, Parsing approaches: top-down, bottom-up, chart parsers, Morphology: Inflectional and Derivational morphology, Morphological processing using Finite State Transducers (FSTs), POS tagging and role in syntactic analysis, Human parsing preferences and ambiguity

Unit III - Feature Structures and Augmented Grammars - (09 Hours)

Feature-based grammars: introduction and need, Feature structures for morphological and syntactic analysis, Definite Clause Grammars (DCG), Augmented Transition Networks (ATN), Unification Grammars and Generalized Feature Systems, Parsing with features and handling agreement constraints

Unit IV - Statistical NLP and Language Modeling - (09 Hours)

Basics of probability theory in NLP, Language modeling: Unigrams, Bigrams, Trigrams, and Smoothing Techniques, Probabilistic Context-Free Grammars (PCFGs), Hidden Markov Models (HMMs) for tagging, Lexical probabilities and estimating ambiguity, Evaluation metrics (Precision, Recall, F1-score, Perplexity)

Unit V - Semantics and Lexical Resources - (09 Hours)

Word senses, ambiguity, and disambiguation, Logical form representations and predicate logic, Case roles, selectional restrictions, and thematic roles, WordNet and its structure, FrameNet, VerbNet, Ontologies and the Semantic Web, Introduction to distributional semantics (word embeddings preview)

Learning Resources

Text Books

1. D. Jurafsky and J. H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 3rd ed. Draft available online: https://web.stanford.edu/~jurafsky/slp3/, 2023.

2. C. D. Manning and H. Schütze, Foundations of Statistical Natural Language Processing. Cambridge, MA, USA: MIT Press, 1999.

Reference Books:

1. J. Allen, Natural Language Understanding, 2nd ed. Boston, MA, USA: Benjamin/Cummings, 1995.

2. S. Bird, E. Klein, and E. Loper, Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit. Sebastopol, CA, USA: O'Reilly Media, 2009.

SWAYAM / MOOC / YouTube Links

1. P. Bhattacharyya, "Natural Language Processing," NPTEL Course, Indian Institute of Technology Bombay, Available: https://nptel.ac.in/courses/106/101/106101007/

2. Natural Language Processing, IIT Kharagpur nptel.ac.in/courses/106105158

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-521C- AI Blockchain Technology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Linear Algebra, Basic Probability and Statistics, Foundations of Machine Learning

Course Objectives: The course aims to:

1. To understand the core concepts, architecture, and functioning of blockchain technology.
2. To explore consensus algorithms and their role in maintaining distributed ledgers.
3. To study smart contracts and decentralized applications (D-Apps).
4. To analyze the integration of blockchain in data systems for trust, transparency, and auditability.
5. To examine recent advancements in data storage, processing, and sharing mechanisms.
6. To gain practical experience using blockchain platforms and next-generation data systems.

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

- CO1: Understand foundational concepts of blockchain architecture and cryptographic tools.
- CO2: Develop and deploy smart contracts using Ethereum/Solidity and Hyperledger.
- CO3: Analyze blockchain-based solutions in real-world domains like healthcare and DeFi.
- CO4: Explore decentralized file systems and blockchain-based data sharing.
- CO5: Integrate blockchain with modern data platforms and architectures.

Course Contents

Unit I - Introduction to Blockchain - (09 Hours)

Basics of Blockchain: Blocks, Hashes, Chains, Transactions, Public vs Private Blockchains, Cryptographic foundations: Hashing, Public-Key Cryptography, Merkle Trees, Blockchain structure and data immutability, Distributed Ledger Technologies (DLT): basics

Unit II - Distributed Ledger Technologies (DLT) - (09 Hours)

Architecture of DLTs: Nodes, Transactions, and Blocks, Popular Platforms: Bitcoin, Ethereum, Hyperledger Fabric, Peer-to-Peer Networks and IPFS, Challenges in Decentralized Data Sharing

Unit III - Smart Contracts and Blockchain Applications - (09 Hours)

Smart Contracts: Design, Deployment, and Testing, Ethereum and Solidity programming, Hyperledger Fabric and chaincode, Use Cases: Voting systems, DeFi, Healthcare, Supply Chain, Token Standards: ERC-20, ERC-721 (NFTs)

Unit IV - Blockchain with Modern Data Architectures - (09 Hours)

Modern Data Architecture: Data Lakehouse, Data Mesh, Delta Lake, Apache Hudi, Apache Iceberg, Real-time streaming systems: Apache Kafka, Apache Pulsar, Object Storage Systems: AWS S3, MinIO, Data Governance and Provenance

Unit V - Blockchain for Data Integrity and Decentralized Storage - (09 Hours)

Blockchain for Data Integrity, Provenance, and Sharing, InterPlanetary File System (IPFS): hands-on and applications, Decentralized Storage Systems (Filecoin, Arweave), Case Studies: Blockchain in healthcare data, audit trails, and finance, Project Work: Build a prototype integrating blockchain with a modern data pipeline

Learning Resources

Text Books

1. Imran Bashir, Mastering Blockchain.
2. Daniel Drescher, Blockchain Basics.
3. Stephen Grider, Ethereum and Solidity: The Complete Developer's Guide.
4. Martin Kleppmann, Designing Data-Intensive Applications.
5. Hyperledger & Ethereum Developer Documentation, [Online].
6. Apache Iceberg, Delta Lake, and Kafka Documentation, [Online].

Reference Books:

1. Andreas M. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies, O'Reilly Media, 2017.
2. Roger Wattenhofer, The Science of the Blockchain, CreateSpace Independent Publishing Platform, 2016.
3. Melanie Swan, Blockchain: Blueprint for a New Economy, O'Reilly Media, 2015

SWAYAM / MOOC / YouTube Links

1. Blockchain Technology — IIT Madras -https://onlinecourses.nptel.ac.in/noc22_cs93/preview
2. Blockchain and Cryptocurrency — IIT Kanpur -https://onlinecourses.nptel.ac.in/noc21_cs68/preview
3. Introduction to Cryptography and Security — IIT Kanpur -https://onlinecourses.nptel.ac.in/noc21_cs61/p
4. Decentralized Finance and Blockchain Technology — IIT Madras (periodic/offered sometimes)

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-521D-AI - Computer Vision		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Fundamentals of Programming, Mathematics, Machine learning and Image processing basics

Course Objectives: The course aims to:

1. To apply key image processing techniques.
2. To implement and evaluate feature detection
3. To develop object detection and matching algorithms
4. To design and evaluate end-to-end computer vision applications

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

- CO1: Analyze visual data using image processing techniques.
- CO2: Extract and interpret features from images.
- CO3: Apply machine learning and deep learning models (e.g., CNNs) for tasks like image classification, detection, and segmentation.
- CO4: Develop end-to-end computer vision pipelines for real-world applications such as face recognition, surveillance, and autonomous driving.
- CO5: Evaluate and optimize vision systems using appropriate performance metrics and interpretability tools.

Course Contents

Unit I - Fundamentals of Image Processing - (08 Hours)

Digital image fundamentals, Color spaces (RGB, HSV, YCbCr), Histogram equalization, filtering, edge detection (Sobel, Canny)

Unit II - Image Segmentation and Morphological Operations (08 Hours)

Thresholding: Basic, Otsu's method, Adaptive Thresholding, Iterative, Color Thresholding, Image Segmentation: region-based segmentation, Thresholding based segmentation, Edge-based segmentation, Morphological Operations: Watershed, k-means clustering, Morphological operations (erosion, dilation, opening, closing)

Unit III - Feature Detection and Matching - (08 Hours)

Harris and FAST corner detectors, Scale-Invariant Feature Transform (SIFT), Speeded-Up Robust Features (SURF), Oriented FAST and Rotated BRIEF (ORB) descriptors, Feature matching (Brute-force, Fast Library for Approximate Nearest Neighbors (FLANN))

Unit IV - Object Recognition and Classification - (08 Hours)

Template matching, HOG features: Gradient computation (Sobel operator), Cell-based histogram calculation, Block normalization (L2, L1 norms), Bag of Visual Words: Keypoint detection (SIFT, ORB, etc.), Descriptor extraction, Codebook generation is clustering (K-means), Feature quantization (vector of visual words), Histogram representation of images, Introduction to CNNs for image classification

Unit V - Deep Learning for Vision - (08 Hours)

Face recognition (eigenfaces, deep embeddings), Scene understanding, semantic segmentation (YOLO), Applications: medical imaging, autonomous vehicles, surveillance

Learning Resources

Text Books

1. S. Szeliski, Computer Vision: Algorithms and Applications, 2nd ed. Cham, Switzerland: Springer, 2022.
2. R. Szeliski, D. Forsyth, and J. Ponce, Computer Vision: A Modern Approach, 3rd ed. Boston, MA, USA: Pearson, 2023.

Reference Books:

1. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA, USA: MIT Press, 2016.
2. R. C. Gonzalez and R. E. Woods, Digital Image Processing, 4th ed. Hoboken, NJ, USA: Pearson, 2018.

SWAYAM / MOOC / YouTube Links

1. Digital Image Processing, Prof. Prabir Kumar Biswas, IIT Kharagpur.
2. Computer Vision and Image Processing – Fundamentals and Applications - Course, by Prof. M. K. Bhuyan (IIT Guwahati)

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-522-AI - Skill Based Laboratory - I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 04 Hours/Week	02	**Term Work** : 25 Marks **Oral** : 25 Marks

Elective Laboratory Practice I (LP I) is companion course of theory elective courses in Semester I. It is recommended that set of assignments and one capstone project is to be completed. Set of problem statements are suggested. Student has to submit a report/Journal consisting of appropriate documents - Prologue, Certificate, Table of Contents, and other suitable write-up like (Introduction, Motivation, Aim and Objectives, Outcomes, Brief Theory, Requirements Analysis, Design Aspects, Algorithms, Mathematical Model, Complexity Analysis, Results, Analysis and Conclusions). Soft copy of report/journal and code is to be maintained by department/institute in digital repository.

Suitable platform/framework/language is to be used for completing mini- project/assignments.

Guidelines for Term Work Assessment

Continuous assessment of laboratory work is done based on performance of student. Each assignment/capstone project assessment is to be done based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as mini-project assessment include- timely completion, performance, innovation, efficient codes, usability, documentation and adhering to SDLC comprehensively.

Guidelines for practical Examination

It is recommended that practical examination should be conducted based on the understanding and knowledge of the subject as well as on the capstone projects completed and the content understanding of laboratory work.

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Artificial Intelligence (2025 Pattern)

Semester II

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-551-AI - Deep Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Fundamentals of Programming Languages , Mathematics

Course Objectives: The course aims to:

1. To introduce the fundamental mathematical concepts relevant to understand the deep learning.
2. To impart knowledge about the various deep learning approaches.
3. To introduce the working of various state of the art DL algorithms.
4. To learn to choose the appropriate DL algorithm to solve the given problem.

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

- CO1: Construct a Neural Network for a Suitable application.
- CO2: Selection of appropriate activation function for Deep Neural network.
- CO3: Apply Techniques to improve neural network performance.
- CO4: Understand functionality of all layers in a Convolutional Neural Network and Recurrent Neural Networks.

Course Contents

Unit I - Fundamentals of Neural Networks - (12 Hours)

Machine Learning Vs Deep Learning, Foundations of neural networks and deep learning, Perceptron and Multilayer Perceptron (MLPs), Activation function, Loss functions, Logistic regression as a neural network, different activation function, logistic regression cost function, logistic regression gradient descent, vectorizing logistic regression, forward and backward propagation.

Techniques to improve neural networks: regularization and optimizations, hyperparameter tuning, batch normalization, data augmentation, deep learning frameworks

Unit II - Deep Neural Networks and Regularization - (12 Hours)

Deep Neural Network Architectures, Weight Initialization: Zero Initialization, Random Initialization, Xavier Initialization (Glorot Initialization), He Initialization (Kaiming Initialization), LeCun Initialization, Orthogonal Initialization, Sparse Initialization, Batch Normalization, Hyperparameter Tuning, Dropout, Overfitting and Underfitting, Regularization Techniques: L1, L2, Early Stopping

Unit III Convolutional Neural Networks - (12 Hours)

Convolutional Neural Networks & Different types, padding, dropout, strided convolution, pooling layers, convolutional implementation of sliding windows.

Architectures: LeNet, AlexNet, VGG, ResNet, Applications: Image Classification, Object Detection,

Unit IV - Recurrent Neural Networks (RNNs) and Sequence Models - (12 Hours)

Introduction to Sequential Data, Recurrent Neural Networks: Basic RNN, Bidirectional RNN, Vanishing Gradient Problem, Long Short-Term Memory (LSTM), Bi-directional LSTM and Gated Recurrent Units (GRU)

Applications: Time Series Forecasting, Sentiment Analysis

Unit V - Advanced Concepts in Deep Learning - (12 Hours)

Transfer Learning: Introduction to Transfer Learning, Transfer Learning Approaches, Popular Pretrained Models, Hands-on Implementation, Challenges and Best Practices for transfer learning,

Autoencoders (Denoising, Variational), Generative Adversarial Networks (GANs), Transformers: Transformer architecture, attention mechanism.

Deep Reinforcement Learning (DQN, Policy Gradients), Multimodal Learning (Vision-Language Models), Explainable AI (XAI) for Deep Learning, Ethical AI & Bias in Deep Learning

Capstone Project

The capstone project is the culminating experience of this course, where students apply deep learning techniques to solve a real-world problem. Students will design, train, and evaluate a model using advanced architectures (e.g., CNNs, RNNs, Transformers, or GANs) and present their findings. Projects must demonstrate originality, rigorous experimentation, and critical analysis of results.

Learning Resources

Text Books

1. Goodfellow, Y. Bengio, and A. Courville, Deep Learning. Cambridge, MA, USA: MIT Press, 2016.
2. H. Hapke and C. Nelson, Building Machine Learning Pipelines: Automating Model Life Cycles with TensorFlow. Sebastopol, CA, USA: O'Reilly Media, 2020.

Reference Books:

1. 1. C. Chen, N. R. Murphy, K. Parisa, D. Sculley, and T. Underwood, Reliable Machine Learning: Applying SRE Principles to ML in Production. Sebastopol, CA, USA: O'Reilly Media, 2022.

SWAYAM / MOOC / YouTube Links

1. Deep Learning By Prof. Prabir Kumar Biswas https://onlinecourses.nptel.ac.in/noc20_cs62/preview

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-552- AI - Generative AI		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Course : Students should have prior knowledge of Fundamentals of NLP, Deep learning, Programming

Course Objectives: The course aims to:

1. To define and describe fundamental Generative modeling techniques (GANs, VAEs, Transformers, Diffusion Models)
2. To implement and fine-tune Generative models using modern ML frameworks.
3. To analyze model performance and behavior using quantitative and qualitative evaluation techniques.
4. To evaluate the ethical, legal, and societal implications of generative AI applications.
5. To design and create end-to-end generative AI solutions for real-world use cases

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

- CO1: Develop mathematical foundations for generative AI
- CO2: Implement and fine-tune generative models using Hugging Face, langChain.
- CO3: Comprehend the issues in the existing architectures of generative AI.
- CO4: Understand the RAG implementation for contextual responses.
- CO5: Apply generative AI techniques to tasks such as image synthesis, text generation, and data augmentation.

Course Contents

Unit I - Foundations of Generative AI - (12 Hours)

Discriminative vs. Generative models, Latent variable models, Maximum Likelihood Estimation (MLE), KL divergence, ELBO, Basic probabilistic models: Gaussian Mixture Models, Hidden Markov Models

Case Study: Implement a basic Gaussian Mixture Model and sample from it

Unit II - Probabilistic Models & VAEs - (12 Hours)

GAN architecture: Generator and Discriminator, Loss functions, minimax optimization, Variants: DCGAN, Conditional GANs, StyleGAN, CycleGAN, Challenges: Mode collapse, training instability, Lab: Implement a DCGAN for MNIST or CIFAR-10

Case study: Image-to-image translation using CycleGAN

Unit III - Variational Autoencoders (VAEs) and Diffusion Models - (12 Hours)

Autoencoders and limitations, Introduction to VAEs: Probabilistic encoding, reparameterization trick, Denoising Diffusion Probabilistic Models (DDPM), Latent Diffusion, Stable Diffusion overview
Lab: Train a VAE on Fashion-MNIST
Project Idea: Text-to-image generation using latent diffusion models

Unit IV - Generative Transformers and Large Language Models - (12 Hours)

Language modeling and autoregressive generation, Transformer architecture (Self-attention, Positional encoding),GPT family, T5, BERT vs GPT, Fine-tuning, prompt engineering, in-context learning,
Lab: Use HuggingFace Transformers to fine-tune a GPT-2 model
Project Idea: Story or poetry generation using GPT-2 or GPT-3 API

Unit V - Applications, Safety, and Ethics in Generative AI - (12 Hours)

Applications: Art, code (Codex), audio (Jukebox), video, medicine, Evaluation metrics: Inception Score, FID, BLEU, ROUGE, Risks: Misinformation, bias, deepfakes, copyright, Guardrails: RLHF, Vector databases, RAG, watermarking, policy and governance frameworks
Lab: Build a fake image detector using CNNs
Discussion: Case studies on AI hallucination and model misuse

Learning Resources

Text Books

1. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.
2. Foster, D. (2022). Generative deep learning: Teaching machines to paint, write, compose, and play (2nd ed.). O'Reilly Media.
3. Vaswani, A., Shazeer, N., Parmar, N., Uszkoreit, J., Jones, L., Gomez, A. N., Kaiser, Ł., & Polosukhin, I. (2017). Attention is all you need. In Advances in Neural Information Processing Systems (Vol. 30, pp. 5998–6008). https://papers.nips.cc/paper_files/paper/2017/file/3f5ee243547dee9
Paper.pdf

Reference Books:

1. Kingma, D. P., & Welling, M. (2013). Auto-encoding variational Bayes. arXiv preprint arXiv:1312.6114. https://arxiv.org/abs/1312.6114
2. Ho, J., Jain, A., & Abbeel, P. (2020). Denoising diffusion probabilistic models. arXiv preprint arXiv:2006.11239. https://arxiv.org/abs/2006.11239
3. OpenAI. OpenAI API documentation. Retrieved May 21, 2025, from https://platform.openai.com/docs
4. Hugging Face. Hugging Face documentation. Retrieved May 21, 2025, from https://huggingface.co/do

SWAYAM / MOOC / YouTube Links

1. Generative AI with Large Language Models - https://www.coursera.org/learn/generative-ai-with-llms

2. Programming with Generative AI – NPTEL (IISc Bangalore)
3. Generative AI and Large Language Models – SWAYAM
4. Generative AI: Prompt Engineering Basics - https://www.coursera.org/learn/generative-ai-prompt-engineering-for-everyone

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PCC-553-AI - IoT and Smart Systesm		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :

Course Objectives: The course aims to:

1. To understand the architecture, components, and technologies involved in the Internet of Things.
2. To explore communication protocols, hardware platforms, and development tools used in IoT systems.
3. To develop skills to collect, analyze, and manage data generated by IoT devices.
4. To study the role of smart systems, security mechanisms, and future trends in IoT-based data analytics.

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

- CO1: Design and develop IoT-based applications using embedded systems and sensor networks.
- CO2: Implement secure and scalable communication protocols for real-time IoT systems.
- CO3: Analyze and derive insights from data generated by smart systems using modern analytics tools.
- CO4: Evaluate and apply IoT solutions in real-world domains like smart cities, healthcare, and industrial automation.

Course Contents

Unit I - Introduction to IoT - (12 Hours)

Definition and Characteristics of IoT, IoT Applications and Domains (Smart Homes, Cities, Health, Agriculture), IoT Ecosystem and Architecture, Sensors and Actuators: Types and Selection, Challenges and Future Trends in IoT

Unit II - IoT Protocols and Communication Technologies - (12 Hours)

IoT Network Layer and Protocol Stack, Communication Models: MQTT, CoAP, HTTP, AMQP, Wireless Technologies: Bluetooth, Zigbee, RFID, LoRa, NB-IoT, IPv6, 6LoWPAN, and LPWAN, Cloud and Edge Connectivity

Unit III - Smart Systems Design and Development - (12 Hours)

Architecture of Smart Systems, Embedded Systems for IoT, Data Acquisition and Control in Smart Devices, Integration of Smart Devices and Services, Use of Raspberry Pi, Arduino, ESP32, Real-time OS for IoT

Unit IV - Data Analytics in IoT - (12 Hours)

Data Collection, Cleaning, and Processing from IoT Devices, Time Series Data Analysis, Streaming Data and Edge Analytics, Integration with Cloud Platforms (AWS IoT, Azure IoT Hub, Google Cloud IoT), Case Studies: Smart Health Monitoring, Smart Grid, Smart Transportation

Unit V - Security, Privacy, and Future Trends - (12 Hours)

Security Issues in IoT Systems, Authentication, Encryption, and Access Control, Blockchain and AI Integration in IoT, Digital Twins, Cyber-Physical Systems, Green IoT and Sustainable Technologies

Learning Resources

Text Books

1. "Internet of Things: Principles and Paradigms" – Rajkumar Buyya, Amir Vahid Dastjerdi
2. "Internet of Things: A Hands-On Approach" – Arshdeep Bahga, Vijay Madisetti
3. "The Internet of Things: Key Applications and Protocols" – Olivier Hersent, David Boswarthick, Omar Elloumi
4. "Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia" – Anthony M. Townsend

Reference Books:

1. "Smart Sensors and Systems" – C.-H. Chen
2. "Internet of Things: Technologies, Applications, Challenges and Solutions" – Qusay F. Hassan

SWAYAM / MOOC / YouTube Links

1. Introduction to Internet of Things, IIT Kharagpur Prof. Sudip Misra https://nptel.ac.in/courses/106105
2. Design for internet of things, IISc Bangalore Prof. T V Prabhakar - https://nptel.ac.in/courses/1081080

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

Computational Laboratory II is companion course of theory core courses in Semester II. It is recommended that set of assignments or at least one mini-project/study project per course is to be completed. Set of problem statements are suggested. Course/ Laboratory instructors may frame suitable problem statements. Student has to submit a report/Journal consisting of appropriate documents - prologue, Certificate, table of contents, and other suitable write-up like (Introduction, motivation, aim and objectives, outcomes, brief theory, requirements analysis, design aspects, algorithms, mathematical model, complexity analysis, results, analysis and conclusions). Softcopy of report/journal and code is to be maintained by department/institute in digital repository.

Suitable platform/framework/language is to be used for completing mini- project/assignments.

Guidelines for Term Work Assessment

Continuous assessment of laboratory work is done based on performance of student. Each assignment/ mini-project assessment is to be done based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as mini-project assessment include- timely completion, performance, innovation, efficient codes, usability, documentation and adhering to SDLC comprehensively.

Guidelines for practical Examination

It is recommended that practical examination should be conducted based on the understanding and knowledge of the subject as well as on the mini projects completed and the content understanding of laboratory work.

Suggested List of Laboratory Assignments

A. Deep Learning

1. Design and implement logic gates (AND, OR, NOR, XOR) using a Perceptron model.

2. To observe how different weight initialization strategies affect the training behavior of a neural network using a simple 2D classification task.

- Use the make_moons dataset from sklearn.datasets, which generates a non-linearly separable two-class dataset ideal for visualizing decision boundaries and convergence behavior.

3. MNIST Digit Classification with a Feedforward NN

- Build a neural network using PyTorch/TensorFlow to classify handwritten digits (MNIST dataset).

4. Text Generation with LSTM

- Train an LSTM to generate Shakespeare-like text.

B. Generative AI

1. Dynamic PowerPoint Presentation Generator:

- Create an application that converts textual input into structured PowerPoint slides by using tools: Python, python-pptx, React/Angular.

2.AI-Generated Music Composition:

- Build a tool that composes music based on user-defined parameters by using Python, Magenta, TensorFlow.

3. Voice Cloning and Synthesis Application:

- Create a system that generates synthetic speech from text input by using Python, Tacotron, WaveGlow tools.

4. AI-Powered Personalized Learning Assistant:

- Develop a smart assistant that analyzes student learning behavior and generates personalized quizzes, study materials, and feedback based on input documents or topics.

Reinforcement Learning (Any Two)

1.Traffic Signal Control:

- Optimize traffic signal timings in a simulated environment by using Python, OpenAI Gym, NumPy tools.

2.Stock Trading Agent:

- Develop an agent to make trading decisions in a simulated stock market by using Python, OpenAI Gym, Pandas tools.

3.Multi-Armed Bandit Problem:

- Implement and compare various strategies for the multi-armed bandit problem by using Python, NumPy.

4. Smart Vacuum Cleaner Agent

- Simulate a smart vacuum cleaning robot that navigates and cleans a grid-based environment using reinforcement learning to optimize its path and cleaning efficiency.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-561A-AI -AI for Game Development		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Fundamentals of Linear Algebra, AI/ML , Fundamentals of Programming

Course Objectives: The course aims to:

1. To understand and apply AI Techniques in Games development
2. To explore Machine Learning and Deep Learning techniques for Game AI
3. To introduce the working of various state of the art ML algorithms.
4. To develop practical skills in Game Engine Integration.
5. To encourage innovation and research in Game AI.

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

- CO1: Develop critical and interdisciplinary thinking for cutting-edge technology in traditional field of game development.
- CO2: Explain the role and evolution of AI in various game genres and player experiences.
- CO3: Apply state-of-the-art AI techniques (e.g., pathfinding, behavior trees, reinforcement learning) to develop intelligent non-player characters (NPCs).
- CO4: Analyze player behavior data to drive personalization and adaptive gameplay using ML algorithms.
- CO5: Implement ML/AI pipelines within game engines (e.g., Unity ML-Agents or Unreal with Python APIs).

Course Contents

Unit I - Foundations of Game AI - (08 Hours)

History of AI in games (from chess to open-world games), Types of game AI: scripted vs. adaptive, Game loop structure & AI hooks, Finite State Machines (FSMs) for NPC behavior, Rule-based systems

Unit II - Navigation and Pathfinding (08 Hours)

Graph representations of game worlds, A* algorithm and Dijkstra's algorithm, Navigation meshes and dynamic pathfinding, Obstacle avoidance and local steering behaviors, Grid-based vs. mesh-based worlds

Unit III - Decision Making & Behavior Modeling - (08 Hours)

Decision Trees and Utility AI, Behavior Trees (BTs) and Planners (GOAP), Influence maps and threat maps, Group behaviors and flocking, Probabilistic behaviors (Markov Models, Bayesian Networks)

Unit IV - Learning Agents and Reinforcement Learning - (08 Hours)

Reinforcement Learning basics (MDPs, Q-learning, Deep Q-Networks), Lmitation learning and inverse reinforcement learning, Reward shaping in games, Exploration vs. exploitation in games, Unity ML-Agents, OpenAI Gym for 2D/3D environments

Unit V - Generative AI & Modern Game AI - (08 Hours)

Procedural Content Generation (PCG): Terrain, maps, narratives, puzzles; GANs for generating game textures, levels; NLP for dialogue generation using LLMs; Player modeling & personalization; Ethical AI in games: fairness, bias, manipulation

Learning Resources

Text Books

1. I. Millington and J. Funge, Artificial Intelligence for Games, 2nd ed. Boca Raton, FL, USA: CRC Press, 2009.
2. R. Nystrom, Game Programming Patterns. Genever Benning, 2014.

Reference Books:

1. Artificial Intelligence by Stuart Russell
2. Reliable Machine Learning by Cathy Chen and Emmanuel Ameisen

SWAYAM / MOOC / YouTube Links

1.https://www.youtube.com/watch?v=_Z0wWY4lfyE&ab_channel=StanfordOnline

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-561B-AI - AI for Social Impact		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Introduction to AI and ML, Data Science.

Course Objectives: The course aims to:

1. To understand the scope of AI applications for social impact.
2. To identify opportunities and risks in deploying AI in real-world contexts.
3. To analyze the ethical, legal, and policy challenges associated with AI.
4. To design and prototype AI solutions addressing specific social issues.

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

- CO1: Identify and analyze real-world social problems using AI techniques.
- CO2: Apply foundational AI/ML methods to social impact domains.
- CO3: Evaluate the ethical implications of AI applications.
- CO4: Communicate technical results and social implications of AI solutions

Course Contents

Unit I - Introduction - (08 Hours)

AI for Social Impact: History, Evolution, Societal Challenges and Opportunities. Data for Social Impact: Data Sources- NGOs, Public datasets, Citizen science. Data Challenges- Scarcity, Privacy, messiness. Responsible data handling and governance.
Case Study: AI in disaster relief

Unit II - Ethical and Social Implications of AI - (08 Hours)

Ethics: Introduction to Ethics in AI, Historical and philosophical foundations of ethics, Ethical decision-making models. Ethical challenges in AI research.
Social Implications: Impact of AI on society ethical considerations in AI development and deployment. Bias, fairness, and accountability in AI transparency.

Unit III - AI and Human Rights - (08 Hours)

AI and privacy rights. Predictive policing, Bias in facial recognition. Implications of AI in law enforcement and criminal justice, AI in freedom of expression. AI-powered decision-making systems. AI rights to access information and fair trial.

Unit IV - Human AI for Public Communication - (08 Hours)

AI-Human Interaction/Communication, AI integrated communication. Prompt engineering. Text generation and NLP. AI and data-driven political communication in citizen–government contexts. AI mediated messaging under uncertainty.

Unit V - Domain-Specific Applications - (08 Hours)

AI in Healthcare: Disease outbreak prediction, AI in diagnostics for radiology, pathology.
AI for Education: Personalized learning systems, Predictive modeling for dropouts.
AI in Environment & Climate: Predictive modeling for disasters, Smart agriculture, conservation tech by using Remote sensing, geospatial AI.
Case Study: Case Study: COVID-19 contact tracing

Learning Resources

Text Books

1. Tambe, Fang, Wilder. AI for Social Impact (AI4SI) available at ai4sibook.org
2. Milind Tambe, Fei Fang & Bryan Wilder, Artificial Intelligence for Social Good.

Reference Books:

1. Paula Boddington, Towards a Code of Ethics for Artificial Intelligence , Springer, 2017
2. Sundar, S. S. Rise of machine agency: A framework for studying the psychology of human–AI interaction (HAII). Journal of Computer Mediated Communication, 25(1), 74-88, Multivariable Calculus by William Briggs

SWAYAM / MOOC / YouTube Links

1. AI For Social Good (by Raja Iqbal, Data Science Dojo)

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-561C-AI - AI for Healthcare		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Students should have prior knowledge of

1. Basics of Programming and Problem Solving
2. Fundamentals of Artificial Intelligence
3. Basics of Biology and Human Anatomy (desirable)

Course Objectives: The Objective of this course is to provide students with

1. To introduce the role and impact of Artificial Intelligence in the Healthcare domain.
2. To understand Machine learning and Deep learning models in the context of medical data.
3. To develop problem-solving skills using AI for real-time healthcare scenarios.
4. To analyze ethical, legal, and societal implications of AI applications in healthcare.

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

- CO1: Understand and analyze healthcare data and its challenges.
- CO2: Apply Machine learning and Deep learning models to healthcare problems.
- CO3: Evaluate Medical Imaging techniques using AI.
- CO4: Implement Intelligent systems for diagnosis, prognosis, and drug discovery.
- CO5: Examine ethical issues and regulatory compliance in AI-driven healthcare systems

Course Contents

Unit I - Introduction to AI in Healthcare - (08 Hours)

Overview of healthcare ecosystem Types of healthcare data: clinical, Genomics, sensor, HER Introduction to AI, ML, DL – concepts and healthcare relevance, Role of NLP in healthcare (e.g., clinical notes processing)

Case Study: ChatGPT and symptom checkers in telemedicine

Unit II - Medical Data Analysis and Preprocessing (08 Hours)

Data collection and cleaning, Feature engineering for health datasets, Handling imbalanced data and missing values, Evaluation metrics for healthcare models (AUC, ROC, F1-score)

Case Study: Predicting diabetes or heart disease from health records

Unit III - ML/DL Models for Healthcare - (08 Hours)

Supervised learning for disease prediction, Unsupervised learning in patient segmentation, Deep learning: CNN for medical image analysis, RNN for sequential data

Case Study: Chest X-ray classification using CNN

Unit IV - Intelligent Systems and Applications - (08 Hours)

Explainability and transparency in AI models, Bias and fairness in healthcare AI, Data privacy (HIPAA, GDPR), consent, and security, Emerging trends: federated learning, personalized medicine

Case Study: Google DeepMind and NHS data sharing controversy

Unit V -Ethics, Regulations, and Future Trends - (08 Hours)

Explainability and transparency in AI models, Bias and fairness in healthcare AI, Data privacy (HIPAA, GDPR), consent, and security, Emerging trends: federated learning, personalized medicine

Case Study: Google DeepMind and NHS data sharing controversy

Learning Resources

Text Books

1. K. McGroarty and P. Szolovits, Artificial Intelligence in Medicine. Cambridge, MA, USA: MIT Press, 2007.
2. P. Shah, Artificial Intelligence for Healthcare. Hoboken, NJ, USA: Wiley, 2020.

Reference Books:

1. E. Topol, Deep Medicine: How Artificial Intelligence Can Make Healthcare Human Again. New York, NY, USA: Basic Books, 2019.
2. J. Leskovec, Mining of Massive Datasets. Cambridge, U.K.: Cambridge University Press, 2014.
3. S. J. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 4th ed. Boston, MA, USA: Pearson, 2020.

SWAYAM / MOOC / YouTube Links

1. AI for Medicine, deeplearning.ai, Coursera. [Online]. Available: https://www.coursera.org/learn/ai-for-medicine
2. AI Applications in Healthcare, NPTEL. [Online]. Available: https://nptel.ac.in/courses/109/105/1091
3. CS230: Deep Learning, Stanford University. [Online]. Available: https://cs230.stanford.edu/

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-561D-AI - AI for Cyber Security		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Students should have prior knowledge of

1. Basic knowledge of Computer Networks and Cyber security concepts
2. Familiarity with Python programming or any programming language
3. Basic understanding of Statistics and Machine Learning fundamentals

Course Objectives: The course aims to:

1. To introduce the fundamentals of Artificial Intelligence (AI) and its significance in cyber security.
2. To explore Machine learning techniques for detecting and mitigating cyber threats.
3. To understand AI applications in email threat detection and user authentication.
4. To examine behavioral analytics and AI-based incident response systems.
5. To evaluate AI model performance, explainability, and ethical considerations in cyber security practices.

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

- CO1: Understand foundational AI concepts and its role in cyber security, including applications in Security Operations Centers (SOCs).
- CO2: Apply Supervised learning and Data preprocessing to detect cyber threats using ML algorithms.
- CO3: Analyze email threats and implement AI-based authentication using behavioral biometrics.
- CO4: Examine behavioral analytics and AI-driven incident response, including SOAR integration.
- CO5: Evaluate AI model performance, explainability, and ethical issues in cyber security.

Course Contents

Unit I - AI Fundamentals for Cyber security - (08 Hours)

Role of AI and ML in cyber security, Overview of traditional vs. AI-driven security, Types of cyber threats and data sources (logs, network, endpoints), AI workflow: data collection - training – deployment – response, Case studies: Real-world usage of AI in security operation centers (SOCs),

Applications of AI in cyber security: malware detection, intrusion detection systems (IDS), SIEM enhancement

Unit II- Data Analysis and Supervised Learning for Threat Detection (08 Hours)

Data preprocessing: normalization, encoding, cleaning security datasets, Overview of supervised learning (classification and regression), Algorithms: Decision Tree, Random Forest, SVM, k-NN, Model performance metrics (accuracy, precision, recall, F1-score, ROC curve), Challenges: imbalanced datasets, false positives/negatives .

Unit III - AI in Email Threat Detection and User Authentication - (08 Hours)

Email-based threats: phishing, spam, spoofing — overview, Email header and metadata analysis using AI, AI in authentication: Behavioral biometrics: keystroke dynamics, mouse movement, AI in multifactor and adaptive authentication, Comparison of biometric vs. behavioral authentication methods

Unit IV - Behavioral Analytics and Incident Response with AI - (08 Hours)

User and Entity Behavior Analytics (UEBA): concept and need, Anomaly detection methods: K-Means clustering, DBSCAN, Isolation Forests, Insider threat detection using behavior modeling, AI for automated incident response: Threat prioritization, Alert triaging, SOAR platforms and AI integration

Unit V -AI Model Evaluation, Explainability & Ethics in Cyber security - (08 Hours)

Model training issues: over fitting, under fitting, Model validation techniques: train-test split, cross-validation, Explainable AI (XAI): Importance in cyber security, Techniques like SHAP, LIME (intro only), Security of AI models: adversarial attacks and model poisoning, Ethics and legal aspects: Data privacy and bias in AI models GDPR, AI Act (brief overview), Responsible AI use in cyber security

Learning Resources

Text Books

1. M. Stamp, Artificial Intelligence for Cybersecurity: Techniques and Applications. Cham, Switzerland: Springer, 2021.
2. E. Tsukerman, Machine Learning for Cybersecurity Cookbook. Birmingham, U.K.: Packt Publishing, 2020.

Reference Books:

1. C. Chio and D. Freeman, Machine Learning and Security: Protecting Systems with Data and Algorithms. Sebastopol, CA, USA: O'Reilly Media, 2018.
2. L. F. Sikos, AI in Cybersecurity. Cham, Switzerland: Springer, 2020.
3. C. M. Bishop, Pattern Recognition and Machine Learning. New York, NY, USA: Springer, 2006.
4. S. Halder and S. Ozdemir, Hands-On Machine Learning for Cybersecurity. Birmingham, U.K.: Packt Publishing, 2021.

SWAYAM / MOOC / YouTube Links

1. The Complete Artificial Intelligence for Cybersecurity. Udemy. [Online]. Available: https://www.udem
intelligence-for-cybersecurity/

2. AI Fundamentals for Cybersecurity Professionals. Coursera. [Online]. Available: https://www.coursera
for-cybersecurity

3. Introduction to AI for Cybersecurity. Coursera. [Online]. Available: https://www.coursera.org/learn/a
cybersecurity

4. Cyber Security and Privacy, NPTEL. [Online]. Available: https://nptel.ac.in/courses/106/104/106104

5. Introduction to AI for Cybersecurity, Johns Hopkins University. [Online]. Available: https://www.cours
cybersecurity-jhu

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-562A-AI - Robotics and Automation		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Students should have prior knowledge of Fundamentals of Programming, Mathematics

Course Objectives: The course aims to:

1. To develop Mathematical and Computational models for robotic motion, control, and automation tasks.
2. To explore automation technologies and industrial applications involving programmable logic controllers (PLCs), robotic arms, and intelligent systems.
3. To provide hands-on experience in robotic simulation and control, integrating software tools like ROS (Robot Operating System) and Gazebo.
4. To understand the role of AI, Computer Vision, and Machine learning in Autonomous Robotic Systems.

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

- CO1: Model robotic systems using kinematics, dynamics, and control principles.
- CO2: Implement motion planning algorithms and trajectory generation for autonomous robots.
- CO3: Evaluate the performance of robotic and automated systems in industrial and real-world scenarios.
- CO4: Comprehend the role of AI in robotics and relevant industrial applications.
- CO5: Apply automation strategies in industrial robotics for tasks such as pick-and-place, assembly, and inspection

Course Contents

Unit I -Foundations of Robotics and Automation - (08 Hours)

Introduction to robotics: history, applications, and classification of robots, Types of robots: industrial, service, mobile, and humanoid, Anatomy of a robot: sensors, actuators, power sources, and control systems; Industrial automation: hierarchy of control, PLCs (Programmable Logic Controllers), SCADA (Supervisory Control and Data Acquisition); Overview of robot software architectures: ROS (Robot Operating System), Gazebo simulator; Introduction to digital twins and virtual commissioning.

Unit II -Kinematics, Dynamics, and Control - (08 Hours)

Coordinate frames and spatial transformations, Forward and inverse kinematics using Denavit–Hartenberg (D-H) convention; Velocity kinematics and Jacobians; Dynamics of robotic manipulators (Euler-Lagrange, Newton-Euler methods); Trajectory planning and generation; Control strategies: PID control, adaptive control, computed torque control

Unit III - Robot Perception and Computer Vision - (08 Hours)

Camera models, calibration, stereo vision, and depth perception; Feature extraction and matching: SIFT, ORB, SURF; Object detection and recognition; 3D perception: point clouds and depth sensors; SLAM (Simultaneous Localization and Mapping): visual, LiDAR-based approaches.

Unit IV - AI for Planning and Control - (08 Hours)

Classical path planning: A*, D*, RRT, PRM; Task and motion planning: finite state machines, behavior trees; Markov Decision Processes (MDPs) for decision making; Reinforcement Learning (RL) in robotics: Q-learning, DDPG, PPO.

Unit V - Autonomous Systems and Multi-Robot Coordination- (08 Hours)

Sensor fusion techniques: IMU, LiDAR, GPS; Kalman and Particle filters; Human-robot interaction (HRI) and collaborative robots (cobots); Multi-robot coordination: task allocation, communication, and swarm intelligence; Swarm robotics: bio-inspired algorithms, Boids, ant colony optimization; Ethics, safety, and societal impact of AI-enabled robotic systems.

Learning Resources

Text Books

1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 4th ed. Hoboken, NJ, USA: Pearson, 2020.
2. T. R. Kurfess, Ed., Robotics and Automation Handbook, vol. 414. Boca Raton, FL, USA: CRC Press, 2005.

Reference Books:

1. K. M. Lynch and F. C. Park, Modern Robotics: Mechanics, Planning, and Control. Cambridge, U.K.: Cambridge University Press, 2017.
2. B. Siciliano and L. Sciavicco, Robotics: Modelling, Planning and Control. London, U.K.: Springer, 2009.
3. J. J. Craig, Introduction to Robotics: Mechanics and Control, 3rd ed. Upper Saddle River, NJ, USA: Pearson, 2004.

SWAYAM / MOOC / YouTube Links

1. MIT OCW Robotics Courses: Introduction to Robotics | Mechanical Engineering | MIT | OpenCourseWare.
2. Introduction to robotics by Prof. Asokan T, Prof. Balaraman Ravindran, Prof. Krishna Vasudevan | IIT Madras-https://onlinecourses.nptel.ac.in/noc21_de13/preview

3. Robotics by Prof. Dilip Kumar Pratihar | IIT Kharagpurhttps://onlinecourses.nptel.ac.in/noc21_me76/

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-562B-AI - Reinforcement Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Linear Algebra, Basic Probability and Statistics, Foundations of Machine Learning

Course Objectives: The course aims to:

1. To introduce the core principles of Reinforcement Learning and the structure of intelligent agents.
2. To understand foundational techniques including Markov Decision Processes (MDPs), Dynamic Programming, and Monte Carlo methods.
3. To explore Temporal Difference (TD) learning and Deep Reinforcement Learning techniques.
4. To apply value-based and policy-based reinforcement learning algorithms to sequential decision-making problems.
5. To analyze advanced actor-critic methods and function approximation techniques for solving high-dimensional RL tasks

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

- CO1: Describe the elements of reinforcement learning and frame real-world problems as MDPs.
- CO2: Evaluate and compare policy iteration and value iteration using Dynamic Programming.
- CO3: Design and develop reinforcement learning solutions for real-world tasks.
- CO4: Develop end-to-end pipelines for reinforcement learning.
- CO5: Explore applications for reinforcement learning.

Course Contents

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

Reinforcement Learning, History, Examples, Elements, Components of Reinforcement Learning - Agent, Environment, Observations, Actions, Limitations and Scope.

Tabular Solution Methods: Multi-arm Bandits- An n-Armed Bandit Problem, Action-Value Methods, Incremental Implementation, Tracking a Nonstationary Problem, Gradient Bandits, Associative Search (Contextual Bandits) .

Unit II - Markov Decision Processes - (08 Hours)

Markov Decision Processes: The Markov Property, Markov Decision Processes, Optimal Value Functions, Optimality and Approximation

Dynamic Programming: Policy Evaluation, Improvement and Iteration. Asynchronous Dynamic Programming. Efficiency of Dynamic Programming.

Unit III - Dynamic Programming and Monte Carlo Methods - (08 Hours)

Monte Carlo (MC) Prediction, Monte Carlo Estimation of Action Values, First-Visit MC (FVMC), Every-Visit MC (EVMC), Temporal Difference Learning (TD), Monte Carlo Control, Monte Carlo Control without Exploring Starts, Q-learning, double Q-learning, Off-Policy Monte Carlo Control, Off-policy Prediction via Importance Sampling. Importance Sampling on Truncated Returns.

Unit IV - Temporal-Difference Learning - (08 Hours)

Deep reinforcement learning agents with sequential feedback, evaluative feedback, sampled feedback, state-value function and action-value function with and without function approximation, Neural Fitted Q (NFQ), Deep Q-Network (DQN), Double Deep-Q Networks (DDQN), Dueling DDQN, Prioritized Experience Replay (PER).

Unit V - Function Approximation and Deep Reinforcement Learning - (08 Hours)

Policy Based Reinforcement Learning: Policy Gradient and Actor-Critic Methods—REINFORCE Algorithm and Stochastic Policy Search, Vanilla Policy Gradient (VPG), Asynchronous Advantage Actor-Critic (A3C), Generalized Advantage Estimation (GAE), Advantage Actor-Critic(A2C), Deep Deterministic Policy Gradient (DDPG), Twin-Delayed DDPG (TD3), Soft Actor-Critic (SAC), proximal policy optimization (PPO).

Learning Resources

Text Books

1. R. S. Sutton and A. G. Barto, Reinforcement Learning: An Introduction, 2nd ed. Cambridge, MA, USA: MIT Press, 2018.

2. M. Lapan, Deep Reinforcement Learning Hands-On, 2nd ed. Birmingham, U.K.: Packt Publishing, 2020.

Reference Books:

1. C. Szepesvári, Algorithms for Reinforcement Learning. San Rafael, CA, USA: Morgan & Claypool Publishers, 2010.

SWAYAM / MOOC / YouTube Links

1. Reinforcement Learning, IIT Madras Dr. B. Ravindran nptel.ac.in/courses/106106143

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-562C-AI - Quantum Computing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Students should have prior knowledge of

1. Fundamentals of Programming (preferably Python)
2. Linear Algebra, Discrete Mathematics
3. Basic understanding of Artificial Intelligence and Machine Learning (for courses involving Quantum ML or hybrid algorithms)
4. Graph Theory (useful for optimization algorithms like QAOA)

Course Objectives: The course aims to:

1. To understand foundational concepts of the quantum technology.
2. To develop hands-on experience with experiments in quantum computing.
3. To explore quantum computational models and emerging applications for quantum computing.

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

- CO1: Comprehensive understanding of quantum computing concepts.
- CO2: Analyze the computation models.
- CO3: Model the circuits using quantum computation environments and frameworks.
- CO4: Understand the quantum operations such as noise and error-correction.
- CO5: Interpret the interfacing of classical and quantum technologies.

Course Contents

Unit I -Quantum Computation Fundamentals - (08 Hours)

Qubits, Superposition, Entanglement; Quantum Gates, Circuits, Measurement; Postulates of Quantum Mechanics; Tools: Qiskit or Cirq basics.

Unit II - Quantum Computing Architectures and Algorithms (08 Hours)

Guiding principles, Conditions for quantum computation, Harmonic oscillator quantum computer, Optical photon quantum computer, Optical cavity quantum electrodynamics, Ion traps, Nuclear magnetic resonance, Other implementation schemes, The quantum Fourier transform and its applications, Quantum search algorithms

Unit III - QUANTUM INFORMATION AND ERROR CORRECTION - (08 Hours)

Quantum noise and quantum operations: Classical noise and Markov processes, Quantum operations, Examples of quantum noise and quantum operations, Applications of quantum operations, Limitations of the quantum operations formalism, Introduction, The Shor code, Theory of quantum error-correction, Constructing quantum codes, Stabilizer codes, Fault-tolerant quantum computation.

Unit IV - ENTROPY AND INFORMATION THEORY - (08 Hours)

Entropy : Shannon Entropy, Basic properties of entropy, Von Neumann entropy, Strong sub additivity, Quantum information theory : Distinguishing quantum states and the accessible information, Data compression, Classical information over noisy quantum channels, quantum information over noisy quantum channels, Entanglement as a physical resource, Quantum cryptography

Unit V - Interfacing of Quantum and Classical Computing - (08 Hours)

Foundations of Quantum-Classical Interfaces, Variational Hybrid Algorithms, Programming hybrid systems, Challenges, Design Patterns, and Applications

Learning Resources

Text Books

1. M. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum Information, 10th Anniversary ed. Cambridge, U.K.: Cambridge University Press, 2010.
2. C. Bernhardt, Quantum Computing for Everyone. Cambridge, MA, USA: MIT Press, 2019.
3. Y. Kitaev, A. Shen, and M. Vyalyi, Classical and Quantum Computation. Providence, RI, USA: American Mathematical Society, 2002.

Reference Books:

1. E. R. Johnston, N. Harrigan, and M. Gimeno-Segovia, Programming Quantum Computers. Sebastopol, CA, USA: O'Reilly Media, 2019.
2. IBM Q Team, Learn Quantum Computation Using Qiskit, 2020. [Online]. Available: https://qiskit.org/

SWAYAM / MOOC / YouTube Links

1. Hands-on quantum error correction with Google Quantum AI by Austin Fowler https://www.coursera.o error-correction?
2. Introduction to Quantum Computing: Quantum Algorithms and Qiskit | https://onlinecourses.nptel.ac

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
PEC-562D-AI - High Performance AI Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives:

1. To design AI systems that perform well under pressure and at scale.
2. To learn how AI systems work at a deeper level to spot and fix performance issues.
3. To apply AI in time-critical, real-world applications with speed and reliability.
4. To choose the best tools and hardware for high performance and energy efficiency.

Course Outcomes:

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

- CO1: Design AI systems optimized for speed, scalability, and efficiency.
- CO2: Analyze and tune AI performance using profiling and debugging tools.
- CO3: Select suitable hardware for deploying high-performance AI models.
- CO4: Apply AI solutions effectively in real-world, time-critical environments.

Course Contents

Unit I - Foundations of High-Performance AI Systems - (08 Hours)

Introduction to high-performance AI, Need for performance in AI systems, Challenges in deploying AI at scale, Metrics for performance measurement (latency, throughput, efficiency), System bottlenecks in AI pipelines, Accuracy-speed-resource trade-offs

Unit II - Efficient Model Design and Optimization Techniques - (08 Hours)

Model architecture choices (MobileNet, EfficientNet), Model compression (pruning, quantization, weight sharing), Knowledge distillation, Neural Architecture Search (NAS), Performance tuning strategies, Case studies on model optimization

Unit III - Hardware Acceleration and Parallel Computing in AI - (08 Hours)

Overview of AI hardware (CPU, GPU, TPU, FPGA), Hardware-software co-design, Data and model parallelism, CUDA and OpenCL basics, Frameworks for acceleration (TensorFlow XLA, TorchScript), Distributed training tools (Horovod, DeepSpeed)

Unit IV - Profiling, Debugging, and Bottleneck Analysis - (08 Hours)

Profiling tools (TensorBoard, PyTorch Profiler, NVIDIA Nsight), Memory and compute usage monitoring, Identifying training and inference bottlenecks, Debugging performance issues, Optimizing data pipelines, Best practices for tuning AI systems

Unit V - Real-World Deployment Strategies and Case Studies - (08 Hours)

Deployment challenges, Edge and real-time deployment strategies, Model conversion and optimization tools (ONNX, TensorRT), Industry applications (autonomous systems, voice AI, healthcare), Sustainable and ethical AI practices, Future of efficient AI.

Learning Resources

Text Books

1. AI Systems Performance Engineering by Chris Fregly,O'really Publication
2. High-Performance Computing and Artificial Intelligence in Process Engineering by Mingheng Li, Yi Heng

Reference Books:

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

E-books:

1. "J. Xie, Optimization for Data Science, Lecture Notes, FS 23 [Online]. Available: https://n.ethz.ch/~jia
2. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, Cambridge, MA, USA: MIT Press, 2016. [Online]. Available: https://www.deeplearningbook.org/

SWAYAM / MOOC / YouTube Links

1. Applied Accelerated Artificial Intelligence By Prof. Satyajit Das, Prof. Satyadhyan Chickerur, Prof. Bharatkumar Sharma, Prof. Adesuyi Tosin, Prof.Ashrut Ambastha | IIT Palakkad, KLE Technological University, NVIDIA, NVIDIA

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Course)		
SEM-581-AI - 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. - Artificial Intelligence (2025 Pattern)

Semester III

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Pattern)		
RM-631-AI - Research Methodology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite::

1. Familiarity with project-based learning (e.g., mini projects, seminars, post graduate 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 (since research is often domain-specific).

Course Objectives: The course aims to:

1. To understand the philosophy of research in general
2. To learn the methodology to conduct the Literature Survey
3. To acquaint with the tools, techniques, and processes of doing research
4. To learn the effective report writing skills and allied documentations
5. To 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: Formulate research problems with clear objectives, hypotheses, and scope.
- CO2: Design appropriate research methodologies using qualitative, quantitative, or mixed approaches.
- CO3: Conduct literature reviews, identify research gaps, and critically evaluate scholarly articles.
- CO4: Apply statistical and analytical tools for data collection, analysis, and interpretation.
- CO5: Prepare technical reports, research papers, and project proposals adhering to ethical and academic standards.

Course Contents

Unit I - Foundations of Research - (12 Hours)

Meaning, Objectives, Motivation. Concept of theory, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition,

Variable. Research Process. Problem Identification & Formulation – Research Question – Investigation Question – Measurement Issues – Hypothesis – Qualities of a Good Hypothesis –Null Hypothesis &; Alternative Hypothesis. Hypothesis Testing – Logic &; Importance

Unit II - Research Design - (12 Hours)

Concept and Importance in Research – Features of a good research design – Exploratory Research Design – concept, types, and uses, Descriptive Research Designs – concept, types, and uses. Experimental Design: Concept of Independent & Dependent variables. Qualitative and Quantitative Research: Qualitative research – Quantitative research – Concept of measurement, causality, generalization, and replication. Merging the two approaches

Unit III - Sampling, Measurement and Data Analysis - (12 Hours)

Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non-Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic, Sample, Stratified Random Sample & Multi-stage Sampling. Determining the size of the sample – Practical considerations in sampling and sample size. Concept of measurement– what is measured?, Problems in measurement in research – Validity and Reliability. Levels of measurement – Nominal, Ordinal, Interval, Ratio. Data Analysis: Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages). 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 - Thesis writings, Paper Writing and IPR- (12 Hours)

Draft thesis, Layout of a Research Paper, paper communication, and publications, Journals, Impact factor of Journals, When and where to publish? Ethical issues related to publishing, Plagiarism, and Self-Plagiarism. Major contribution, outcome of the research, patent possibilities.

Unit V - Databases and Use of Tools - (12 Hours)

Use of Encyclopedias, Research Guides, Handbook etc., Academic Databases for Computer Science Discipline. Use of tools / techniques for Research: methods to search required information effectively, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism.

Suggested Assignment

1.**Literature Review and Research Gap Identification:**

- Select a research topic in your field of interest. Conduct a systematic literature review by collecting at least 15 relevant research papers. A report summarizing the key findings, methodologies, and conclusions from the papers, and clearly identify one or more gaps or open questions in the existing research.

2. **Research Proposal Writing:**

- Write a complete research proposal including introduction, problem statement, literature review, research questions, methodology, and expected outcomes.

- A formal research proposal document ready for submission or peer review.

3.**Presentation and Visualization of Research Findings:**

- Create visualizations (charts, graphs) to represent data findings and prepare a research presentation summarizing the study.
- A slide deck with clear visuals and a summary report explaining the findings.

Learning Resources

Text Books

1. C. R. Kothari and G. Garg, Research Methodology: Methods and Techniques, 4th ed. New Delhi, India: New Age International Publishers, 2019.
2. J. W. Creswell and J. D. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, 5th ed. Thousand Oaks, CA, USA: SAGE Publications, 2017.
3. R. Kumar, Research Methodology: A Step-by-Step Guide for Beginners, 5th ed. Thousand Oaks, CA, USA: SAGE Publications, 2019.

Reference Books:

1. W. J. Goode and P. K. Hatt, Methods in Social Research. New York, NY, USA: McGraw-Hill, 1952.
2. Thomas, C. G. (2021). Research methodology and scientific writing (pp. 135-151). Thrissur: Springer.

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) - Artificial Intelligence		
OJT-602-AID - 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 - Artificial Intelligence (2025 Course)		
SEM-603-AI- Technical Seminar - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:**25 Marks **Oral/Presentation:** 25 Marks

Course Description:

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

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

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

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

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

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

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

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

Responsibility of the students:

- This Seminar should be carried out individually by each student based on the research project.
- A student should identify the area or topics in recent trends and developments in consultation with the guide
- A student should report to his/her respective guide regularly (at least once in a week) and report the progress of the seminar work.
- A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
- Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the project diary. The project diary must be presented during each review presentation to the reviewers.

- A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
- A student should Incorporate constructive feedback to improve the quality and rigor of the research
- For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
- Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
- A student should invest time and effort in preparing for seminar presentations and the oral presentation of the seminar
- **Topic Selection**
  - Relevance: Topics must be directly related to Computer Engineering, encompassing current research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
  - Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - Examples of Broad Areas: Artificial Intelligence/Machine Learning, Data Science & Big Data, Cybersecurity, Cloud Computing, Internet of Things (IoT), Computer Networks, Software Engineering, High-Performance Computing, Embedded Systems, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.
- **Seminar Structure and Deliverable :** The technical seminar typically involves the following stages and deliverable
  - Topic Proposal (2-3 weeks after topic approval)
  - A concise document (1-2 pages) outlining:
    * Proposed Seminar Title
    * Brief Description/Abstract of the Topic
    * Motivation and Relevance to Computer Engineering
    * Preliminary List of Key References (at least 5-7 reputable sources)
    * Tentative Scope and Outline of the Presentation

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

- **Seminar Report (Due 2-3 weeks before presentation):**
  - A written report (typically 20-25 pages, excluding references and appendices) detailing the seminar content.
  - Format: Follow a professional academic paper format (e.g., IEEE transaction style).
  - Sections:
    - Abstract: A concise summary of the seminar topic and key findings.
    - Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
    - Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
    - Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
    - Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
    - Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
    - References: A comprehensive list of all cited sources, properly formatted.
    - Appendices (Optional): Supplementary material if necessary.

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

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

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

Learning Resources

Text Books

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Course)		
RPR-604-AI - 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. - Artificial Intelligence (2025 Pattern)

Semester IV

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Course)		
SEM-651-AI - Technical Seminar - III		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:**50 Marks **Oral/Presentation:** 50 Marks

Course Description:

The seminar aims to enhance students' research, presentation, and critical thinking skills, preparing them for advanced academic pursuits and professional careers. Technical Seminars will provide students with the opportunity and support to improve their self-study skills using modern information technologies and apply new knowledge and skills in practice, including in new areas.

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

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

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

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

Guidelines for Seminar

- **Responsibility of the students:**
  - The Seminar should be carried out individually by each student.
  - A student should identify the area or topics in recent trends and developments in consultation with the guide.
  - A student should report to his/her respective guide regularly (at least once in a week) and report the progress of the seminar work.
  - A student should follow the timelines and deadlines and inform the supervisor in case of any difficulty/delay.
  - Students should maintain the record of all the meetings, remarks given by guide/reviewers and progress of the work in the diary. The diary must be presented during each review presentation to the reviewers.
  - A student should conduct the research ethically, adhere to the academic integrity standards, and cite sources whenever using any existing results
  - A student should incorporate constructive feedback to improve the quality and rigor of the research work towards seminar.
  - For final examination, students should complete the Seminar Report in all aspects including formatting and citation.
  - Each student should prepare the report, get it approved by his/her guide and submit the duly signed copy within the deadline.
  - A student should invest time and effort in preparing for seminar presentations and the oral presentation of the seminar.
- **Topic Selection**
  - Relevance: Topics must be directly related to Computer Engineering, encompassing current research trends, emerging technologies, advanced concepts, or interdisciplinary applications.
  - Scope: The topic should be sufficiently focused to allow for in-depth exploration within the seminar timeframe, yet broad enough to demonstrate a comprehensive understanding. Avoid overly narrow or excessively broad topics.
  - Novelty (Desired): While not strictly a research paper, students are encouraged to explore topics that have recent advancements, open problems, or areas where their unique insights can be presented. Avoid merely summarizing introductory textbook material.
  - Guide / Supervisor Approval: Each student must select a seminar topic in consultation with and obtain approval from an assigned faculty supervisor. The supervisor will guide the student in refining the topic and identifying relevant resources.
  - Examples of Broad Areas: Artificial Intelligence/Machine Learning, Data Science & Big Data, Cybersecurity, Cloud Computing, Internet of Things (IoT), Computer Networks, Software Engineering, High-Performance Computing, Embedded Systems, Computer Vision, Natural Language Processing, Blockchain, Quantum Computing.

- **Seminar Structure and Deliverable :** The technical seminar typically involves the following stages and deliverable
  - Topic Proposal (2-3 weeks after topic approval)
  - A concise document (1-2 pages) outlining:
    * Proposed Seminar Title
    * Brief Description/Abstract of the Topic
    * Motivation and Relevance to Computer Engineering
    * Preliminary List of Key References (at least 5-7 reputable sources)
    * Tentative Scope and Outline of the Presentation
    * Submission: To the faculty supervisor for approval.
    * Literature Review and Research (Ongoing): Sources: Students must primarily rely on peer-reviewed academic sources (IEEE Xplore, ACM Digital Library, SpringerLink, arXiv, Google Scholar), reputable conference proceedings, and established industry standards. Wikipedia and unverified blogs are generally not acceptable as primary sources.
    * Critical Analysis: Beyond mere summarization, students are expected to critically analyze the literature, identifying different approaches, their advantages/disadvantages, open issues, and potential future directions.
    * Note-Taking & Organization: Maintain systematic notes and organize research material effectively.
- **Seminar Report (Due 2-3 weeks before presentation):**
  - A written report (typically 20-25 pages, excluding references and appendices) detailing the seminar content.
  - Format: Follow a professional academic paper format (e.g., IEEE transaction style).
  - Sections:
    * Abstract: A concise summary of the seminar topic and key findings.
    * Introduction: Background, motivation, problem statement (if applicable), and outline of the report.
    * Literature Review/Background: Detailed discussion of relevant concepts, theories, and existing work.
    * Core Content: In-depth exploration of the chosen topic, presenting different methodologies, architectures, algorithms, or challenges as relevant.
    * Analysis/Discussion: Critical evaluation of the presented material, comparing different approaches, discussing implications, and identifying gaps.
    * Future Trends/Conclusion: Summarization of key takeaways, potential future directions, and concluding remarks.
    * References: A comprehensive list of all cited sources, properly formatted.

* Appendices (Optional): Supplementary material if necessary.

- **Oral Presentation :**
  - Duration: Typically 25-30 minutes for presentation, followed by 10-15 minutes for Q&A.
  - Audience: Faculty members, peers, and potentially other interested individuals.
  - Content: The presentation should effectively convey the key aspects of the seminar topic. It should not simply be a reading of the report.
  - Visual Aids: High-quality presentation slides (e.g., PowerPoint, Google Slides, LaTeX Beamer) are mandatory. Slides should be clear, concise, visually appealing, and support the oral delivery. Avoid excessive text on slides.
  - Delivery: Clear articulation, confident posture, good eye contact, and appropriate pace. Practice the presentation thoroughly.
  - Q&A Session: Be prepared to answer questions from the audience on all aspects of the seminar topic. Demonstrate a strong understanding and ability to defend your perspectives.
- **Evaluation Criteria :** The technical seminar will be evaluated based on the following criteria:
  - **Topic Selection and Scope (10%):** Relevance, timeliness, and appropriate depth of the chosen topic. Clarity and focus of the topic proposal.
  - **Literature Review and Research (25%):** Breadth and depth of literature surveyed. Quality and credibility of sources used. Critical analysis and synthesis of information.
  - **Seminar Report/Paper (30%):** Clarity, organization, and logical flow of content. Technical accuracy and depth of discussion. Adherence to academic writing standards (grammar, spelling, formatting, referencing). Originality in synthesis and critical insights. Absence of plagiarism.
  - **Oral Presentation (35%):** Content: Clarity, completeness, and accuracy of the presented material. Organization: Logical flow, effective use of time. Visual Aids: Quality, clarity, and effectiveness of slides. Delivery: Confidence, clarity of speech, enthusiasm, engagement with the audience. Q&A: Ability to answer questions accurately, comprehensively, and confidently.

Learning Resources

Text Books

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

NPTEL Courses

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence (2025 Course)		
RPR-652-AI - 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. Vandana Dhingra - Member, Board of Studies - Computer Engineering

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