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 and Data Science (AI&DS)

(With effect from Academic Year 2025-26)

www.unipune.ac.in

Contents

Nomenclature

AI&DS Artificial Intelligence and Data Science

AICTE All India Council for Technical Education

CCE Continuous and Comprehensive Evaluation

ESE End Semester Examiantion

KAP A Knowledge and Attitude Profile

PCC Programme Core Course

PEC Programme Elective Course

PEO Programme Educational Objectives

PO Programme Outcomes

PSO Program Specific Outcomes

UGC University Grants Commission

WK Knowledge and Attitude Profile

Master of Engineering in Artificial Intelligence and Data Science - 2025 Pattern

Preface by Board of Studies

Dear Students and Teachers,

We, the members of Board of Studies Computer Engineering, are very happy to present Master of Artificial Intelligence and Data Science (AI&DS) syllabus effective from the Academic Year 2025-26 (2025 Pattern). The domains of AI and Data Science are rapidly evolving, reshaping industries and creating unprecedented opportunities. This program is meticulously designed to equip you with the theoretical knowledge and practical skills necessary to thrive in this dynamic landscape. Our curriculum balances foundational concepts with cutting-edge advancements, ensuring you gain a comprehensive understanding of machine learning, deep learning, big data analytics, and their real-world applications.

The curriculum revision is mainly focused on knowledge component, skill based activities, experiential learning and project based activities. The revised syllabus falls in line with the objectives of Savitribai Phule Pune University, AICTE New Delhi, UGC, and various accreditation agencies by keeping an eye on the technological developments, innovations, and industry requirements. This program is your platform to innovate, solve complex problems, and contribute meaningfully to a future driven by data and intelligence. We would like to place on record our gratefulness to the faculty, students, industry experts and stakeholders for having helped us in the formulation of this syllabus.

I wish you all the very best in your academic pursuits.

Dr. Nilesh Uke

Chairman - Board of Studies - Computer Engineering

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Programme Educational Objectives (PEO)

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

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

Master of Engineering - Artificial Intelligence and Data Science (2025 Course)

Knowledge and Attitude Profile (WK)

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

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

Programme Outcomes (PO)

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

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

Program Specific Outcomes (PSOs)

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

PSO1	**Develop and Deploy Intelligent Systems :** Graduates will be able to apply advanced concepts of AI, machine learning, and deep learning to design, develop, and deploy intelligent systems that can solve complex, real-world problems.
PSO2	**Implement the Data Science Pipeline:** Graduates will be able to manage the entire data science lifecycle, from data acquisition and cleaning to analysis and visualization.
PSO3	**Conduct Advanced Research and Innovation:** Graduates will possess the research skills to identify, formulate, and investigate complex problems in AI and data science. They will be able to conduct independent research, synthesize information from a wide range of sources, and contribute to cutting-edge advancements in the field.

Master of Engineering (2025 Pattern) – Artificial Intelligence and Data Science

Curriculum Structure - Semester I

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
PCC-501-AID	Programme Core Course	Mathematics for Data Science	4	-	50	50	-	-	-	100	4	-	4
PCC-502-AID	Programme Core Course	Natural Language Understanding	4	-	50	50	-	-	-	100	4	-	4
PCC-503-AID	Programme Core Course	Machine Learning Techniques	4	-	50	50	-	-	-	100	4	-	4
PCC-504-AID	Programme Core Course	Generative Artificial Intelligence	4	-	50	50	-	-	-	100	4	-	4
PCC-505-AID	Programme Core Course	Computational Laboratory-I	-	4	-	-	25	-	25	50	-	2	2
PEC-521-AID	Programme Elective Course	Elective I	3	-	50	50	-	-	-	100	3	-	3
PEC-522-AID	Programme Elective Course	Skill Based Laboratory -I	-	2	-	-	25	-	25	50	-	1	1
Total			**19**	**6**	**250**	**250**	**50**	**-**	**50**	**600**	**19**	**3**	**22**

Elective I - Courses	
PEC-521A-AID	Cloud Computing
PEC-521B-AID	Deep Learning
PEC-521C-AID	Blockchain Technology
PEC-521D-AID	Recommendation Systems

Master of Engineering (2025 Pattern) – Artificial Intelligence and Data Science

Curriculum Structure - Semester II

Course Code	Course Type	Course Name	Teaching Scheme		Examination Scheme						Credits		
			Theory	Practical	CCE	EndSem	Term Work	Practical	Oral	Total	Theory	Practical	Total
PCC-551-AID	Programme Core Course	Explainable Artificial Intelligence	4	-	50	50	-	-	-	100	4	-	4
PCC-552-AID	Programme Core Course	AI in Cyber Security	4	-	50	50	-	-	-	100	4	-	4
PCC-553-AID	Programme Core Course	Data Visualization Techniques	4	-	50	50	-	-	-	100	4	-	4
PCC-554-AID	Programme Core Course	Computational Laboratory-II	-	4	-	-	25	-	25	50	2	-	2
PEC-561-AID	Programme Elective Course	Elective –II	3	-	50	50	-	-		100	3	-	3
PEC-562-AID	Programme Elective Course	Elective –III	3	-	50	50	-	-	-	100	3		3
SEM-581-AID	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-AID	Social Media Analytics	PEC-562A-AID	Federated Learning
PEC-561B-AID	Quantum Computing	PEC-562B-AID	Bigdata Analytics
PEC-561C-AID	Business Intelligence	PEC-562C-AID	Reinforcement Learning
PEC-561D-AID	Spatial Data Analytics	PEC-562D-AID	Game Theory and Applications

Master of Engineering (2025 Pattern) – Artificial Intelligence and Data Science

Curriculum Structure - Semester III

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

Curriculum Structure - Semester IV

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

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Artificial Intelligence and Data Science (2025 Pattern)

Semester I

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-501-AID - Mathematics for Data Science		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Discrete Mathematics

Course Objectives: The course aims to:

1. To develop a foundation in linear algebra, probability, statistics, and optimization used in data science.
2. To study mathematical tools for data representation, pattern recognition, and model building.
3. To prepare students to apply mathematical methods to machine learning and AI problems.

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

- CO1: Apply linear algebra concepts to manipulate datasets and model transformations.
- CO2: Use calculus for understanding optimization in machine learning algorithms.
- CO3: Understand and apply concepts of probability and distributions in data analysis.
- CO4: Perform statistical analysis and hypothesis testing on real-world data.
- CO5: Solve optimization problems relevant to data fitting and predictive modeling.

Course Contents

Unit-I- Linear Algebra for Data Science-(12 Hours)

Overview of vectors, matrices, tensors, matrix operations, properties, types of matrices, identity, diagonal, orthogonal, inverse, dot product, cross Product, norms,
eigenvalues and eigenvectors. Principal component analysis (PCA) – Mathematical Intuition, dimensionality reduction, image data transformation.

Unit-II- Calculus and Functions-(12 Hours)

Functions, limits, continuity, differential calculus, derivatives, chain rule, gradient, jacobian, partial derivatives and directional derivatives, integral Calculus - area under curves, expected values, optimization techniques - maxima, minima, gradient descent, cost function minimization in ML models.

Unit III- Probability Theory-(12 Hours)

Overview of probability, sample space, events, axioms, conditional probability, Bayes' Theorem, random variables – Discrete and Continuous, probability distributions - Bernoulli, Binomial, Poisson, Normal, exponential joint, marginal distributions, Central Limit Theorem, applications for Classification, decision-making under uncertainty.

Unit IV- Statistics & Data Analysis -(12 Hours)

Overview of descriptive Statistics - mean, median, mode, variance, standard deviation, correlation, covariance, sampling, estimation, confidence intervals, hypothesis testing - null and alternative hypotheses, p-values, Chi-square test, t-test, ANOVA, applications for statistical inference, feature importance, A/B testing, tools - NumPy, Matplotlib, Scikit-learn, Jupyter Notebooks.

Unit V- Applications in Data Science-(12 Hours)

Convex sets, convex functions, unconstrained and constrained optimization, Lagrange multipliers, linear programming, stochastic gradient descent, regularization - L1, L2 norms, applications for model fitting, regression, neural network training.

Learning Resources

Text Books:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, “Mathematics for Machine Learning”, Cambridge University Press, 2020.
2. Sheldon M. Ross, “Introduction to Probability and Statistics for Engineers and Scientists”, Elsevier Academic Press, Third Edition, ISBN: 0-12-598057-4

Reference Books:

1. Biswadip Basu Mallik, Kirti Verma, Rahul Kar, Ashok Kumar Shaw, Sardar M. N. Islam, Advanced Mathematical Applications in Data Science “ , Bentham Books Publisher, ISBN: 978-981-5124-85-9.
2. Gilbert Strang, “Linear Algebra and Its Applications”, Fourth Edition.

E Books:

1. MIT OpenCourseWare: Mathematics for Computer Science.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-502-AID - Natural Language Understanding		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Introduce foundational concepts of language structure and computational linguistics.
2. Applying data science and AI techniques to language understanding tasks.
3. Provide knowledge of statistical, neural, and transformer-based NLU models.
4. Develop the ability to solve real-world language problems.

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

- CO1: Understand the structure and meaning of natural language using linguistic and statistical techniques.
- CO2: Apply machine learning and deep learning models to core NLU tasks.
- CO3: Analyze and compare traditional NLP pipelines with modern transformer-based approaches.
- CO4: Evaluateand optimize NLU systems for accuracy and performance.
- CO5: Design and evaluate scalable NLU systems for AI applications.

Course Contents

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

Foundation of Natural Language Understanding, Natural Language Processing, linguistic levels, morphology, syntax, semantics, pragmatics, tokenization, lemmatization, POS tagging, corpus creation, annotation formats, CoNLL, JSONL, overview of NLU data pipelines, annotation tools like Prodigy, Doccano.

Unit II - Syntax and Structure Based Understanding - (12 Hours)

Introduction to context-free grammars, parsing algorithms, top-down & bottom-up parsing, dependency parsing, constituency parsing, feature structure, unification, POS tagging with Hidden Markov Models, CRFs Shallow Parsing, deep parsing, statistical parsing, Chunking, role of downstream ML tasks.

Unit III-Semantic Understanding and Representation-(12 Hours)

Introduction word sense disambiguation, semantic role labeling, logic based meaning representation, lexical semantic, distrubutional semantics, vector semantics, TF-IDF, Word2Vec, GloVe, knowledge graphs, WordNet, ConceptNet, word embedding, embedding language data into machine-readable vectors for modeling, semantic search engine.

Unit IV-Deep Learning and Transformer Architectures-(12 Hours)

Traditional neural networks for text classification, neural networks for RNN, LSTM, GRU, attention mechanisms, overview of transformer architecture - BERT, GPT, transfer learning, fine tuning, pre-trained models for NLU, building NLU pipelines, overview of tools like HuggingFace.

Unit V- Applications of NLU - (12 Hours)

Dialogue systems, Intent detection, slot filling, text classification & summarization, question answering, information extraction, explainability, transformers for building domain-specific chatboat, analysis of gender bias in NLP datasets, case studies for real AI systems like ChatGPT, Alexa, Google BERT-based search.

Learning Resources

Text Books

1. Daniel Jurafsky, James H. Martin, “Speech and Language Processing”, Third Edition, 2025.
2. Yoav Goldberg, “Neural Network Methods for Natural Language Processing”, Springer, 2017.
3. Denis Rothman, “Transformers for Natural Language Processing”, Packt, 2021.
4. Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit by Steven Bird, Ewan Klein, Edward Loper.

Reference Books:

1. Steven Bird, Ewan Klein, Edward Loper, “ Security Essentials, Natural Language Processing with Python”, Orelly, 2009.
2. Soyeon Caren Han , Henry Weld , Yan Li , Jean Lee , Josiah Poon, “ Natural Language Understanding in Conversational AI with Deep Learning”, Springer, 2025.

E- Books :

1. James Allen, “ Natural Language Understanding”. https://www.scribd.com/document/537550277/Jar Allen-Natural-Language-Understanding

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-503-AID - Machine Learning Techniques		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Design of Analysis & Algorithms

Course Objectives: The course aims to:

1. To design robust predictive models using ensemble methods, regularization, and hyper parameter tuning.
2. To investigate semi-supervised learning for improved performance with limited labeled data.
3. To implement and evaluate unsupervised learning for clustering, dimensionality reduction, and anomaly detection.
4. To understand and apply representation learning (embeddings, deep metric learning) for meaningful data representations.
5. To employ active learning strategies for efficient data labeling.
6. To leverage transfer learning to adapt pre-trained models to new tasks with limited data.

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

- CO1: Apply supervised learning algorithms to build and evaluate predictive models.
- CO2: Use semi-supervised learning methods to enhance model performance with limited labeled data.
- CO3: Implement and evaluate unsupervised learning techniques for clustering, dimensionality reduction, and anomaly detection.
- CO4: Develop and analyze data representations using embedding's and deep learning models.
- CO5: Design and apply active learning strategies to minimize labeling efforts in machine learning tasks.

Course Contents

Unit I- Supervised and Semi-Supervised Learning -(12 Hours)

Supervised Learning: Ensemble Methods: Bagging (e.g., Random Forests), Boosting (Ada Boost, XG Boost, Light GBM). Model Calibration, Regularization Techniques: L1, L2, Elastic Net for preventing overfitting, Cross-validation, Hyper parameter Tuning.

Semi-Supervised Learning: Self-training, Co-training, Graph-based Methods, Generative Models for Semi-supervised Learning (e.g., Semi-supervised GANs), Applications in NLP and Computer Vision.

Unit II-Unsupervised Learning Algorithms-(12 Hours)

Clustering Techniques: Partitional Clustering: K-Means and its variations, Density-Based Clustering: DBSCAN, HDBSCAN for identifying clusters of varying shapes, Hierarchical Clustering: Agglomerative and divisive approaches, Model-Based Clustering: Gaussian Mixture Models (GMM) and Expectation-Maximization (EM) algorithm.

Dimensionality Reduction: Linear & Non-linear Methods, Auto-encoders (as an unsupervised method for learning compressed representations). Anomaly Detection Techniques, Evaluation Metrics: Silhouette Score, Davies-Bouldin Index for assessing clustering quality.

Unit III- Representation Learning:-(12 Hours)

Embedding Methods: Word Embedding's: Word2Vec (Skip-gram, CBOW), Doc2Vec for representing words and documents in a vector space, GloVe (Global Vectors for Word Representation).

Contrastive Learning: SimCLR (Simple Framework for Contrastive Learning of Visual Representations) & MoCo (Momentum Contrast for Unsupervised Visual Representation Learning).

Deep Metric Learning: Triplet Loss, Siamese Networks. Representation in Graphs: Node embedding's, Graph Neural Networks (GNNs)

Unit IV- Active Learning -(12 Hours)

Query Strategies: Pool-Based Sampling, Stream-Based Sampling, Membership Query Synthesis (brief overview), and Uncertainty Sampling: Entropy, Margin Sampling, and Least Confidence.

Query by Committee (QBC), Expected Model Change, and Active Learning in Deep Learning: Bayesian neural networks, Monte Carlo (MC) Dropout for uncertainty estimation, Human-in-the-loop Systems: The role of human experts in the active learning process.

Tools/Frameworks: mod AL (Python library for modular active learning), PyTorch/Tensor Flow (for model training), Label Studio (for annotation).

Unit V- Transfer Learning -(12 Hours)

Feature-based Transfer Learning: Extracting and reusing learned features from a source model, Fine-tuning Pre trained Networks: Adapting large-scale models (CNNs like ResNet, EfficientNet; Transformers like BERT, large language models) to new tasks, Domain Adaptation: Techniques for bridging the gap between different data distributions (source and target domains), Domain Generalization: Learning models that can generalize well to unseen target domains, Few-shot and Zero-shot Learning: Learning with very limited or no labeled data in the target domain, Multi-task Learning: Training a single model to perform multiple related tasks simultaneously. Applications: Natural Language Processing (BERT and other large language models), Computer Vision, Speech recognition.

Learning Resources

Text Books:

1. Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, by Aurélien Géron.
2. Pattern Recognition and Machine Learning, by Christopher Bishop.
3. The Hundred-Page Machine Learning Book, by Andriy Burkov

Reference Books:

1. Artificial Intelligence: A Modern Approach, by Stuart Russell and Peter Norvig.
2. Deep Learning with Python" by François Chollet
3. Introduction to Machine Learning with Python" by Andreas C. Müller and Sarah Guido

E-Books Links

1. http://www.ru.ac.bd/wpcontent/uploads/sites/25/2019/03/207_05_01_Rajchka_Using-Python-for-machinelearning-2015.pdf
2. Foundation of Machine Learning: https://cs.nyu.edu/~mohri/mlbook/
3. Dive into Deep Learning: http://d2l.ai/
4. A brief introduction to machine learning for Engineers: https://arxiv.org/pdf/1709.02840.pdf
5. Feature selection: https://dl.acm.org/doi/pdf/10.5555/944919.944968
6. Introductory Machine Learning Nodes : http://lcsl.mit.edu/courses/ml/1718/MLNotes.pdf

MOOC Courses:

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-504-AID - Generative Artificial Intelligence		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Course : Artificial Intelligence

Course Objectives: The course aims to:

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

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

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

Course Contents

Unit I - Introduction to Generative AI - (12 Hours)

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

Unit II - Foundation Models & Architectures- (12 Hours)

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

Unit III - Generative AI for Text, Image & Audio Generation- (12 Hours)

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

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

Unit IV -Tools, Frameworks, and Applications - (12 Hours)

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

Unit V - Industry Use Cases & Future Trends - (12 Hours)

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

Learning Resources

Text Books

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

Reference Books:

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

SWAYAM / MOOC / YouTube Links

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

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

Prerequisite Courses : Mathematics for Data Science, Natural Language Understanding, Machine Learning Techniques, Generative Artificial Intelligence

Course Objectives: The course aims to:

1. Provide knowledge of Mathematics for Data Science for solving engineering problems
2. Explain various algorithms for solving engineering problems
3. Tell use of various Machine Learning Techniques techniques for solving engineering problems
4. Describe Generative Artificial Intelligence for solving engineering problems

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

- CO1: Apply knowledge of Mathematics for Data Science for solving engineering problems
- CO2: Choose appropriate algorithms for solving engineering problems
- CO3: Develop Machine Learning Techniques techniques for improving engineering problems solution
- CO4: Create Generative Artificial Intelligence environment while solving engineering problems

Guidelines:

- Computational Laboratory-I assignments are based on 4 Programme Core courses (Mathematics for Data Science, Natural Language Understanding, Machine Learning Techniques, Generative Artificial Intelligence)
- Respective course faculty assigned will frame course objectives, course outcomes, list of assignments, mini projects, if any
- The list of sample assignments is given for preparation of assignments which will be approved by the respective heads of Department before conduction of laboratory.

List of Assignments

Part A: Mathematics for Data Science (Any One)

1	Write a program for data transformation and reduce data dimensions in linear algebra. Implement matrix operations - addition, multiplication, inverse, eigenvalues, using Python NumPy.
2	Write a prpogram for probability distributions. Simulate and visualize - normal, binomial, and Poisson distributions and calculate expected value and variance using Python, Matplotlib, SciPy
Part B: Natural Language Understanding (Any One)	
1	Write a program for named entity recognition. Apply NER tagging to extract entities for custom text dataset using Python, spaCy.
2	Write a program for Intent Classification using BERT. Develop a fine tune a pre-trained BERT model for an intent classification dataset using tools like HuggingFace Transformers, PyTorch/TensorFlow.
Part C: Machine Learning Techniques (Any TWO)	
1	Support vector machine for multiclass classification using Python: Implement a classification model using Support vector machine algorithm for news article topic classification like science, technology, politics, sports, etc. Use sklearn dataset and/or fetch dataset using APIs.
2	Write a program for classification using Decision Trees and Random Forest. Train models on the Titanic dataset and evaluate using accuracy, precision, recall using tools Scikit-learn, Pandas.
3	Convolution Neural Network for face recognition using Python: Implement a real-world application like AI Face Recognition Entry Agent using CNN. It detects and recognizes faces in real-time environment. It should grant or denies the entry based on known faces of pre-trained databases
4	Write a program for K-Means Clustering for Customer Segmentation. Apply K-Means on customer data to identify distinct customer groups based on features like spending, income, etc. using Python, Scikit-learn, Seaborn.
Part D: Generative Artificial Intelligence (Any TWO)	
1	Coordination Problem. Two processes, A and B, communicate by sending and receiving messages on a bidirectional channel. Neither process can fail. However, the channel can experience transient failures, resulting in the loss of a subset of the messages that have been sent. Devise a protocol where either of two actions α and β are possible, but (i) both processes take the same action and (ii) neither take both actions.
2	Write a program for mage Generation using DCGAN. Develop a Deep Convolutional GAN for MNIST dataset to generate handwritten digit images using TensorFlow / PyTorch.
3	Election Problem. A set of processes P1, P2, ..., Pn must select a leader. Each process Pi has a unique identifier uid(i). Devise a protocol so that all of the processes learn the identity of the leader. Assume all processes start executing at the same time and that all communi--4 cate using broadcasts that are reliable.

4	Write a program for Text Generation using GPT pre-trained model to generate coherent text given a seed prompt. Explore text temperature and length effects using tools like HuggingFace Transformers, Colab.
Mini Project (Any ONE)	
1	Students are expected to develop a mini project based on above topics.

Learning Resources

Reference Books:

1. Sebastien Roch, “Mathematical Methods in Data Science with Python
2. Steven Bird, Ewan Klein, Edward Loper, “ Security Essentials, Natural Language Processing with Python”, Orelly, 2009.
3. Introduction to Machine Learning with Python by Andreas C. Müller and Sarah Guido
4. Hands-On Generative AI with Transformers – Utkarsh Sinha, Packt Publishing, 2023.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-521A-AID - Cloud Technology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To introduce concepts of Cloud Computing.
2. To shed light on the Security issues in Cloud Computing
3. To introduce about the Cloud Standards
4. To Implement various cloud computing environments

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

- CO1: Articulate the main concepts, key technologies, strengths, and limitations of cloud computing and the possible applications for state-of-the-art cloud computing
- CO2: Identify the architecture and infrastructure of cloud computing, including SaaS, PaaS, IaaS, public cloud, private cloud, hybrid cloud, etc.
- CO3: Explain the core issues of cloud computing such as security, privacy, and interoperability.
- CO4: Provide the appropriate cloud computing solutions and recommendations according to the applications used.

Course Contents

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

History of Centralized and Distributed Computing - Overview of Distributed Computing, Cluster computing, Grid computing. Technologies for Network based systems- System models for Distributed and cloud computing- Software environments for distributed systems and clouds.

Unit II - Cloud Computing Models (08 Hours)

Introduction to Cloud Computing- Cloud issues and challenges - Properties - Characteristics - Service models, Deployment models. Cloud resources: Network and API - Virtual and Physical computational resources - Data-storage. Virtualization concepts - Types of Virtualizations- Introduction to Various Hypervisors - High Availability (HA)/Disaster Recovery (DR) using Virtualization, Moving VMs

Unit III- Service Models-(08 Hours)

Service models - Infrastructure as a Service (IaaS) - Resource Virtualization: Server, Storage, Network - Case studies. Platform as a Service (PaaS) - Cloud platform & Management: Computation, Storage - Case studies. Software as a Service (SaaS) - Web services - Web 2.0 - Web OS - Case studies – Anything as a service (XaaS).

Unit IV- Cloud Programming -(08 Hours)

Cloud Programming and Software Environments – Parallel and Distributed Programming paradigms – Programming on Amazon AWS and Microsoft Azure – Programming support of Google App Engine – Emerging Cloud software Environment

Unit V- Cloud Access and Security- (08 Hours)

Cloud Access: authentication, authorization and accounting - Cloud Provenance and meta-data - Cloud Reliability and fault-tolerance - Cloud Security, privacy, policy and compliance- Cloud federation, interoperability and standards.

Learning Resources

Text Books

1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, "Distributed and cloud computing from Parallel Processing to the Internet of Things", Morgan Kaufmann, Elsevier – 2012.

2. Toby Velte, Anthony Velte, Robert Elsenpeter, Robert C. Elsenpeter , "Cloud Computing, A Practical Approach" , McGraw Hill LLC, ISBN: 9780071626958, 0071626956, 2009.

Reference Books:

1. Barrie Sosinsky, "Cloud Computing Bible" John Wiley & Sons, 2010

2. Tim Mather, Subra Kumaraswamy, and Shahed Latif, Cloud Security and Privacy an Enterprise Perspective on Risks and Compliance, O'Reilly 2009.

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

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

Course Objectives: The course aims to:

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

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

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

Course Contents

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

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

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

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

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

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

Unit III Deep Learning Model Development- (08 Hours)

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

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

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

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

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

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

Unit V - Deep Learning Applications in AI and DS - (08 Hours)

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

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

Learning Resources

Text Books

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

Reference Books:

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

SWAYAM / MOOC / YouTube Links

1. https://www.deeplearningbook.org/

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

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

Course Objectives: The course aims to:

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

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

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

Course Contents

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

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

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

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

Blockchain Scalability and Interoperability

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

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

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

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

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

Blockchain and Cloud Computing

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

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

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

Learning Resources

Text Books

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

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

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

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

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

Reference Books:

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

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

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

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

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-521D-AID: Recommendation Systems		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Provide knowledge of Basic Models of Recommender Systems.
2. Elaborate Model-Based Collaborative Filtering.
3. Explain Content-Based and Knowledge-Based Recommender Systems
4. Describe for building a Recommender Systems for Movies.

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

- CO1: Understand Basic Models of Recommender Systems.
- CO2: Explain Model-Based Collaborative Filtering.
- CO3: Analyze Content-Based and Knowledge-Based Recommender Systems
- CO4: Build a Recommender Systems for Movies.

Course Contents

Unit I-Introduction to Recommender Systems-(08 Hours)

Introduction, Goals of Recommender, Basic Models of Recommender Systems, Domain-Specific Challenges in Recommender Systems, Advanced Topics and Applications

Unit II-IoT: Neighborhood-Based and Model-Based Collaborative Filtering-(08 Hours)

Introduction, Key Properties of Ratings, Predicting Ratings with Neighborhood-Based Methods, Clustering and Neighborhood-Based Methods, Dimensionality Reduction and Neighborhood, A Regression Modeling View of Neighborhood, Graph Models for Neighborhood-Based Methods

Decision and Regression Trees, Rule-Based Collaborative Filtering, Naive Bayes Collaborative Filtering, Using an Arbitrary Classification Model as a Black-Box, Latent Factor Models, Integrating Factorization and Neighborhood Models

Unit III- Content-Based and Knowledge-Based Recommender Systems-(08 Hours)

Content-Based and Knowledge-Based Recommender Systems

Basic Components of Content-Based Systems, Preprocessing and Feature Extraction, Learning User Profiles and Filtering, Content-Based Versus Collaborative, Using Content-Based Models for Collaborative Filtering.

Constraint-Based Recommender, Case-Based Recommenders, Persistent Personalization in Knowledge-Based Systems

Unit IV- Ensemble-Based and Hybrid Recommender Systems-(08 Hours)

Ensemble Methods from the Classification Perspective, Weighted Hybrids, Switching Hybrids, Cascade Hybrids, Feature Augmentation Hybrids, Meta-Level Hybrids, Feature Combination Hybrids, Mixed Hybrids

Unit V- Evaluating Recommender Systems-(08 Hours)

Evaluation Paradigms, General Goals of Evaluation Design, Accuracy Metrics in Offline Evaluation, Limitations of Evaluation Measures

Learning Resources

Text Books

1. Charu C. Aggarwal, "Recommender Systems", Springer, 2016, ISBN 978-3-3-319-29657-9, ISBN 978-3-319-29659-3 (eBook), DOI 10.1007/978-3-319-29659-3.

2. Dietmar Jannach, Markus Zanker, Alexander Felfernig and Gerhard Friedrich, Recommender Systems: An Introduction, Infinity Science Press,2008 ISBN: 978-1-934015-16-2.

Reference Books:

1. Francesco Ricci, Lior Rokach, Bracha Shapira and Paul B. Kantor, Recommender Systems Handbook, Springer, ISBN 978-0-387-85819-7, e-ISBN 978-0-387-85820-3, DOI 10.1007/978-0-387-85820-3

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-522-AID - Skill Based Laboratory - I		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 02 Hours/Week	01	**Term Work** : 25 Marks **Oral**: 25 Marks

Prerequisite Courses : Programme Elective Course

Guidelines for Skill Based Laboratory

- Skill Based Laboratory are based on the electives chosen by the students (Cloud Computing, Deep Learning, Blockchain Technology, Recommendation Systems)
- Respective course faculty assigned will frame course objectives, course outcomes, list of assignments, mini projects and references
- The list of assignments should be prepared and approved by the respective heads of Department before conduction of laboratory

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

Part A - Cloud Computing

1. Create a virtual machine on AWS EC2, launch an EC2 instance and install a web server Apache /Nginx to deploy a static website using tools - AWS Free Tier, EC2, SSH.
2. Manage a cloud storage with Amazon S3 / Google Cloud Storage and upload, retrieve, manage files using CLI and SDKs in S3 buckets using tools - AWS CLI / Google Cloud CLI, Python SDK.
3. Deploy dockerized App on Google Kubernetes Engine to containerize a Python/Flask app and deploy it on GKE with auto-scaling enabled using tools like - Docker, Kubernetes, GCP

Part A - Deep Learning

1. Write a program to build CNN model for mage Classificationon the CIFAR-10/ MNIST datasets using tools - TensorFlow/Keras or PyTorch.
2. Write a program to build LSTM model to classify movie reviews - positive/negative for sentiment analysis using LSTM using tools - Keras, NLTK, IMDB datasets.
3. Write a program to build a fine-tune a pretrained CNN model for a custom image classification datasets for transfer learning with Pretrained ResNet /VGG using tools - PyTorch/ TensorFlow.

Part A - Blockchain Technology

1. Create a basic blockchain with blocks, proof-of-work, and hashing mechanism using Python.
2. Develop a smart contract to write, deploy and interact with smart contract - voting / wallet using tools Solidity, Remix IDE, MetaMask.

3. Set up a private Ethereum blockchain and deploy a smart contract using Truffle using tools Ganache, Truffle Suite.

Part A - Recommendation Systems

1. Write a program for movie recommendation system using collaborative filtering and cosine similarity. Use user rating matrix and similarity measures and tools - Python, Pandas, Scikit-learn.

2. Write a program for articles / movies recommendation using content-based filtering and TF-IDF similarity matrix . Use tools - Scikit-learn, Pandas.

3. Write a program for matrix factorization using SVD to reduce dimensionality and improve recommendation quality using tools- Python, Surprise library.

Part B - Mini Project

- **Cloud Computing :** Multi-Tier Web Application Deployment on AWS Cloud: Design a full-stack cloud-native apps with real-world deployment and deploy a secure, scalable cloud-based web app using tools - EC2, RDS, S3.

- **Deep Learning :** AI-based Face Mask Detection System using Deep Learning: Design a deep learning model - CNN to detect face masks in real-time video inference using tools - PyTorch/ TensorFlow. (Instructor can select any DL models for any real- world problems).

- **Blockchain Technology :** Blockchain-based Certificate Issuing System: Design DApp architecture with immutability and trust features. Build a DApp that stores and verifies academic certificates securely on blockchain.

- **Recommendation Systems :** Personalized Book Recommendation System: Develop a hybrid recommender system to handle data preprocessing, model evaluation and hybrid model integration that combines content and collaborative filtering for personalized book suggestions.

Learning Resources

Text Books:

1. Toby Velte, Anthony Velte, Robert Elsenpeter, Robert C. Elsenpeter , “Cloud Computing, A Practical Approach” , McGraw Hill LLC, ISBN: 9780071626958, 0071626956, 2009.

2. "Deep Learning with Python" by Francois Chollet

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

4. Charu C. Aggarwal, “Recommender Systems”, Springer, 2016, ISBN 978-3-3-319-29657-9, ISBN 978-3-319-29659-3 (eBook), DOI 10.1007/978-3-319-29659-3.

Savitribai Phule Pune University, Pune

Maharashtra, India

M. E. - Artificial Intelligence and Data Science (2025 Pattern)

Semester II

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-551-AID: Explainable Artificial Intelligence		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Understand the importance and need for interpretability in AI systems.
2. Explore techniques for explainability in classical ML and deep learning models.
3. Explore explainability in deep learning and NLP models, including attention-based and saliency-based techniques.
4. Gain hands-on experience with XAI tools and libraries.
5. Examine case studies and applications in healthcare, finance, and autonomous systems.

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

- CO1: Justify the need for explainability in AI systems.
- CO2: Implement and compare various XAI methods.
- CO3: Analyze deep learning models using explainability tools such as saliency maps and attention visualizations.
- CO4: Apply XAI in real-world domains like healthcare, finance, legal tech, etc.
- CO5: Apply visual explanations techniques such as PDP, ICE, Surrogate Models, and Feature Importance.

Course Contents

Unit I- Introduction to XAI -(12 Hours)

Introduction to the multidisciplinary topics of explainable AI, what is XAI, why is it important, XAI terminologies Dimensions of interpretability,
Ethical and legal implications (GDPR, etc.), Types of explainability and Taxonomy, Explainability in the model development process.

Unit II- Interpretable Machine Learning-(12 Hours)

Broad taxonomy of XAI methods including Intrinsic vs post hoc, model-specific vs model-agnostic, and local vs global.
Perturbation-based feature attribution (LIME, Anchors, SHAP, etc.)
Propagation-based feature attribution methods (e.g., Relevance Propagation, Saliency methods, etc.)
Tools: ELI5, LIME

Unit III- Explainability in Deep Learning-(12 Hours)

Feature visualization, Saliency maps, Grad-CAM, and LRP, Attention mechanisms, Concept activation vectors (TCAV)

XAI for Natural Language Processing: Attention and explainability in Transformers, Attribution methods for NLP, Challenges in interpreting language models

Unit IV- Intrinsically explainable models-(12 Hours)

Intrinsically explainable models including Linear Regression, Logistic Regression, Generalized Linear Model (GLM), Generalized Additive Model (GAM), and Decision Tree.

Unit V- Visual Explanations-(12 Hours)

XAI methods include Partial Dependence Plot (PDP), Conformal Prediction, Individual Conditional Expectation (ICE), Feature Importance, and Saliency Maps.

Local Interpretable Model-Agnostic Explanations (LIME), SHAP, Integrated Gradient (IG) Evaluation of explainability

Learning Resources

Text Books

1. "Interpretable Machine Learning" by Christoph Molnar (open access)
2. "Explainable AI: Interpreting, Explaining and Visualizing Deep Learning" edited by Samek et al.

Reference Books:

1. “Explainable AI for Practitioners”, by Michael Munn, David Pitman. Released October 2022 Publisher(s): O’Reilly Media, Inc.ISBN: 9781098119133
2. Explainable AI: Interpreting, Explaining and Visualizing Deep Learning, Lecture Notes in Artificial Intelligence, Springer Nature, 2019
3. Denis Rothman “Hands-On Explainable AI (XAI with Python”, Packt Publishing, 2020.
4. "Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way" By Virginia Dignum.
5. "Explainable AI: Foundations, Developments, Prospects and Challenges" by Wilfried Grossmann

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-552-AID: AI in Cyber Security		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To introduce AI techniques and their applicability in cybersecurity systems.
2. To enable the use of machine learning and deep learning for real-time threat detection.
3. To equip students with the skills to design intelligent, secure systems using data science.
4. To understand adversarial attacks, defense strategies, and AI model robustness.
5. To explore the ethics, privacy, and compliance aspects of AI in security.

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

- CO1: Analyze cyber threats using AI/ML models.
- CO1: Apply supervised and unsupervised learning for anomaly and intrusion detection.
- CO1: Develop AI-based models for malware, phishing, and fraud detection.
- CO1: Evaluate adversarial machine learning challenges and secure model training.
- CO1: Demonstrate understanding of ethical and privacy issues in AI-driven cybersecurity system.

Course Contents

Unit I- Foundations of AI in Cybersecurity -(12 Hours)

Introduction of Cybersecurity, threats, vulnerabilities, attacks, role of AI in cyber privacy and security, cybersecurity data, Logs, events, network flows, user behavior, Introduction to AI/ML/DL for Cybersecurity, Cyber threat detection, imbalanced data, concept drift, real-time requirements.

Unit II- Machine Learning for Cyber Threat Detection -(12 Hours)

Supervised Learning, SVM, Decision Trees, Naive Bayes, Random Forest, unsupervised learning -k-Means, DBSCAN, autoencoders, semi-supervised learning, reinforcement learning in Security, feature Engineering for security datasets. intrusion detection Prevention using ML

Unit III- Deep Learning and NLP in Cybersecurity -(12 Hours)

Overview of DL and NLP, CNN & RNN for packet analysis and malware detection, LSTM for Log sequence analysis, transformer models like BERT, GPT for threat intelligence, NLP for phishing email, URL detection, dark web monitoring, applications for spam filtering, threat detection, limitations of deep models in Security.

Unit IV- Adversarial AI & Model Security -(12 Hours)

Adversarial machine learning, attack surface in AI models, attack types - evasion, poisoning, inference attacks, Adversarial training, robust ML, privacy-preserving AI, differential Privacy, security in AI Pipelines - data integrity, model hardening, Explainability in AI security models.

Unit V- AI for Cyber Security (12 Hours)

Adversarial attacks on ML systems, model poisoning, Security Information and Event Management(SIEM), Phishing Detection, User and Entity Behavior Analytics(UEBA) Behavior Analytics, Malware Analysis, Security Log Analysis, End Point Security, Benefits and Challenges of using AI in cyber security.

Learning Resources

Text Books

1. Artificial Intelligence for Cybersecurity: Techniques, Applications, and Challenges, Springer
2. Hands-On Machine Learning for Cybersecurity, Soma Halder & Sinan Ozdemir.

Reference Books:

1. Machine Learning and Security, Clarence Chio, David Freeman, O'Reilly
2. Cyber Security Essentials, James Graham, Richard Howard and Ryan Otson, CRCPress.
3. Introduction to Cyber Security, Chwan-Hwa(john) Wu,J. David Irwin, CRC Press T&FGroup.
4. Introduction to Cyber Security: Jatindra Pandey.

SWAYAM / MOOC / YouTube Links

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PCC-553-AID: Data Visualization Techniques		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Know the art and science of turning data into readable graphics.
2. Design and create data visualizations based on data available and tasks to be achieved.
3. Know the processes includes data modeling, data processing, mapping data attributes to graphical attributes, and strategic visual encoding based
4. Learn and evaluate the effectiveness of visualization designs, and think critically about each design decision, such as choice of color and choice of visual encoding.

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

- CO1: Familiarize with the fundamentals of Data Visualization Techniques.
- CO2: Perform data visualizations based on data available and tasks to be achieved.
- CO3: Apply data modeling, data processing, mapping data attributes and strategic visual encoding
- CO4: Distinguish color and choice of visual encoding.
- CO5: evaluate the effectiveness of visualization designs in real life problem.

Course Contents

Unit I- Fundamentals of Data Visualization Techniques-(12 Hours)

Foundation: Importance of analytics and visualization in the era of data abundance, 2-D Graphics, 2-D Drawing, 3-D Graphics, Photorealism, Non-Photorealism, The Human Retina, Perceiving Two Dimensions, Perceiving Perspective.

Unit II- Visualization of Numerical Data-(12 Hours)

Visualization of Numerical Data: Data Mapping, Charts, Glyphs, Parallel Coordinates, Stacked Graphs, Tufte's Design Rules, Using Colours.

Unit III- Visualization of Non-Numerical Data -(12 Hours)

Visualization of Non-Numerical Data: Graphs and Networks, Embedding Planar Graphs, Graph Visualization, Tree Maps, Principal Component Analysis, Multidimensional Scaling, Packing.

Unit IV- Visualization Dashboard-(12 Hours)

Visualization Dashboard: Visualization Systems, Database Visualization, Visualization System Design.

Unit V- Analysis Case Studies - (12 Hours)

Graph-Theoretic Scagnostics, VisDB, Hierarchical Clustering Explorer, PivotGraph, InterRing Constellation Application of models in Data Visualization Techniques.

Learning Resources

Text Books

1. T. Munzner, Visualization Analysis and Design, CRC Press, 2015.
2. Edward Tufte, The Visual Display of Quantitative Information (2nd edition), Graphics Press.
3. Colin Ware, Information Visualization: Perception for Design (2nd edition), Morgan Kaufmann.
4. Alberto Cairo, The Functional Art: An Introduction to Information Graphics and Visualization, New Riders, Pearson Education.
5. Nathan Yau, Data Points: Visualization That Means Something, Wiley.
6. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press.
7. Will Schroeder, Ken Martin, and Bill Lorensen, The Visualization Toolkit: An Object-Oriented Approach to 3D Graphics, Kitware Inc. Publisher

Reference Books:

1. Nathan Yau, Data Points: Visualization That Means Something, Wiley.
2. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press.
3. Will Schroeder, Ken Martin, and Bill Lorensen, The Visualization Toolkit: An Object-Oriented Approach to 3D Graphics, Kitware Inc. Publisher

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

Course Objectives: The course aims to:

1. Understand and apply ML techniques to improve transparency and trust in AI systems.
2. Apply explainable AI techniques to understand decision making models.
3. Visually explore and interpret data using various visualization tools and techniques.

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

- CO1: Understand feature importance and model behavior on real-world datasets using tools.
- CO2: Develop AI-based systems to identify suspicious activity in real-world scenarios.
- CO3:Create charts and visual summaries using tools like Matplotlib, Plotly, or Excel.

Guidelines:

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

List of Assignments

Part A: Explainable Artificial Intelligence (Any one)	
1	Write a program to generate and interpret the feature importance charts to explain model behavior using global explainability for health datasets.
2	Write a program to Interpret House Price Predictions using regression mode / XGBoost. Use SHAP values to explain price predictions and housing datasets.
Part B: AI for Cyber Security (Any TWO)	
1	Write a program to distinguish between spam and non-spam emails using Naive Bayes / Logistic Regression model spam detection dataset - SMS Spam Collection.
2	Write a program to detecting unusual login behavior of a model and secure systems from unauthorized access using dataset with login times, user IDs, and IP addresses.
Part C: Data Visualization Techniques (Any two)	
1	Loading a Sample Dataset and Calculating the Mean using NumPy

	a) to compute the Mean, Median, Variance, and Standard Deviation of a Dataset
	b) use the features to index, slice, split, and iterate
2	Loading a Sample Dataset and Calculating the Mean using Pandas
	a) to Compute the Mean, Median, and Variance of a Dataset
	b) use the features to index, slice, split, and iterate
3	Visualizing Stock Trends by Using a line plot, basic plots
4	Analyzing Visualizations for choosing the best suitable plot for a scenario.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-561A-AID: Social Media Analytics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

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

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

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

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

Course Contents

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

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

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

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

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

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

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

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

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

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

Learning Resources

Text Books

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

Reference Books:

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

SWAYAM / MOOC / YouTube Links

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-561B-AID: Quantum Computing		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

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

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

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

Course Contents

Unit I -Introduction and The Leap from Classical to Quantum - (08 Hours)

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

Unit II - Basic Quantum Theory & Architecture- (08 Hours)

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

Unit III -Algorithms & Programming Languages - (08 Hours)

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

Unit IV - Theoretical Computer Science and Cryptography- (08 Hours)

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

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

Unit V - Information Theory & Hardware - (08 Hours)

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

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

Learning Resources

Text Books

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

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

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

Reference Books:

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

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

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-561C-AID: Business Intelligence		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses : Linear algebra and Probability

Course Objectives: The course aims to:

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

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

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

Course Contents

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

Why Business Intelligence? The Information Asset, Exploiting Information, Business Intelligence and Program Success, what is Business Intelligence? Actionable Knowledge

Business Case, Business Intelligence Process, System Infrastructure, Information Access, Delivery, and Analysis Services, Management Issues

Unit II - Business Models (08 Hours)

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

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

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

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

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

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

Unit IV - Information Integration- (08 Hours)

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

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

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

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

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

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

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

Learning Resources

Text Books

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

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

Reference Books:

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-561D-AID: Spatial Data Analytics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Explain Geographic Information Systems components
2. Describe Geographic Information Systems Analysis and Modeling
3. Elaborate Spatial Data Analyses Techniques
4. Discuss Geostatistical Analysis Techniques
5. Explore decision making process and decision support systems

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

- CO1: Understand Geographic Information Systems components
- CO2: Apply Geographic Information Systems Analysis and Modeling for real-time example
- CO3: Implement Spatial Data Analyses Techniques for chosen real-time example
- CO4: Analyse Geostatistical Analysis Techniques for chosen real-time example
- CO5: Use decision making process to create real-time decision support system.

Course Contents

Unit I- Introduction to Spatial Data -(08 Hours)

Basic concepts: Definition and history, Components of GIS, Data structure and formats, Spatial data models – Raster and Vector, Data base design - editing and topology creation in GIS, Linkage between spatial and non-spatial data, Data inputting in GIS

Unit II- Introduction to GIS Analysis and Modeling -(08 Hours)

Spatial Data: Definition, Analysis, Processes & Steps, Software and Tools Raster-Based and Vector-Based GIS Modeling, Binary Models, Index Models, Regression Models, Process Models Geodatabase Model, Role of Databases in GIS, Creating, Editing and Managing

Unit III- Spatial Data Analyses Techniques -(08 Hours)

Classification Scheme of Vector-Based and Raster-Based GIS Operations

Raster–Based Techniques: Methods of Reclassification, Overlay Analysis, Slope and Aspects, Buffering, Cost-Distance Calculation

Vector-Based Techniques: Map Manipulation Techniques, Buffering, Overlay Analysis, Network Analysis

Digital Terrain Analyses and Modeling: TIN and DEM, Surface Representation & Analysis

Unit IV- Geostatistical Analysis Techniques -(08 Hours)

Introduction to Spatial Interpolation: Control Points
Global Methods: Trend Surface Analysis, Regression Models
Local Methods: Thiessen Polygons, Density Estimation, Inverse Distance Weighted
Interpolation Kriging: Ordinary Kriging (Semivariance, Semivariogram), Universal Kriging,

Unit V- Decision Support System -(08 Hours)

GIS and decision support system, Introduction to decision making process and decision support systems, Introduction of a frame work for planning and decision making, Spatial Decision Making, Development of DSS, DSS Architecture, Principles and components of multiple-criteria decision making, Main multiple-criteria evaluation methods/techniques, Spatial multiple criteria decision making, Multiple-criteria decision making in spatial data analysis
Introduction to AHP, Basic Principles of AHP, Effect Table, Pair Wise comparison, Standardization, Consistency, Weightage, performance score, Different method in PWC

Learning Resources

Text Books

1. Burrough, Peter A. and Rachael McDonnell., (1998), Principles of Geographical Information Systems. Oxford University Press, New York
2. Laurini, Robert and Derek Thompson. , (1992), Fundamentals of Spatial Information Systems. Academic Pr., London
3. Kluwer Fotheringham A S, O'Kelly M E., (1998), Spatial Interaction Models: Formulations and Applications.
4. Paul Longley, Michael Goodchild, David Maguire and David Rhind:, (2005), Geographical Information Systems: Principles, Techniques, Applications and Management. John Wiley & Sons.

Reference Books:

1. Bonczek, R.H., C.W. Holsapple, and A.B. Whinston, (1981), Foundations of Decision Support Systems, Academic Press, New York.
2. House, W.C. (ed.), (1983). Decision Support Systems, Petrocelli, New York.
3. Sprague, R.H., and Carlson, E.D., (1982). Building Effective Decision Support Systems, Prentice-Hall, Englewood Cliffs NJ.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-562A-AID - Federated Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

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

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

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

Course Contents

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

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

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

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

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

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

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

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

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

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

Learning Resources

Text Books

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

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

Reference Books:

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

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

SWAYAM / MOOC / YouTube Links

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-562B-AID: Bigdata Analytics		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Understand the Big Data Platform and its Use cases
2. Provide an overview of Apache Hadoop
3. Provide HDFS Concepts and Interfacing with HDFS
4. Understand Map Reduce Jobs and Provide hands on Hodoop Eco System
5. Apply analytics on Structured, Unstructured Data.

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

- CO1: Identify Big Data and its Business Implications.
- CO2: List the components of Hadoop and Manage Job Execution in Hadoop Environment
- CO3: Access and Process Data on Distributed File System
- CO4: Develop Big Data Solutions and analyze Infosphere Big Insights .
- CO5: Apply Machine Learning Techniques using R.

Course Contents

Unit I- INTRODUCTION TO BIG DATA AND HADOOP -(08 Hours)

Types of Digital Data, Introduction to Big Data, Big Data Analytics, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, Analysing Data with Hadoop, Hadoop Streaming, Hadoop Echo System, IBM Big Data Strategy, Introduction to Infosphere Big Insights and Big Sheets.

Unit II- HDFS (Hadoop Distributed File System) -(08 Hours)

The Design of HDFS, HDFS Concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data Ingest with Flume and Scoop and Hadoop archives, Hadoop I/O: Compression, Serialization, Avro and File-Based Data structures.

Unit III- Map Reduce -(08 Hours)

Anatomy of a Map Reduce Job Run, Failures, Job Scheduling, Shuffle and Sort, Task Execution, Map Reduce Types and Formats, Map Reduce Features.

Unit IV- Hadoop Eco System -(08 Hours)

Pig : Introduction to PIG, Execution Modes of Pig, Comparison of Pig with Databases, Grunt, Pig Latin, User Defined Functions, Data Processing operators.

Hive : Hive Shell, Hive Services, Hive Metastore, Comparison with Traditional Databases, HiveQL, Tables, Querying Data and User Defined Functions.

Hbase : HBasics, Concepts, Clients, Example, Hbase Versus RDBMS.

Big SQL

Unit V- Data Analytics with R -(08 Hours)

Machine Learning : Introduction, Supervised Learning, Unsupervised Learning, Collaborative Filtering. Big Data Analytics with BigR.

Learning Resources

Text Books

1. Tom White “Hadoop: The Definitive Guide” Third Edit on, O’reily Media, 2012.
2. Seema Acharya, Subhasini Chellappan, "Big Data Analytics” Wiley 2015.

Reference Books:

1. Michael Berthold, David J. Hand, "Intelligent Data Analysis”, Springer, 2007.
2. Jay Liebowitz, “Big Data and Business Analytics” Auerbach Publications, CRC press (2013)
3. Tom Plunkett, Mark Hornick, “Using R to Unlock the Value of Big Data: Big Data Analytics with Oracle R Enterprise and Oracle R Connector for Hadoop”, McGraw-Hill/Osborne Media (2013), Oracle press.
4. Anand Rajaraman and Jeffrey David Ulman, “Mining of Massive Datasets”, Cambridge University Press, 2012.
5. Bill Franks, “Taming the Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics”, John Wiley & sons, 2012.
6. Glen J. Myat, “Making Sense of Data”, John Wiley & Sons, 2007
7. Pete Warden, “Big Data Glossary”, O’Reily, 2011.
8. Michael Mineli, Michele Chambers, Ambiga Dhiraj, "Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today’s Businesses", Wiley Publications, 2013.
9. ArvindSathi, “Big Data Analytics: Disruptive Technologies for Changing the Game”, MC Press, 2012
10. Paul Zikopoulos ,Dirk DeRoos , Krishnan Parasuraman , Thomas Deutsch , James Giles , David Corigan , "Harness the Power of Big Data The IBM Big Data Platform ", Tata McGraw Hill Publications, 2012.

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-562C-AID: Reinforcement Learning		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. Explain dynamic programing-based methods
2. Describe iteration and value iteration algorithms for control of MDP
3. Elaborate incremental computation of Monte Carlo Methods, Temporal Difference (TD) methods.
4. Provide knowledge of different on and off policy evaluation and control methods with function approximation.
5. Explain naive REINFORCE algorithm, different variance reduction techniques and Actor-Critic methods

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

- CO1: Evaluate policies using dynamic programing-based methods
- CO2: Understand policy iteration and value iteration algorithms for control of MDP
- CO3: Understand incremental computation of Monte Carlo Methods, different Temporal Difference (TD) methods.
- CO4: Get familiar with different on and off policy evaluation and control methods with function approximation.
- CO5: Get familiar with naive REINFORCE algorithm, different variance reduction techniques and Actor-Critic methods.

Course Contents

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

Origin and history of Reinforcement Learning research. Its connections with other related fields and with different branches of machine learning. Brush up of Probability concepts - Axioms of probability, concepts of random variables, PMF, PDFs, CDFs, Expectation. Concepts of joint and multiple random variables, joint, conditional and marginal distributions. Correlation and independence.

Unit II- Markov Decision Process-(08 Hours)

Introduction to RL terminology, Markov property, Markov chains, Markov reward process (MRP). Introduction to and proof of Bellman equations for MRPs along with proof of existence of solution to Bellman equations in MRP. Introduction to Markov decision process (MDP), state and action value

functions, Bellman expectation equations, optimality of value functions and policies, Bellman optimality equations.

Unit III- Prediction and Control by Dynamic Programing-(08 Hours)

Overiew of dynamic programing for MDP, definition and formulation of planning in MDPs, principle of optimality, iterative policy evaluation, policy iteration, value iteration, Banach fixed point theorem, proof of contraction mapping property of Bellman expectation and optimality operators, proof of convergence of policy evalutation and value iteration algorithms, DP extensions.

Unit IV- Temporal Difference Methods for Model Free Prediction and Control-(08 Hours)

Overview of Monte Carlo methods for model free RL, First visit and every visit Monte Carlo, Monte Carlo control, On policy and off policy learning, Importance sampling.

Incremental Monte Carlo Methods for Model Free Prediction, Overview TD(0), TD(1) and TD(λ), k-step estimators, unified view of DP, MC and TD evaluation methods, TD Control methods - SARSA, Q-Learning and their variants.

Unit V- Function Approximation Methods-(08 Hours)

Getting started with the function approximation methods, Revisiting risk minimization, gradient descent from Machine Learning, Gradient MC and Semi-gradient TD(0) algorithms, Eligibility trace for function approximation, Afterstates, Control with function approximation, Least squares, Experience replay in deep Q-Networks. Log-derivative trick, Naive REINFORCE algorithm, bias and variance in Reinforcement Learning, Reducing variance in policy gradient estimates, baselines, advantage function, actor-critic methods.

Learning Resources

Text Books

1. “Reinforcement Learning: An Introduction”, Richard S. Sutton and Andrew G. Barto, 2nd Edition, The MIT Press, 2018

2. “An Introduction to Deep Reinforcement Learning”, Vincent François-Lavet, Peter Henderson, Riashat Islam, Marc G. Bellemare and Joelle Pineau,

3. “Algorithms for Reinforcement Learning”, Csaba Szepesvari.

Reference Books:

1. “Probability, Statistics, and Random Processes for Electrical Engineering”, 3rd Edition,

2. Alberto Leon-Garcia, Lecture Notes on Introduction to Probability, Dimitri P. Bertsekas and John N. Tsitsiklis,

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
PEC-562D-AID : Game Theory and Applications		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 03 Hours/Week	03	**CCE** : 50 Marks **End-Semester**: 50 Marks

Course Objectives: The course aims to:

1. To understand the game concept and visualization
2. To study user interface and various elements of game.
3. To understand game design process and & apply to develop game applications.
4. To be able to design 2D and 3D Models using tools.
5. To study AI principles to problem solving, knowledge representation, learning.

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

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

Course Contents

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

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

Case study: Write a game architecture for target shooting game

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

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

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

Unit III- Game Design Process-(08 Hours)

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

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

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

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

Unit V- Game Applications -(08 Hours)

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

Learning Resources

Text Books

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

Reference Books:

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

SWAYAM / MOOC / YouTube Links

1. Mike MrMike McShaffry , David Rez Graham, “Game Coding Complete”, Fourth Edition, Course Technology, a part of Cengage Learning Publisher, ISBN-13: 978-1-133-77657-4. https://ms.z-library.sk/book/2072433/3f7bf2/game-coding-complete-fourth-edition.html
2. Gabe Zechermann, Christopher Cunningham, Gamification by Design, Oreilly, ISBN: 978-1-449-39767-8, 2011. http://storage.libre.life/Gamification_by_Design.pdf
3. Jun Tanimoto, Fundamentals of Game Theory and its Applications, Volume 6, Springer, ISBN: 978-4-431-54961-1, 2015. https://link.springer.com/book/10.1007/978-4-431-54962-8

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
SEM-581-AID - 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 and Data Science (2025 Pattern)

Semester III

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
RM-601-AID - Research Methodology		
Teaching Scheme	**Credits**	**Examination Scheme**
Theory : 04 Hours/Week	04	**CCE** : 50 Marks **End-Semester**: 50 Marks

Prerequisite Courses :

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

Course Objectives: The course aims to:

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

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

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

Course Contents

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Learning Resources

Text Books

1. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
2. Kothari, C.R.,1985, Research Methodology-Methods and Techniques, New Delhi, Wiley Eastern Limited.
3. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed), Singapore, Pearson Education.
4. Neeraj Pandey, Intellectual Property Rights ,1st Edition, PHI
5. Shrivastava, Shenoy& Sharma, Quantitative Techniques for Managerial Decisions, Wiley

Reference Books:

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

SWAYAM / MOOC / YouTube Links

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

Savitribai Phule Pune University Master of Engineering (2025 Course) - Artificial Intelligence and Data Science		
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 and Data Science (2025 Course)		
SEM-603-AID - Technical Seminar - II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 08 Hours/Week	04	**Term Work:**50 Marks **Oral/Presentation:** 50 Marks

Course Description:

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

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

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

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

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

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

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

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

Responsibility of the students:

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

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

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

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

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

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

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

Learning Resources

Text Books

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

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
RPR-604-AID - 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 and Data Science (2025 Pattern)

Semester IV

Savitribai Phule Pune University Master of Engineering - Artificial Intelligence and Data Science (2025 Course)		
SEM-651-AID - 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 and Data Science (2025 Course)		
RPR-652-AID - Research Project Stage-II		
Teaching Scheme	**Credits**	**Examination Scheme**
Practical: 36 Hours/Week	18	**Term Work:**150 Marks **Oral/ Presentation :** 50 Marks

Prerequisite : Research Project Stage-I

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

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

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

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

Guidelines for Research Project

- **General Guidelines**
  - The student shall consolidate and complete the remaining part of the research work started in Semester III. This will consist of Selection of Technology, Installations, implementations, testing, Results, measuring performance, discussions using data tables per parameter considered for the improvement with existing/known algorithms/systems, comparative analysis, validation of results and conclusions.

- The student shall prepare the duly certified final report of dissertation in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.
- The students are expected to validate their study undertaken by publishing it at standard platforms.
- The investigations and findings need to be validated appropriately at standard platforms like conference and/or peer reviewed journal.
- The student has to exhibit continuous progress through regular reporting and presentations and proper documentation of the frequency of the activities in the sole discretion of the PG coordination/Head of the department. The continuous assessment of the progress needs to be documented unambiguously.
- Supervisor Interaction: Minimum one meeting per week.
- Logbook: Maintain a record of work progress and supervisor comments.
- Ethics: No plagiarism, false results, or unethical practices allowed.
- Backup: Keep source code, datasets, and reports backed up securely.
- Submission Format: Soft copy (PDF) + Hard copy as per institute norms.

- **Key Components:**
  - **Implementation**
    - Complete development/simulation/testing of the system or model.
    - Ensure correctness, efficiency, and validation of results.
  - **Results & Analysis**
    - Include experimental setup, datasets used, performance metrics.
    - Graphs, tables, and comparison with existing techniques.
    - Highlight key findings and their significance.
  - **Conclusion and Future Work**
    - Summarize outcomes, contributions, and applications.
    - Suggest extensions or improvements for future research.
  - **Paper Publication**
    - At least one paper (optional/encouraged) in peer-reviewed conference/journal.
    - Attach publication/proof as appendix (if available).
  - **Final Report Format**
    - Revised version of Stage 1 report with added implementation, results, and conclusion chapters.
    - Maintain academic writing standards and include all necessary references.
  - **Plagiarism Report**

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

- **Evaluation Parameters**
    - Completeness and quality of implementation
    - Anaysis and originality of results
    - Qulity of documentation and adherence to format
    - Viv-voce performance and clarity of understanding
    - Contribution to knowledge or innovation

Task Force for Curriculum Design and Development

Programme Coordinator

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

Team Members for Course Design

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