

Zeal Education Society's
ZEAL COLLEGE OF ENGINEERING & RESEARCH, PUNE – 41

(An Autonomous Institute Affiliated to Savitribai Phule Pune University)

NBA Accredited, NAAC Accredited with A+ Grade, ISO 21001:2018



DEPARTMENT OF ARTIFICIAL INTELLIGENCE & DATA SCIENCE

Curriculum Structure and Syllabus of

T.Y. B. Tech. – Artificial Intelligence & Data Science

(With effect from - Academic Year 2026 - 27)
(2024 Pattern)

VISION OF THE INSTITUTE

To be a premier institute in technical education by imparting academic excellence, research, social and entrepreneurial attitude.

MISSION OF THE INSTITUTE

- To achieve academic excellence through innovative teaching and learning process.
- To imbibe the research culture for addressing industry and societal needs.
- To inculcate social attitude through community engagement initiatives.
- To provide conducive environment for building the entrepreneurial skills



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

MISSION:

- M1:** To empower students for developing intelligent systems and innovative products through academic excellence.
- M2:** To produce competent computer professionals to serve the needs of the society by preserving human core values.
- M3:** To provide research culture and conducive environment for entrepreneurship and to solve industry needs.

PROGRAM EDUCATIONAL OBJECTIVES (PEOs):

- PEO1:** To provide graduates with the proficiency to utilize the fundamental knowledge of basic sciences, mathematics, Artificial Intelligence, data science and statistics to build systems that require management and analysis of large volume of data.
- PEO2:** To enrich graduates with necessary technical skills to pursue pioneering research in the field of AI and Data Science and create disruptive and sustainable solutions for the welfare of ecosystems.
- PEO3:** To enable graduates to think logically, pursue lifelong learning and collaborate with an ethical attitude in a multidisciplinary team.

PROGRAM OUTCOMES (POs):

- PO1: Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- PO2: Problem analysis:** Problem Analysis: Identify, formulate, analyze, and solve complex engineering problems using computational thinking, artificial intelligence, machine learning, and data analytics techniques..
- PO3: Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- PO4: Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.



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- PO5: Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- PO6: The engineer and society:** The Engineer and Society: Apply engineering principles while considering societal needs, legal regulations, ethics, cybersecurity, privacy, safety, inclusiveness, and the broader impact of AI technologies.
- PO7: Ethics and Professional Responsibility:** Demonstrate integrity, professional ethics, responsible AI practices, fairness, transparency, accountability, intellectual property awareness, and adherence to applicable standards and regulations..
- PO8: Individual and Team Work:** Function effectively as an individual and as a member or leader in multidisciplinary and multicultural teams to accomplish engineering, research, and innovation objectives..
- PO9: Communication:** Communicate effectively through technical reports, software documentation, research publications, presentations, visualizations, and professional interactions with engineering communities and society..
- PO10: Project management and finance:** Apply engineering management principles, entrepreneurship, innovation, financial planning, leadership, and teamwork to manage AI and data science projects effectively.
- PO11: Life-long learning:** Recognize the need for continuous learning and independently acquire emerging knowledge and skills in artificial intelligence, data science, computing, and related interdisciplinary domains

PROGRAM SPECIFIC OUTCOMES (PSOs):

- PSO1:** Apply theoretical and practical knowledge of Information Technology to design, develop, and manage efficient information systems and interdisciplinary applications
- PSO2:** Analyze real-world problems, identify system requirements, and design appropriate IT infrastructure and solutions, particularly for large-scale and enterprise computing systems.
- PSO3:** Demonstrate understanding of professional, ethical, legal, and societal responsibilities in IT practices, along with business and security processes.
- PSO4:** Exhibit effective communication, teamwork, and decision-making skills using modern tools and technologies to perform responsibly in professional environments.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

LIST OF ABBREVIATIONS	
Abbreviation	Description
BSC	Basic Science Course
ESC	Engineering Science Course
PCC	Program Core Course
PEC	Program Elective Course
MDM	Multidisciplinary Minor
OE	Open Elective - Other than a particular program
VSEC	Vocational and Skill Enhancement Course
AEC	Ability Enhancement Course
ENTR	Entrepreneurship
EC	Economics
MC	Management Courses
IKS	Indian Knowledge System
VEC	Value Education Courses
RM	Research Methodology
CEP	Community Engagement Project
FP	Field Project
PROJ	Project
INT	Internship
OJT	On Job Training
CC	Co-curricular Courses
HSSM	Humanities Social Science and Management
ELC	Experiential Learning Course
B. Tech	Bachelor of Technology
L	Lecture
P	Practical
T	Tutorial
H	Hours
CR	Credits
CIE	Continuous Internal Evaluation
ETE	End Term Evaluation
TW	Term Work
OR	Oral
PR	Project



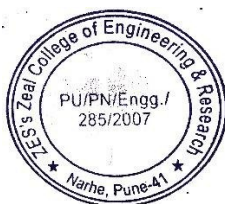
DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Third Year B. Tech. – ARTIFICIAL INTELLIGENCE AND DATA SCIENCE - V

Course Code	Course Type	Course Name	Teaching Scheme (hrs./Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
ADPC508	PCC	Regression and Classification Algorithms	3	-	-	3	3	-	3	40	60	-	-	-	100
ADPC508P	PCC	Regression and Classification Algorithms Lab	-	2	-	2	-	1	1	-	-	-	25	-	25
ADPC509	PCC	Machine Learning	4	-	-	4	4	-	4	40	60	-	-	-	100
ADPC509P	PCC	Machine Learning Lab	-	2	-	2	-	1	1	-	-	-	50	-	50
ADPC510	PCC	Artificial Neural Networks	3	-	-	3	3	-	3	40	60	-	-	-	100
ADPE501	PEC	Program Elective Course - I*	3		-	3	3		3	40	60	-	-	-	100
ADPE501P	PEC	Program Elective Course - I* Lab	-	2	-	-	-	1	1	-	-	-	-	50	50
ALOE503	OE	Open Elective - III#	2	-	-	2	2	-	2	-	-	50	-	50	100
ADMD503	MDM	Statistical Methods for Data Modelling	1	2	-	3	1	1	2	-	-	50	-	-	50
ADIN504	ELC - INT	Internship – IV	4 Weeks					2	2	-	-	25	-	-	25
Total			16	8	-	22	16	6	22	160	240	125	75	100	700

Singh

BoS Chairman



Arbete
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Director



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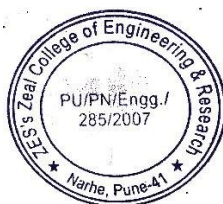
DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

# - Select any one course from the given Program Elective-I		
Courses	Course Type	Program Elective – I
ADPE501A	PEC	Information Retrieval
ADPE501AP		Information Retrieval Lab
ADPE501B		Cloud Computing Fundamentals
ADPE501BP		Cloud Computing Fundamentals Lab
ADPE501C		Optimization Techniques and Evolutionary Algorithms
ADPE501CP		Optimization Techniques and Evolutionary Algorithms Lab
ADPE501D		Signal Processing for Artificial Intelligence
ADPE501DP		Signal Processing for Artificial Intelligence Lab

# - Select any one course from the given Open Elective-III		
Courses	Course Type	Open Elective – III
ALOE503A	OEC	Data Analytics
ALOE503B		Green Building
ALOE503C		Electrical Mobility
ALOE503D		Introduction to Stock Market
ALOE503E		Patent Law for Engineers and Scientist

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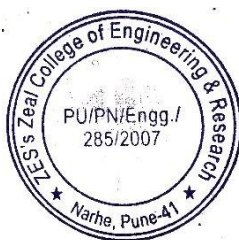
DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Third Year B. Tech. – ARTIFICIAL INTELLIGENCE AND DATA SCIENCE – VI

Course Code	Course Type	Course Name	Teaching Scheme (Hrs/Week)							Evaluation Scheme					
			L	P	T	H	CR			CIE	ETE	TW	PR	OR	Total
							TH	PR/Tut	Total						
ADPC611	PCC	Deep Learning	3	-	-	3	3	-	3	40	60	-	-	-	100
ADPC611P	PCC	Deep Learning Lab	-	2	-	2	-	1	1			-	25	-	25
ADPC612	PCC	Natural Language Processing	3	-	-	3	3		3	40	60	-	-	-	100
ADPC612P	PCC	Natural Language Processing Lab	-	2	-	2	-	1	1			-	25	-	25
ADPE602	PEC	Program Elective Course - II *	3	-	-	3	3	-	3	40	60	-	-	-	100
ADPE602P	PEC	Program Elective Course - II *Lab	-	2	-	2	-	1	1	-	-	-	-	25	25
ADPE603	PEC	Program Elective Course - III *	3	-	-	3	3	-	3	40	60	-	-		100
ADMD604	MDM	Retrieval-Augmented Generation	2		-	2	2	-	2	40	60	-	-	-	100
ADMD604P	MDM	Retrieval-Augmented Generation Lab	-	2	-	2	-	1	1	-	-	50	-	-	50
ADVS605	VSEC	Data Visualization & Business Intelligence Lab	1	2	-	3	1	1	2	-	-	50	-	-	50
ADIN605	ELC -INT	Internship - V	4 Weeks					2	2	-	-	25	-	-	25
Total			15	10	-	25	15	7	22	200	300	125	50	25	700

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- Select any one course from the given Program Elective-II Courses

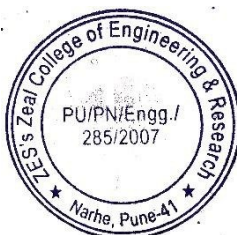
Course Code	Course Type	Program Elective – II
ADPE602A	PEC	Big Data Analytics
ADPE602AP		Big Data Analytics Lab
ADPE602B		Soft Computing
ADPE602BP		Soft Computing Lab
ADPE602C		DevOps for Cloud
ADPE602CP		DevOps for CloudLab

- Select any one course from the given Program Elective - III Courses

Course Code	Course Type	Program Elective – III
ADPE603A	PEC	Data Mining
ADPE603B		Pattern Recognition
ADPE603C		Computer Vision

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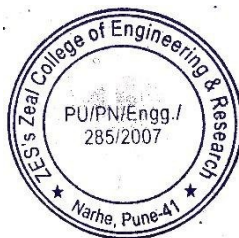
DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

INDEX

Sr. No.	Course Code	Course Name	Page No.
Third Year B. Tech.: Semester – V			
1	ADPC508	Regression and Classification Algorithms (RCA)	11
2	ADPC508P	Regression and Classification Algorithms (RCA)Lab	15
3	ADPC509	Machine Learning	19
4	ADPC509P	Machine Learning Lab	21
5	ADPC510	Artificial Neural Networks	24
7	ADPE501	Program Elective Course - I*	27
8	ALOE503	Open Elective - III#	52
9	ADMD503	Statistical Methods for Data Modelling	69
10	ADIN504	Internship – IV	73
Third Year B. Tech.: Semester – VI			
1	ADPC611	Deep Learning	76
2	ADPC611P	Deep Learning Lab	80
3	ADPC612	Natural Language Processing	83
4	ADPC612P	Natural Language Processing Lab	88
5	ADPE602	Program Elective Course - II *	90
7	ADPE603	Program Elective Course - III *	110
8	ADMD604	Retrieval-Augmented Generation	123
9	ADMD604P	Retrieval-Augmented Generation Lab	126
10	ADVS605	Data Visualization & Business Intelligence Lab	129
12	ADIN605	Internship - V	133

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SYLLABUS

SEMESTER - V



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Regression and Classification Algorithms (RCA)							Code: ADPC508		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Machine Learning Fundamentals									
Course Objectives:									
1. To explain the fundamental concepts, mathematical foundations, and working principles of regression and classification algorithms.									
2. To demonstrate model training using optimization techniques such as Gradient Descent, loss functions, and regularization.									
3. To apply Linear Regression, Logistic Regression, KNN, SVM, Decision Trees, and ensemble learning techniques to real-world problems.									
4. To evaluate machine learning models using appropriate performance metrics, validation techniques, error analysis, and model comparison.									
5. To select and justify suitable algorithms based on dataset characteristics, feature properties, model complexity, interpretability, and business requirements.									
6. To develop skills in hyperparameter tuning, model persistence, and basic local deployment of regression and classification solutions									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Explain the mathematical foundations, assumptions, and working principles of major regression and classification algorithms.							BL2 – Understand Analyze	
CO2	Apply regression and classification algorithms using appropriate training, optimization, and regularization techniques.							BL3 – Apply	
CO3	Analyze machine learning models using suitable evaluation metrics, validation methods, error analysis, and performance measures.							BL4 – Analyze	
CO4	Evaluate and compare machine learning algorithms based on dataset characteristics, feature properties, interpretability, computational requirements, and predictive performance.							BL5 – Evaluate	
CO5	Design and fine-tune regression and classification models using feature selection, cross-validation, ensemble methods, and hyperparameter optimization.							BL6 – Create	
CO6	Develop and demonstrate a basic end-to-end machine learning solution by selecting, evaluating, and locally deploying an appropriate regression or classification model.							BL5 – Evaluate	
Course Contents:									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Unit	Description	Duration (Hrs.)
1.	Unit I: Regression Foundations & Linear Regression Regression problem formulation; continuous target variables; regression versus classification; simple and multiple linear regression; interpretation of coefficients, intercepts and residuals; assumptions and limitations of linear regression; loss functions and least-squares method; Mean Squared Error (MSE); optimization and model fitting. Mapped Outcomes and Bloom's Level: CO1 – Understand (BL2), CO2 – Apply (BL3)	05 Hrs.
2.	Unit II: Classification & Logistic Regression Classification: binary and multiclass problems; probability-based prediction; decision boundaries and thresholds; Logistic Regression: sigmoid, log-odds, probability interpretation, log-loss/cross-entropy and optimization; One-vs-Rest and multiclass strategies; regularization, feature scaling, class weights and threshold selection. Mapped Outcomes and Bloom's Level: CO1 – Understand (BL2), CO2 – Apply (BL3)	05 Hrs.
3.	Unit III: Classification Evaluation, KNN & SVM Confusion matrix; accuracy, precision, recall, F1-score, ROC curve and ROC-AUC; imbalanced classification and basic handling strategies; K-Nearest Neighbors: distance measures, choice of K, decision boundaries, scaling, strengths and limitations; Support Vector Machine: maximum-margin classification, support vectors, hard and soft margins, C parameter, kernel intuition, linear and nonlinear classification, and Support Vector Regression Mapped Outcomes and Bloom's Level: CO2 – Apply (BL3), CO3-Analyze(BL4)	05 Hrs.
4.	Unit IV: Gradient Descent, Polynomial Regression & Regularization Gradient Descent optimization; learning rate, iterations and convergence; batch, stochastic and mini-batch Gradient Descent; effect of feature scaling; polynomial regression and feature transformations; Ridge and Lasso regression; coefficient shrinkage, feature selection and bias-variance trade-off. Mapped Outcomes and Bloom's Level: CO1 – Understand (BL2), CO2 – Apply (BL3), CO3 – Analyze (BL4)	05 Hrs.
5.	Unit V: Decision Trees & Ensemble Learning Decision Trees: recursive splitting, Gini impurity, entropy, information gain, regression tree criteria, depth, stopping conditions and pruning; algorithm selection based on dataset size, dimensionality, scaling, nonlinear patterns, noise and interpretability; feature considerations and introduction to PCA; Ensemble learning: motivation, weak learners, variance and bias reduction; Bagging and bootstrap sampling; Random Forest: random feature selection, tree diversity, ensemble prediction, out-of-bag concept, feature importance and hyper parameters. Mapped Outcomes and Bloom's Level: CO2 – Apply (BL3), CO3 – Analyze (BL4), CO4 – Evaluate (BL5)	05 Hrs.



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6	Unit VI: Model Selection, Fine-Tuning & Deployment Model evaluation and validation; train-validation-test split, cross-validation and learning curves; baseline and comparative modeling; metric selection, error analysis and model interpretation; hyperparameter tuning using Grid Search and Random Search; model persistence, reproducibility and basic deployment using Streamlit or Flask/FastAPI; Random Forest and XGBoost: concepts, key parameters and practical comparison with Decision Trees. Mapped Outcomes and Bloom's Level: CO3 – Analyze (BL4), CO4 – Evaluate (BL5), CO5 – Create (BL6)	05 Hrs.
TOTAL		30 Hrs
Text Books:		
1. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python. 2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.		
Reference Books:		
1. Ethem Alpaydin, Introduction to Machine Learning, MIT Press. 2. Tom M. Mitchell, Machine Learning, McGraw-Hill.		
<u>E-Resources: MOOC / NPTEL / YouTube</u> 1. NPTEL – Introduction to Machine Learning, IIT Kharagpur Link: NPTEL – Introduction to Machine Learning 2. Kaggle Learn – Intro to Machine Learning Link: Kaggle – Intro to Machine Learning 3. Scikit-learn Documentation and Tutorials Link: Scikit-learn User Guide 4. Google Colab / Jupyter Notebook Link: Google Colab 5. Streamlit Documentation Link: Streamlit Documentation <u>EBooks</u> 1. Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python O'Reilly Media. Link: Introduction to Machine Learning with Python – O'Reilly 2. Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow O'Reilly Media. Link: Hands-On Machine Learning – O'Reilly		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Industry Skills Expected at Course Completion:

Students should be able to formulate regression and classification problems; understand the basic intuition of Linear Regression, Logistic Regression, Gradient Descent, KNN, Decision Trees, Random Forest and introductory SVM; recognize when scaling is required; select suitable evaluation metrics; diagnose underfitting and overfitting; apply Ridge and Lasso at a practical level; use cross-validation; compare models fairly; perform basic error analysis; interpret coefficients and feature importance; justify a model choice for a given dataset; save a trained model; and demonstrate a simple prediction application.

Suggested Industry Case Studies:

House Price Prediction, Sales/Demand Prediction, Energy Consumption Prediction, Customer Churn Prediction, Loan/Credit Default Prediction, Manufacturing Defect Detection, Spam Detection, Employee Attrition Prediction, or another faculty-approved regression/classification problem. Case studies should emphasize understanding, evaluation and model comparison rather than implementing a large number of algorithms.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Regression and Classification Algorithms (RCA) Lab							Code: ADPC508P		
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites									
Course Objectives:									
1. To explain the fundamental concepts, mathematical foundations, and working principles of regression and classification algorithms.									
2. To demonstrate model training using optimization techniques such as Gradient Descent, loss functions, and regularization.									
3. To apply Linear Regression, Logistic Regression, KNN, SVM, Decision Trees, and ensemble learning techniques to real-world problems.									
4. To evaluate machine learning models using appropriate performance metrics, validation techniques, error analysis, and model comparison.									
5. To select and justify suitable algorithms based on dataset characteristics, feature properties, model complexity, interpretability, and business requirements.									
6. To develop skills in hyperparameter tuning, model persistence, and basic local deployment of regression and classification solutions									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Explain the mathematical foundations, assumptions, and working principles of major regression and classification algorithms.								
CO2	Apply regression and classification algorithms using appropriate training, optimization, and regularization techniques.								
CO3	Analyze machine learning models using suitable evaluation metrics, validation methods, error analysis, and performance measures.								
CO4	Evaluate and compare machine learning algorithms based on dataset characteristics, feature properties, interpretability, computational requirements, and predictive performance.								
CO5	Design and fine-tune regression and classification models using feature selection, cross-validation, ensemble methods, and hyperparameter optimization.								
CO6	Develop and demonstrate a basic end-to-end machine learning solution by selecting, evaluating, and locally deploying an appropriate regression or classification model.								
LIST OF EXPERIMENTS									
1. Linear Regression & Loss Function: Implement simple and multiple Linear Regression; calculate and interpret MSE, MAE and R ² ; inspect coefficients and residuals.									
2. Gradient Descent Optimization: Implement Gradient Descent for a simple regression problem;									



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visualize convergence and study the effects of learning rate, iterations and feature scaling.

3. **Polynomial Regression & Regularization:** Compare Linear, Polynomial, Ridge and Lasso Regression; analyze underfitting, overfitting, coefficient shrinkage and feature selection.
4. **Logistic Regression Classification:** Build a binary Logistic Regression model; generate probabilities and predictions; study sigmoid output, decision threshold and regularization.
5. **Classification Evaluation & Imbalanced Data:** Construct a confusion matrix and calculate Accuracy, Precision, Recall, F1-score and ROC-AUC; study threshold selection and the effect of class imbalance.
6. **KNN & SVM Classification:** Build KNN and SVM classifiers; study the effect of scaling, K, C and kernel choice; compare decision boundaries and performance.
7. **Decision Tree Classification/Regression:** Build a Decision Tree for classification and/or regression; compare splitting criteria, depth and stopping conditions; analyze overfitting and feature importance.
8. **Random Forest & Bagging:** Build a Random Forest model; study bootstrap sampling, number of trees, depth and feature sampling; evaluate feature importance and compare against a single tree.
9. **Gradient Boosting & XGBoost:** Build an introductory XGBoost model; tune learning rate, estimators and tree depth; study subsampling and early stopping; compare with Random Forest.
10. **Industry Algorithm Selection + Local Deployment:** Given an unfamiliar real-world dataset, select candidate algorithms, train and fine-tune them, compare appropriate metrics, justify the final model and deploy a simple prediction interface locally using Streamlit or Flask/FastAPI.

Text Books:

1. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.

Reference Books:

1. Ethem Alpaydin, Introduction to Machine Learning, MIT Press.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill.

E-Resources: MOOC / NPTEL / YouTube

1. NPTEL – Introduction to Machine Learning, IIT Kharagpur

Link: [NPTEL – Introduction to Machine Learning](#)

2. Kaggle Learn – Intro to Machine Learning

Link: [Kaggle – Intro to Machine Learning](#)

3. Scikit-learn Documentation and Tutorials

Link: [Scikit-learn User Guide](#)



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4. Google Colab / Jupyter Notebook

Link: [Google Colab](#)

5. Streamlit Documentation

Link: [Streamlit Documentation](#)

EBooks

1. Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python

O'Reilly Media.

Link: [Introduction to Machine Learning with Python – O'Reilly](#)

2. Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow

O'Reilly Media.

Link: [Hands-On Machine Learning – O'Reilly](#)

Industry Skills Expected at Course Completion:

Students should be able to formulate regression and classification problems; understand the basic intuition of Linear Regression, Logistic Regression, Gradient Descent, KNN, Decision Trees, Random Forest and introductory SVM; recognize when scaling is required; select suitable evaluation metrics; diagnose underfitting and overfitting; apply Ridge and Lasso at a practical level; use cross-validation; compare models fairly; perform basic error analysis; interpret coefficients and feature importance; justify a model choice for a given dataset; save a trained model; and demonstrate a simple prediction application.

Suggested Industry Case Studies:

House Price Prediction, Sales/Demand Prediction, Energy Consumption Prediction, Customer Churn Prediction, Loan/Credit Default Prediction, Manufacturing Defect Detection, Spam Detection, Employee Attrition Prediction, or another faculty-approved regression/classification problem. Case studies should emphasize understanding, evaluation and model comparison rather than implementing a large number of algorithms.

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Machine Learning							Code: ADPC509		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
04	-	-	04	40	60	-	-	-	100
Prerequisites: Basics of Database Management System (DBMS)									
Course Objectives:									
1. To introduce students to the basic concepts and practical foundations of Machine Learning and its common applications.									
2. To develop basic skills in exploring, cleaning and preparing datasets using Python .									
3. To enable students to build and evaluate basic regression models using scikit-learn.									
4. To enable students to build and evaluate basic classification models using appropriate performance measures.									
5. To introduce students to clustering, model selection and basic Machine Learning workflows .									
6. To develop an end-to-end beginner-level ML application , including model saving and a simple user interface.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Explain basic Machine Learning concepts and identify suitable ML approaches for simple engineering and business problems.							BL2 – Understand	
CO2	Explore, clean, visualize and prepare datasets using Python, Pandas and basic preprocessing techniques.							BL3 – Apply	
CO3	Build and evaluate basic regression and classification models using scikit-learn.							BL3 – Apply	
CO4	Analyze high-dimensional decision boundaries using Support Vector Machines and instance-based algorithms.							BL4 – Analyze	
CO5	Compare models using suitable evaluation measures and apply basic clustering and cross-validation.							BL6 – Create	
CO6	Develop and demonstrate a simple end-to-end ML application with basic documentation and responsible data use.							BL5 – Evaluate	
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Course Structure Unit I: Machine Learning Foundations & Data Preparation Introduction to ML, AI vs ML, types of ML, applications, ML workflow, features and target. Basic data handling using Pandas: missing values, categorical data,							05 Hrs.	



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	simple EDA and visualization. Data preprocessing: encoding and scaling. Practical: Prepare a dataset for ML. Mapped Outcomes and Bloom's Level: CO1 – Understand	
2.	Unit II: Supervised Learning – Regression Concept of regression and continuous prediction. Linear Regression, Multiple Linear Regression and Decision Tree Regression. Training and testing, underfitting and overfitting. Evaluation using MAE, MSE, RMSE and R². Practical: Build a simple regression model for house price/sales prediction. Mapped Outcomes and Bloom's Level: CO2 – Apply	05 Hrs.
3.	Unit III: Supervised Learning – Classification Binary and multiclass classification. Logistic Regression, KNN and Decision Tree. Confusion matrix and basic evaluation metrics: accuracy, precision, recall and F1-score. Practical: Build a classification model for spam/churn/defect prediction. Mapped Outcomes and Bloom's Level: CO3 – Create	05 Hrs.
4.	Unit IV: Clustering & Basic Dimensionality Reduction Introduction to unsupervised learning. K-Means clustering, centroids and Elbow Method. Basic idea of PCA and its use in reducing features. Practical: Perform customer/product clustering using K-Means. Mapped Outcomes and Bloom's Level: CO4 – Analyze	05 Hrs.
5.	Unit V: Model Evaluation & Improvement Train-test split, cross-validation, overfitting and underfitting. Basic hyperparameter tuning and model comparison. Introduction to ML pipelines using scikit-learn. Practical: Compare models and build a simple ML pipeline. Mapped Outcomes and Bloom's Level: CO5 – Create	05 Hrs.
6.	Unit VI: End-to-End ML Project Steps of an ML project: problem definition, data preparation, model building, evaluation and improvement. Saving/loading models using Joblib. Introduction to basic deployment using Streamlit. Practical/Capstone: Develop a simple ML application.	05 Hrs.
TOTAL		30 Hrs
Text Books:		
1. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python. 2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.		
Reference Books:		
1. Ethem Alpaydin, Introduction to Machine Learning, MIT Press. 2. Tom M. Mitchell, Machine Learning, McGraw-Hill.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

E-Resources: MOOC / NPTEL / YouTube

1. **Scikit-learn Documentation and Tutorials**
Link: [scikit-learn Documentation](#)
2. **Kaggle Learn – Intro to Machine Learning**
Link: [Kaggle Learn – Intro to Machine Learning](#)
3. **Google Colab**
Link: [Google Colab](#)
4. **NPTEL – Introduction to Machine Learning, IIT Kharagpur**
Link: [NPTEL – Introduction to Machine Learning](#)
5. **GitHub Documentation and Streamlit Documentation**
Links: [GitHub Documentation](#), [Streamlit Documentation](#)

E-Books / Textbooks

1. **Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python**
Link: [O'Reilly – Introduction to Machine Learning with Python](#)
2. **Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow**
Link: [O'Reilly – Hands-On Machine Learning](#)
3. **Tom M. Mitchell – Machine Learning**
Link: [Tom Mitchell – Machine Learning](#)

Mini Project / Capstone Domains:

Students may select Student Performance Prediction, Employee Attrition Prediction, Customer Churn Prediction, Sales Prediction, Energy Consumption Prediction, Manufacturing Defect Detection, Spam Detection, Customer Segmentation, or another faculty-approved engineering/business ML problem.

Industry Skills Expected at Course Completion

Use NumPy and Pandas for basic data handling; explore and visualize datasets; handle common missing values and duplicates; perform categorical encoding and numerical scaling; formulate a simple ML problem with features and target; build basic regression, classification and clustering models using scikit-learn; select appropriate evaluation metrics; identify underfitting and overfitting; use train/test split and cross-validation; perform basic model comparison and tuning; use simple Pipeline workflows; save and reload trained models; create a basic Streamlit prediction application; organize an ML project with a README and basic Git/GitHub awareness; explain model choices, predictions and limitations; follow basic responsible data-use and privacy practices.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Machine Learning Lab							Code: ADPC509P		
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	50	-	50
Prerequisites: Basics of Database Management System (DBMS)									
Course Objectives:									
1. To introduce students to the basic concepts and practical foundations of Machine Learning and its common applications.									
2. To develop basic skills in exploring, cleaning and preparing datasets using Python .									
3. To enable students to build and evaluate basic regression models using scikit-learn.									
4. To enable students to build and evaluate basic classification models using appropriate performance measures.									
5. To introduce students to clustering, model selection and basic Machine Learning workflows .									
6. To develop an end-to-end beginner-level ML application , including model saving and a simple user interface.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Explain basic Machine Learning concepts and identify suitable ML approaches for simple engineering and business problems.								
CO2	Explore, clean, visualize and prepare datasets using Python, Pandas and basic preprocessing techniques.								
CO3	Build and evaluate basic regression and classification models using scikit-learn.								
CO4	Analyze high-dimensional decision boundaries using Support Vector Machines and instance-based algorithms.								
CO5	Compare models using suitable evaluation measures and apply basic clustering and cross-validation.								
CO6	Develop and demonstrate a simple end-to-end ML application with basic documentation and responsible data use.								
List of Practicals									
1. Dataset Exploration & EDA: Load a real-world dataset using Pandas, inspect its shape, data types, missing values and summary statistics, and create basic visualizations.									
2. Data Cleaning & Feature Preparation: Handle missing values and duplicates, encode categorical variables, scale numerical features, and prepare training and testing data.									
3. Regression Model Development: Implement Linear and Multiple Linear Regression using a suitable									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

dataset, evaluate the model using MAE, MSE, RMSE and R^2 , and interpret the results.

4. **Regression Model Comparison:** Implement Polynomial Regression and Decision Tree Regression, compare their performance, and observe underfitting and overfitting.
5. **Classification Model Development:** Implement Logistic Regression and K-Nearest Neighbor (KNN) classification, generate a confusion matrix, and calculate accuracy, precision, recall and F1-score.
6. **Classification Model Comparison:** Implement Decision Tree and Random Forest classifiers, evaluate their performance using suitable classification metrics, and compare the results.
7. **K-Means & Cross-Validation:** Perform K-Means clustering on a suitable dataset using the Elbow Method, apply cross-validation to a supervised learning model, and compare the results.
8. **End-to-End ML Application:** Develop a complete ML solution involving data preparation, model building and evaluation, save the trained model, create a simple Streamlit prediction interface, and prepare a README file.

Text Books:

1. Andreas C. Müller and Sarah Guido, Introduction to Machine Learning with Python.
2. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow.

Reference Books:

- 1 Ethem Alpaydin, Introduction to Machine Learning, MIT Press.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill.

E-Resources: MOOC / NPTEL / YouTube

1. Scikit-learn Documentation and Tutorials

Link: [scikit-learn Documentation](#)

2. Kaggle Learn – Intro to Machine Learning

Link: [Kaggle Learn – Intro to Machine Learning](#)

3. Google Colab

Link: [Google Colab](#)

4. NPTEL–Introduction to Machine Learning, IIT Kharagpur

Link: [NPTEL – Introduction to Machine Learning](#)

5. GitHub Documentation and Streamlit Documentation

Links: [GitHub Documentation](#), [Streamlit Documentation](#)

E-Books / Textbooks



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

1. Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python

Link: [O'Reilly – Introduction to Machine Learning with Python](#)

2. Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow

Link: [O'Reilly – Hands-On Machine Learning](#)

3. Tom M. Mitchell – Machine Learning

Link: [Tom Mitchell – Machine Learning](#)

Mini Project / Capstone Domains:

Students may select Student Performance Prediction, Employee Attrition Prediction, Customer Churn Prediction, Sales Prediction, Energy Consumption Prediction, Manufacturing Defect Detection, Spam Detection, Customer Segmentation, or another faculty-approved engineering/business ML problem.

Industry Skills Expected at Course Completion

Use NumPy and Pandas for basic data handling; explore and visualize datasets; handle common missing values and duplicates; perform categorical encoding and numerical scaling; formulate a simple ML problem with features and target; build basic regression, classification and clustering models using scikit-learn; select appropriate evaluation metrics; identify underfitting and overfitting; use train/test split and cross-validation; perform basic model comparison and tuning; use simple Pipeline workflows; save and reload trained models; create a basic Streamlit prediction application; organize an ML project with a README and basic Git/GitHub awareness; explain model choices, predictions and limitations; follow basic responsible data-use and privacy practices

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course:- Artificial Neural Network(ANN)							Code: ADPC510		
Teaching Scheme (7 Hrs /week)				Evaluation Scheme					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Linear Algebra, Calculus, and Basics of Programming									
Course Objectives:									
1. To introduce the foundational concepts of biological neurons and their mathematical emulation through artificial threshold logic models. 2. To explain standard supervised learning rules, weight update mechanics, and linear separability boundaries in single-layer perceptrons. 3. To derive the mathematical formulation of error-backpropagation networks and hidden layer weight adjustments. 4. To analyze stability, capacity constraints, and state space trajectories in feedback and associative memory networks. 5. To familiarize concepts of unsupervised competitive learning, vector quantization, and self-organizing topological feature maps. 6. To introduce advanced deep configurations, spatial filter convolutions, and modern generative network architectures.									
Course Outcomes: After completion of this course, student shall be able to									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Understand the basic features of neural systems and be able to build the neural model..								BL2 – Understand
CO2	Perform the training of neural networks using various learning rules.								BL3 – Apply
CO3	Grasping the use of Associative learning Neural Network								BL6 – Create
CO4	Describe the concept of Competitive Neural Networks								BL4 – Analyze
CO5	Implement the concept of Convolutional Neural Networks and its models								BL6 – Create
CO6	Use a new tool /tools to solve a wide variety of real-world problems								BL5 – Evaluate
Course Contents:									
Unit	Description								Duration (Hrs.)



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DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

1.	Unit I: Introduction to Artificial Neural Networks Introduction to ANN, History of Neural Network, Structure and working of Biological Neural Network, Neural network architecture, Topology of neural network architecture, Features, Characteristics, Types, Activation functions, Models of neuron- Mc Culloch & Pitts model, Perceptron, Adeline model ,Basic learning laws, Applications of neural networks, Comparison of BNN and ANN.. Mapped Outcomes and Bloom's Level: CO1 – Understand	7 Hrs
2	Unit II: Learning Algorithms Learning and Memory, Learning Algorithms, Numbers of hidden nodes, Error Correction and Gradient Decent Rules, Perceptron Learning Algorithms, Supervised Learning Backpropagation, Multi-layered Network Architectures, Back propagation Learning Algorithm, Feed forward and feedback neural networks, example and applications.. Mapped Outcomes and Bloom's Level: CO2 – Apply	7 Hrs
3	Unit III: Associative Learning Introduction, Associative Learning, Hopfield network, Error Performance in Hopfield networks, simulated annealing, Boltzmann machine and Boltzmann learning, State transition diagram and false minima problem, stochastic update, simulated annealing. Basic functional units of ANN for pattern recognition tasks: Pattern association, pattern classification and pattern mapping tasks. Mapped Outcomes and Bloom's Level: CO3 – Create	7 Hrs
4	Unit IV: Competitive learning Neural Network Components of CL network, Pattern clustering and feature mapping network, ART networks, Features of ART models, character recognition using ART network. Self-Organization Maps (SOM): Two Basic Feature Mapping Models, Self-Organization Map, SOM Algorithm, Properties of Feature Map, Computer Simulations, Learning Vector Quantization, Adaptive Pattern Classification. Mapped Outcomes and Bloom's Level: CO4 – Analyze	7 Hrs
5	Unit V: Convolution Neural Network Building blocks of CNNs, Architectures, convolution / pooling layers, Padding, Strided convolutions, Convolutions over volumes, Soft Max regression, Deep Learning frameworks, Training and testing on different distributions, Bias and Variance with mismatched data distributions, Transfer learning, multi- task learning, end-to-end deep learning, Introduction to CNN models: LeNet – 5, AlexNet, VGG – 16,Residual Networks. Mapped Outcomes and Bloom's Level: CO5 – Create	7 Hrs
6	Unit VI: Applications of ANN Pattern classification – Recognition of Olympic games symbols, Recognition of printed Characters. Neo cognitron – Recognition of handwritten characters. NET Talk: to convert English text to speech. Recognition of consonant vowel (CV) segments, texture classification and segmentation. Mapped Outcomes and Bloom's Level: CO6 – Evaluate	7 Hrs
	Total	42Hrs



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Textbooks

1. Neural Networks a Comprehensive Foundations, Simon Haykin, PHI edition.
2. Laurene Fausett: Fundamentals of Neural Networks: Architectures, Algorithms & Apps, Pearson, 2004.
3. An introduction to neural networks, Gurney, Kevin, CRC press.

Reference Books

1. Artificial Neural Networks - B. Vegnanarayana Prentice Hall of India P Ltd, 2005
2. 2. Neural Networks in Computer Intelligence- Li Min Fu, MC GRAW HILL EDUCATION, 2003
3. 3. Neural Networks -James A Freeman David M S Kapura, Pearson Education, 2004.
4. 4. Introduction to Artificial Neural Systems- Jacek M. Zurada, JAICO Publishing House Ed., 2006.

MOOC / NPTEL / YouTube Links

1. NPTEL Course on "Neural Networks and Applications" (IIT Kharagpur)
Link: nptel.ac.in
2. Swayam-NPTEL Course on "Deep Learning" (IIT Ropar / IIT Madras Track)
Link: nptel.ac.in
3. Coursera: "Neural Networks and Deep Learning" by DeepLearning.AI
Link: coursera.org

E-Books

1. 1. <https://www.pdfdrive.com/neural-networks-a-comprehensive-foundationpdf-e18774300.html>
2. 2. <https://www.pdfdrive.com/elements-of-artificial-neural-networks-e17103719.html>
3. 3. <https://www.pdfdrive.com/neural-networks-methodology-and-applications-e38107895.html>

MOOC Courses:

1. <https://nptel.ac.in/courses/1171050842>.
2. <https://www.coursera.org/projects/predicting-weather-artificial-neural-networks>

[Back to Structure](#)



Program Elective Course - I



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: V			
Course: Information Retrieval (IR)						Code: ADPE501A			
Teaching Scheme (9 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Data Structures, Database Management Systems, Probability & Statistics, and Machine Learning basics									
Course Objectives:									
1. To understand the basics of Information Retrieval. 2. To understand machine learning techniques for text classification and clustering. 3. To understand various search engine system operations. 4. To learn different techniques of recommender systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Explain the fundamentals of information retrieval and the architecture of an IR system.								BL2 – Understand
CO2	Apply Boolean, vector space and probabilistic models, and compute retrieval evaluation metrics.								BL3 – Apply
CO3	Apply text classification methods to categorize documents.								BL3 – Apply
CO4	Apply clustering methods and build indexing structures to organize document collections.								BL3 – Apply
CO5	Design and implement innovative ranking and crawling features in a search engine.								BL6 – Create
CO6	Design and implement a recommender system using content-based and collaborative techniques.								BL6 – Create
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Introduction Information Retrieval – Early Developments – The IR Problem – The User’s Task – Information versus Data Retrieval – The IR System – The Software Architecture of the IR System – The Retrieval and Ranking Processes – The Web – The e-Publishing								09 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Era – How the Web changed Search – Practical Issues on the Web – How People Search – Search Interfaces Today – Visualization in Search Interfaces. Mapped Outcomes and Bloom's Level: CO1 – Understand	
2.	Unit II: Modeling and Retrieval Evaluation Basic IR Models – Boolean Model – TF-IDF (Term Frequency/Inverse Document Frequency) Weighting – Vector Model – Probabilistic Model – Latent Semantic Indexing Model – Neural Network Model – Retrieval Evaluation – Retrieval Metrics – Precision and Recall – Reference Collection – User-based Evaluation – Relevance Feedback and Query Expansion – Explicit Relevance Feedback. Mapped Outcomes and Bloom's Level: CO2 – Apply	09 Hrs.
3.	Unit III: Text Classification A Characterization of Text Classification – Naïve Text Classification – Supervised Algorithms – Decision Tree – k-NN Classifier – SVM Classifier – Feature Selection or Dimensionality Reduction – Evaluation Metrics – Accuracy and Error. Mapped Outcomes and Bloom's Level: CO3 – Apply	05 Hrs.
4.	Unit IV: Clustering and Indexing Unsupervised Algorithms: Clustering – Organizing the Classes – Indexing and Searching – Inverted Indexes – Sequential Searching – Multi-dimensional Indexing. Mapped Outcomes and Bloom's Level: CO4 – Apply	04 Hrs.
5.	Unit V: Web Retrieval and Web Crawling The Web – Search Engine Architectures – Cluster-based Architecture – Distributed Architectures – Search Engine Ranking – Link-based Ranking – Simple Ranking Functions – Learning to Rank – Evaluations – Search Engine User Interaction – Browsing – Applications of a Web Crawler – Taxonomy – Architecture and Implementation – Scheduling Algorithms – Evaluation. Mapped Outcomes and Bloom's Level: CO5 – Create	09 Hrs.
6.	Unit VI: Recommender System Recommender Systems Functions – Data and Knowledge Sources – Recommendation Techniques – Basics of Content-based Recommender Systems – High Level Architecture – Advantages and Drawbacks of Content-based Filtering – Collaborative Filtering – Matrix Factorization Models – Neighborhood Models. Mapped Outcomes and Bloom's Level: CO6 – Create	09 Hrs.
TOTAL		45 Hrs
Text Books:		
1. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Modern Information Retrieval: The Concepts and Technology behind Search, 2nd Edition, ACM Press Books, 2011. 2. F. Ricci, L. Rokach, B. Shapira, P. B. Kantor, Recommender Systems Handbook, 1st Edition, Springer, 2011.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Reference Books:

1. C. D. Manning, P. Raghavan, and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.
2. Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, Information Retrieval: Implementing and Evaluating Search Engines, The MIT Press, 2010.

E-Resources:

MOOC / NPTEL Links

1. NPTEL course on “Information Retrieval” – nptel.ac.in
2. Stanford (Coursera) – Text Retrieval and Search Engines – coursera.org

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Information Retrieval Lab							Code: ADPE501AP		
Teaching Scheme (4 Hrs /week)							Evaluation Scheme (Marks)		
Teaching Scheme (9 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	-	50	50
Prerequisites: Data Structures, Database Management Systems, Probability & Statistics, and Machine Learning basics.									
Course Objectives: 1. To understand the basics of Information Retrieval. 2. To understand machine learning techniques for text classification and clustering. 3. To understand various search engine system operations. 4. To learn different techniques of recommender systems.									
Course Outcomes: After completion of this course, students will be able to –									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Explain the fundamentals of information retrieval and the architecture of an IR system.								BL2 – Understand
CO2	Apply Boolean, vector space and probabilistic models, and compute retrieval evaluation metrics.								BL3 – Apply
CO3	Apply text classification methods to categorize documents.								BL3 – Apply
CO4	Apply clustering methods and build indexing structures to organize document collections.								BL3 – Apply
CO5	Design and implement innovative ranking and crawling features in a search engine.								BL6 – Create
CO6	Design and implement a recommender system using content-based and collaborative techniques.								BL6 – Create
LIST OF EXPERIMENTS (Out of 13 Experiments, 10 are mandatory)									
1. Text Preprocessing: Perform text preprocessing: tokenization, stop-word removal and stemming/lemmatization. 2. Boolean Retrieval: Implement Boolean retrieval for a collection of documents. 3. TF-IDF Weighting: Implement TF-IDF weighting. 4. Cosine Similarity: Calculate cosine similarity between documents/queries. 5. Retrieval Evaluation: Evaluate retrieval using Precision, Recall and F1-score.									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

6. **Inverted Index:** Implement an inverted index for document retrieval.
7. **Naïve Bayes Text Classification:** Implement Naïve Bayes text classification.
8. **Document Clustering:** Implement document clustering using K-means/Agglomerative clustering.
9. **PageRank:** Implement PageRank for ranking web pages.
10. **Web Crawler:** Build a basic web crawler.
11. **Search Engine:** Build a basic search engine using indexing and ranking.
12. **Content-Based Recommendation:** Implement content-based recommendation.
13. **Collaborative Filtering:** Implement collaborative filtering.

Text Books:

1. Ricardo Baeza-Yates and Berthier Ribeiro-Neto, Modern Information Retrieval: The Concepts and Technology behind Search, 2nd Edition, ACM Press Books, 2011.
2. F. Ricci, L. Rokach, B. Shapira, P. B. Kantor, Recommender Systems Handbook, 1st Edition, Springer, 2011.

Reference Books:

1. C. D. Manning, P. Raghavan, and H. Schütze, Introduction to Information Retrieval, Cambridge University Press, 2008.
2. Stefan Büttcher, Charles L. A. Clarke and Gordon V. Cormack, Information Retrieval: Implementing and Evaluating Search Engines, The MIT Press, 2010.

E-Resources: MOOC / NPTEL / YouTube

1. NPTEL – Information Retrieval <https://nptel.ac.in>
2. Stanford (Coursera) – Text Retrieval and Search Engines <https://www.coursera.org>

Mini-Projects(Out of 3 Mini-Projects, 1 is mandatory):

1. College/Academic Document Search Engine
2. Academic Research Paper Search Engine
3. E-commerce Product Search & Recommendation System

Industry Skills Expected at Course Completion:

Preprocess and clean text data; build and query Boolean and vector-space retrieval models; compute TF-IDF weights and similarity scores; evaluate retrieval quality using Precision, Recall and F1-score; build inverted indexes for fast document lookup; apply text classification and clustering techniques; implement basic ranking algorithms such as PageRank; build a simple web crawler; design content-based and collaborative recommendation systems; combine indexing, ranking and recommendation components into a working search application.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Industry Skills Expected at Course Completion:

Preprocess and clean text data; build and query Boolean and vector-space retrieval models; compute TF-IDF weights and similarity scores; evaluate retrieval quality using Precision, Recall and F1-score; build inverted indexes for fast document lookup; apply text classification and clustering techniques; implement basic ranking algorithms such as PageRank; build a simple web crawler; design content-based and collaborative recommendation systems; combine indexing, ranking and recommendation components into a working search application.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial and Data Science)						Semester: V			
Course: Cloud Computing (CC)						Code: ADPE501B			
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems, and Database Management Systems									
Course Objectives:									
1. To understand the various distributed system models and evolving computing paradigms. 2. To gain knowledge in virtualization of computer resources. 3. To realize the reasons for migrating into a cloud. 4. To introduce the various levels of services that can be achieved by a cloud. 5. To describe the security aspects in a cloud and the services offered by a cloud.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze various service delivery models, computing paradigms and layers of cloud computing.								BL4 – Analyze
CO2	Identify the approaches and models for migrating enterprise applications into the cloud.								BL3 – Apply
CO3	Comprehend virtualization and cloud computing concepts, including implementation levels and virtualization of CPU, memory and I/O.								BL2 – Understand
CO4	Interpret the ways in which the cloud can be programmed and deployed using IaaS and PaaS models.								BL3 – Apply
CO5	Assess the comparative advantages and disadvantages of SaaS and data security approaches in the cloud.								BL5 – Evaluate
CO6	Analyze authentication, confidentiality, privacy and SLA management issues in cloud computing.								BL4 – Analyze
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Cloud Computing Fundamentals Cloud Computing Fundamentals: Definition of Cloud computing – Roots of Cloud Computing – Layers and Types of Clouds – Desired Features of a Cloud –								



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Cloud Infrastructure Management – Infrastructure as a Service Providers – Platform as a Service Providers; Computing Paradigms: High-Performance Computing, Parallel Computing, Distributed Computing, Cluster Computing and Grid Computing. Mapped Outcomes and Bloom's Level: CO1 – Analyze	05 Hrs.
2.	Unit II: Migrating into a Cloud Migrating into a Cloud: Introduction – Broad Approaches to Migrating into the Cloud – The Seven-Step Model of Migration into a Cloud; business and technological reasons for migration; what can be migrated (application, code, design, architecture, usage). Mapped Outcomes and Bloom's Level: CO2 – Apply	05 Hrs.
3.	Unit III: Virtualization Virtualization: Virtual Machines and Virtualization of Clusters and data centers – Implementation Levels of Virtualization (ISA, Hardware Abstraction, Operating System, Library Support and User-Application levels) – Virtualization Structures/Tools and Mechanisms – Hypervisor and Xen architecture – Virtualization of CPU, Memory and I/O Devices – Virtual Clusters and Data Centers. Mapped Outcomes and Bloom's Level: CO3 – Understand	05 Hrs.
4.	Unit IV: Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) Virtual machines provisioning and Migration services – Virtual Machines Provisioning and Manageability – Virtual Machine Migration Services – VM Provisioning and Migration in Action; On the Management of Virtual machines for Cloud Infrastructures; Aneka – Integration of Private and Public Clouds. Mapped Outcomes and Bloom's Level: CO4 – Apply	05 Hrs.
5.	Unit V: Software as a Service (SaaS) and Data Security in the Cloud Software as a Service (SaaS) – Google App Engine – Centralizing Email Communications – Collaborating via Web-Based Communication Tools; An Introduction to the idea of Data Security in the cloud. Mapped Outcomes and Bloom's Level: CO5 – Evaluate	05 Hrs.
6.	Unit VI: SLA Management in Cloud Computing Traditional Approaches to SLO Management – Types of SLA – Life Cycle of SLA – SLA Management in Cloud. Mapped Outcomes and Bloom's Level: CO6 – Analyze	05 Hrs.
TOTAL		30 Hrs
Text Books:		
1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, "Cloud Computing: Principles and Paradigms", Wiley Series on Parallel and Distributed Computing, 2011. (Source of Units I, II, IV and V content.) 2. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, "Distributed and Cloud Computing: From Parallel Processing to the Internet of Things", Morgan Kaufmann/Elsevier, 2012. (Source of Unit III –		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Virtualization content.)

Reference Books:

1. Toby Velte, Anthony Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", Tata McGraw-Hill, 2009.
2. Tim Mather, Subra Kumaraswamy, Shahed Latif, "Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance", O'Reilly Media, 2009.
3. George Reese, "Cloud Application Architectures", O'Reilly Media, 2009.

E-Resources:

MOOC / NPTEL / YouTube Links

1. NPTEL Course on "Cloud Computing" (IIT Kharagpur Track) Link: <https://nptel.ac.in/courses/106105167>
2. NPTEL Course on "Cloud Computing and Distributed Systems" (CMI Track) Link: https://onlinecourses.nptel.ac.in/noc21_cs42/preview
3. Coursera: "Cloud Computing Specialization" by University of Illinois Link: <https://www.coursera.org/specializations/cloud-computing>

Freely Available Course/Lab Material (the actual sources this syllabus and lab list were adapted from)

4. R20A0521 Cloud Computing – Digital Notes, Malla Reddy College of Engineering & Technology (Autonomous, JNTUH) Link: [https://mrcet.com/downloads/digital_notes/CSE/IV%20Year/17062023/CLOUD%20COMPUTING%20%20\(%20R20A0521%20\).pdf](https://mrcet.com/downloads/digital_notes/CSE/IV%20Year/17062023/CLOUD%20COMPUTING%20%20(%20R20A0521%20).pdf)

5. 22CS62 Cloud Computing Laboratory Manual, Dayananda Sagar College of Engineering (Autonomous, VTU) – reference for the List of Experiments Link: <https://www.cliffsnotes.com/study-notes/27193357>

Note: The prescribed text books above (Buyya et al.; Kai Hwang et al.) are commercially published, copyrighted works; no free, legally distributed PDF of the full text is available. The two links above are the actual open lecture-notes/lab-manual pages this document's units and experiment list were adapted from.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: V			
Course: Cloud Computing Fundamentals Lab						Code: ADPE501BP			
Teaching Scheme (4 Hrs /week)						Evaluation Scheme (Marks)			
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	50	-	50
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems, and Database Management Systems.									
Course Objectives: 1. To understand the various distributed system models and evolving computing paradigms. 2. To gain knowledge in virtualization of computer resources. 3. To realize the reasons for migrating into a cloud. 4. To introduce the various levels of services that can be achieved by a cloud. 5. To describe the security aspects in a cloud and the services offered by a cloud.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Analyze various service delivery models, computing paradigms and layers of cloud computing.							BL4 – Analyze	
CO2	Identify the approaches and models for migrating enterprise applications into the cloud.							BL3 – Apply	
CO3	Comprehend virtualization and cloud computing concepts, including implementation levels and virtualization of CPU, memory and I/O.							BL2 – Understand	
CO4	Interpret the ways in which the cloud can be programmed and deployed using IaaS and PaaS models.							BL3 – Apply	
CO5	Assess the comparative advantages and disadvantages of SaaS and data-security approaches in the cloud.							BL5 – Evaluate	
CO6	Analyze authentication, confidentiality, privacy and SLA management issues in cloud computing.							BL4 – Analyze	
LIST OF EXPERIMENTS (Out of 12 Experiments, 10 Experiments are mandatory)									
1. Cloud Service Models: Identify and demonstrate IaaS, PaaS and SaaS using suitable cloud services. 2. Virtual Machine Configuration: Configure a virtual machine and demonstrate basic virtualization. 3. Resource Virtualization: Demonstrate CPU, memory and storage virtualization.									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

4. **Cloud VM Instance:** Create and configure a cloud VM instance.
5. **VM Provisioning and Management:** Demonstrate VM provisioning and basic VM management.
6. **VM Migration:** Demonstrate VM migration/conceptual migration process.
7. **PaaS Application Deployment:** Deploy a simple application using a PaaS environment.
8. **SaaS/Web Application Usage:** Demonstrate cloud-based SaaS/web application usage.
9. **Cloud Storage and Data Security:** Configure cloud storage and demonstrate basic data-security mechanisms.
10. **Authentication and Access Control:** Implement basic cloud authentication/access-control concepts.
11. **Cloud Migration Planning:** Prepare and analyze a cloud migration plan for an application.
12. **SLA Analysis:** Analyze a sample Cloud Service Level Agreement (SLA).

Textbooks:

1. Rajkumar Buyya, James Broberg, Andrzej M. Goscinski, Cloud Computing: Principles and Paradigms, Wiley Series on Parallel and Distributed Computing, 2011.
2. Kai Hwang, Geoffrey C. Fox, Jack J. Dongarra, Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Morgan Kaufmann/Elsevier, 2012.

Reference Books:

1. Toby Velte, Anthony Velte, Robert Elsenpeter, Cloud Computing: A Practical Approach, Tata McGraw-Hill, 2009.
2. Tim Mather, Subra Kumaraswamy, Shahed Latif, Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, O'Reilly Media, 2009.
3. George Reese, Cloud Application Architectures, O'Reilly Media, 2009.

E-Resources: MOOC / NPTEL / YouTube

1. NPTEL Course on "Cloud Computing" (IIT Kharagpur Track) <https://nptel.ac.in/courses/106105167>
2. Coursera – Cloud Computing Specialization, University of Illinois
<https://www.coursera.org/specializations/cloud-computing>

Mini-Projects(Out of 3 Mini-Project, 1 Mini-Projects is mandatory):

1. Cloud-Based Student Performance Analytics System
2. Cloud-Based Document Storage & Search System
3. Cloud-Based AI Application Deployment

Industry Skills Expected at Course Completion:

Differentiate between IaaS, PaaS and SaaS service models; configure and manage virtual machines; understand virtualization of CPU, memory and storage resources; provision, migrate and manage VMs on a cloud platform; deploy applications using a PaaS environment; configure cloud storage and apply basic data-security mechanisms; implement authentication and access-control concepts; plan a cloud migration for an existing app



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Optimization Techniques and Evolutionary Algorithms							Code: ADPE501C		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Linear Algebra and Differential Calculus, Probability and Statistics.									
Course Objectives:									
1. To introduce the mathematical formulation of optimization problems.									
2. To study classical constrained and unconstrained optimization theory (Linear Programming, Lagrangian methods).									
3. To understand the mathematical basis of evolutionary and swarm-based search algorithms.									
4. To apply optimization theory to data-driven decision-making problems, independent of ML model training.									
5. To evaluate trade-offs between deterministic and heuristic optimization approaches.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Formulate real-world problems as mathematical optimization problems							BL3 – Apply	
CO2	Solve constrained optimization problems using Linear Programming and Lagrangian methods.							BL3 – Apply	
CO3	Apply convex optimization theory to decision and resource-allocation problems.							BL3 – Apply	
CO4	Design and implement evolutionary algorithms (Genetic Algorithm, PSO, Ant Colony Optimization).							BL3 – Create	
CO5	Analyze convergence behavior and computational trade-offs of different optimization approaches.							BL3 – Analyze	
CO6	Apply multi-objective optimization techniques to data science resource/scheduling problems.							BL3 – Apply	
Course Contents:									
Unit	Description							Duration	
1.	Unit I: Foundations of Optimization Optimization problem formulation, objective functions, decision variables, feasible region. Classification: linear/nonlinear, convex/non-convex, single/multi-objective, static/dynamic. Local vs global optima, necessary and sufficient conditions. Case Study: Formulating a data-centre resource allocation problem.							05 Hrs.	



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

2.	Unit II: Linear Programming Standard and canonical forms, graphical method, Simplex method, duality theory, sensitivity analysis. Applications in transportation and assignment problems. Case Study: Optimal data pipeline scheduling using LP. Mapped Outcomes and Bloom's Level: CO2 – Apply	05 Hrs.
3.	Unit III: Constrained & Convex Optimization Lagrange multipliers, Karush-Kuhn-Tucker (KKT) conditions, convex sets and functions, duality gap. Applications: network flow optimization, portfolio allocation. Case Study: Bandwidth allocation optimization in data networks. Mapped Outcomes and Bloom's Level: CO2, CO3 – Apply	05 Hrs.
4.	Unit IV: Genetic Algorithms Biological inspiration, encoding schemes, selection, crossover, mutation operators, fitness function design, convergence criteria. Applications: scheduling, combinatorial search. Case Study: Optimal timetable/task-scheduling generation using GA. Mapped Outcomes and Bloom's Level: CO4 – Create	05 Hrs.
5.	Unit V: Swarm and Nature-Inspired Optimization Particle Swarm Optimization (PSO): concept, velocity/position update equations, parameter tuning. Ant Colony Optimization (ACO): pheromone-based search, applications in routing. Comparative analysis of GA vs PSO vs ACO. Case Study: Route optimization for logistics/delivery networks. Mapped Outcomes and Bloom's Level: CO4, CO5 – Create / Analyze	05 Hrs.
6.	Unit VI: Multi-Objective Optimization Concept of Pareto optimality, Pareto front, weighted sum method, overview of NSGA-II. Applications in data science system design (accuracy vs cost, storage vs latency trade-offs) framed at the systems level, not model training. Case Study: Multi-objective optimization of a data warehouse design (cost vs query performance). Mapped Outcomes and Bloom's Level: CO6 – Apply	05 Hrs.
TOTAL		30Hrs.
Text Books:		
1. Edwin K. P. Chong & Stanislaw H. Zak, An Introduction to Optimization, 4th Edition, Wiley, ISBN: 9781118279014. 2. S.S. Rao, Engineering Optimization: Theory and Practice, 4th Edition, Wiley, ISBN: 978-0470183526.		
Reference Books:		
1. Stephen Boyd & Lieven Vandenberghe, Convex Optimization, Cambridge University Press, ISBN: 9780521833783. 2. Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier, ISBN: 978-0124167438. 3. Kalyanmoy Deb, Multi-Objective Optimization Using Evolutionary Algorithms, Wiley, ISBN:		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

9780471873396.

E-Resources: MOOC / NPTEL / YouTube:

1. NPTEL – Optimization Techniques: <https://nptel.ac.in/courses/106106224>

2. NPTEL – Evolutionary Computation for Engineering Optimization:
<https://nptel.ac.in/courses/127106022>

Mini Project / Capstone Domains:

- Human Activity Recognition

Accelerometer data → Signal preprocessing → Feature extraction → ML/DL → Activity classification

-Speech Emotion Recognition

Audio → Noise removal → MFCC/Spectrogram → CNN → Emotion classification

-Predictive Maintenance

Machine vibration signal → Filtering → Feature extraction → ML model → Failure prediction

-ECG Anomaly Detection

ECG signal → Denoising → Feature extraction → Anomaly detection → Abnormal/normal classification

Industry Skills Expected at Course Completion:

Apply mathematical optimization concepts to real-world problems; formulate objective functions, constraints and decision variables; solve linear and nonlinear optimization problems; use gradient-based optimization and understand learning rate, convergence and stopping criteria; apply constrained and unconstrained optimization techniques; use numerical optimization methods with Python; select suitable optimization methods based on problem characteristics; analyze sensitivity to parameters and constraints; compare optimization approaches using solution quality, convergence and computational cost; use optimization techniques for ML model training and hyperparameter tuning; implement basic optimization workflows using NumPy, SciPy and scikit-learn; interpret and validate optimization results; explain assumptions, limitations and trade-offs of optimization methods; organize basic optimization experiments with clear documentation; follow responsible and reproducible computational practices.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Optimization Techniques and Evolutionary Algorithms Lab							Code: ADPC501CP		
Teaching Scheme (4 Hrs /week)							Evaluation Scheme (Marks)		
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	-	50	-	50
Prerequisites: Linear Algebra and Differential Calculus, Probability and Statistics.									
Course Objectives:									
1. To introduce the mathematical formulation of optimization problems. 2. To study classical constrained and unconstrained optimization theory (Linear Programming, Lagrangian methods). 3. To understand the mathematical basis of evolutionary and swarm-based search algorithms. 4. To apply optimization theory to data-driven decision-making problems, independent of ML model training. 5. To evaluate trade-offs between deterministic and heuristic optimization approaches.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome						Bloom's Taxonomy Level		
CO1	Formulate real-world problems as mathematical optimization problems.						BL3 – Apply		
CO2	Solve constrained optimization problems using Linear Programming and Lagrangian methods.						BL3 – Apply		
CO3	Apply convex optimization theory to decision and resource-allocation problems.						BL3 – Apply		
CO4	Design and implement evolutionary algorithms (Genetic Algorithm, PSO, Ant Colony Optimization).						BL3 – Create		
CO5	Analyze convergence behavior and computational trade-offs of different optimization approaches.						BL3 – Analyze		
CO6	Apply multi-objective optimization techniques to data science resource/scheduling problems.						BL3 – Apply		
LIST OF EXPERIMENTS (Out of 12 Experiments, 10 Experiments are mandatory)									
1. Optimization Problem Formulation: Formulate a real-world problem as a mathematical optimization problem and identify the objective function, variables and constraints. 2. Graphical LP Solution: Solve a Linear Programming problem using the graphical method. 3. Simplex Method: Implement the Simplex method for a Linear Programming problem.									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

4. **Lagrange Multipliers:** Implement the Lagrange Multiplier method for a constrained optimization problem.
5. **KKT Conditions:** Verify the KKT conditions for a constrained optimization problem.
6. **Genetic Algorithm for Scheduling:** Implement a Genetic Algorithm for a scheduling problem.
7. **Genetic Algorithm for TSP:** Implement a Genetic Algorithm for the Travelling Salesman Problem.
8. **Particle Swarm Optimization:** Implement Particle Swarm Optimization for function minimization.
9. **Ant Colony Optimization:** Implement Ant Colony Optimization for a shortest-path/routing problem.
10. **Comparative Analysis of GA, PSO and ACO:** Compare GA, PSO and ACO based on solution quality, convergence and computation time.
11. **Weighted Sum Multi-Objective Optimization:** Implement a multi-objective optimization problem using the Weighted Sum method.
12. **Pareto Optimality / NSGA-II:** Implement and experiment with Pareto optimality or NSGA-II.

Text Books:

1. Edwin K. P. Chong & Stanislaw H. Żak, An Introduction to Optimization, 4th Edition, Wiley, ISBN: 9781118279014.
2. S.S. Rao, Engineering Optimization: Theory and Practice, 4th Edition, Wiley, ISBN: 978-0470183526.

Reference Books:

1. Stephen Boyd & Lieven Vandenberghe, Convex Optimization, Cambridge University Press, ISBN: 9780521833783.
2. Xin-She Yang, Nature-Inspired Optimization Algorithms, Elsevier, ISBN: 978-0124167438.
3. Kalyanmoy Deb, Multi-Objective Optimization Using Evolutionary Algorithms, Wiley, ISBN: 9780471873396.

E-Resources: MOOC / NPTEL

1. NPTEL – Optimization Techniques <https://nptel.ac.in/courses/106106224>
2. NPTEL – Evolutionary Computation for Engineering Optimization <https://nptel.ac.in/courses/127106022>

Mini-Projects (Out of 3 Mini-Projects, 1 Mini - Project is mandatory):

1. Data-Centre Resource Allocation Optimization
2. Multi-objective Cloud Resource Optimization using NSGA-II
3. Data Pipeline Scheduling using Linear Programming

Industry Skills Expected at Course Completion:



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Apply mathematical optimization concepts to real-world problems; formulate objective functions, constraints and decision variables; solve linear and nonlinear optimization problems; use gradient-based optimization and understand learning rate, convergence and stopping criteria; apply constrained and unconstrained optimization techniques; use numerical optimization methods with Python; select suitable optimization methods based on problem characteristics; analyze sensitivity to parameters and constraints; compare optimization approaches using solution quality, convergence and computational cost; implement basic optimization workflows using NumPy, SciPy and scikit-learn; interpret and validate optimization results; explain assumptions, limitations and trade-offs of optimization methods.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Signal Processing for Artificial Intelligence							Code: ADPE501D		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Linear Algebra, Calculus, Probability & Statistics, Python, Machine Learning.									
Course Objectives:									
1. Understand fundamental concepts of continuous and discrete signals.									
2. Analyze signals in both time and frequency domains.									
3. Apply sampling, convolution, Fourier transforms and filtering techniques.									
4. Extract meaningful features from real-world signals for AI applications.									
5. Apply machine learning and deep learning techniques to signal data.									
6. Develop AI solutions for audio, speech, sensor, biomedical and other signal-based applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Analyze continuous and discrete signals using appropriate mathematical representations.							BL4 – Analyze	
CO2	Apply sampling, convolution and Fourier-transform techniques to analyze signals.							BL2 – Apply	
CO3	Design basic filtering and feature-extraction techniques for noisy real-world signals.							BL3 – Create	
CO4	Generate time-frequency representations such as spectrograms and apply them to AI problems.							BL6 – Create	
CO5	Apply machine learning and deep learning techniques to signal classification and prediction.							BL3 – Apply	
CO6	Develop an AI-based solution for a real-world signal-processing application.							BL5 – Create	
Course Contents:									
Unit	Description							Duration	
1.	Unit I: Fundamentals of Signals & Systems Introduction to signals, signal vs data, continuous-time and discrete-time signals, deterministic and random signals, periodic and aperiodic signals, energy and power signals, signal representation using amplitude frequency and phase, time-domain representation, basic signal operations including time shifting time scaling amplitude scaling addition and multiplication, sampling theorem, Nyquist rate and frequency, aliasing, under-sampling and over-sampling, ADC							05 Hrs.	



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	AI Connection: Understanding how real-world data such as audio, sensor and biomedical signals are converted into digital form for AI applications. Mapped Outcomes and Bloom's Level: CO1 – Analyze	
2.	Unit II: Convolution & Frequency-Domain Analysis: Continuous and discrete convolution, convolution as filtering, correlation vs convolution, Fourier Series, Fourier Transform, Discrete Fourier Transform (DFT), frequency spectrum, Fast Fourier Transform (FFT), Radix-2 concept, computational advantage of FFT over DFT, time-domain and frequency-domain analysis AI Connection: Understanding how a complex signal is transformed into frequency-domain features before being fed into an ML model. Mapped Outcomes and Bloom's Level: CO2 – Apply	05 Hrs.
3.	Unit III: Digital Filtering & Signal Denoising Need for filtering and noise reduction, low-pass high-pass band-pass and band-stop/notch filters, FIR and IIR filters, moving-average filtering, basic Butterworth filter concept, random and periodic noise removal, smoothing and denoising of practical signals AI Connection: Raw signal → filtering → feature extraction → ML model. Mapped Outcomes and Bloom's Level: CO3 – Create	05 Hrs.
4.	Unit IV: Signal Feature Extraction & Time-Frequency Analysis Basic statistical features including mean variance standard deviation RMS and zero-crossing rate, basic frequency-domain features including spectral energy and dominant frequency, need for time-frequency analysis, introduction to Short-Time Fourier Transform (STFT), spectrograms and their interpretation. AI models for signals: Logistic Regression, SVM, Random Forest, 1D CNN, CNN on spectrograms, RNN/LSTM Mapped Outcomes and Bloom's Level: CO4 – Create	05 Hrs.
5.	Unit V: AI & Deep Learning for Signal Processing Signal representations for AI including raw waveform extracted features and spectrograms, signal data preparation including segmentation feature extraction and train-test split, Logistic Regression, SVM, Random Forest, 1D CNN for signal data, CNN using spectrograms, basic RNN and LSTM concepts for sequential signals AI Connection: Selecting suitable AI models based on signal type, such as 1D CNN for sensor signals, CNN for spectrograms and RNN/LSTM for sequential data. Mapped Outcomes and Bloom's Level: CO5, CO6 – Apply / Create	05 Hrs.
6.	Unit VI: AI Applications in Signal Processing Audio and speech signals, basic audio classification and keyword spotting, biomedical signals such as ECG and EEG, IoT and sensor signals such as vibration	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	and accelerometer data, basic anomaly detection and predictive maintenance, introduction to Edge AI and real-time signal processing. AI Connection: Selecting suitable AI models based on signal type, such as 1D CNN for sensor signals, CNN for spectrograms and RNN/LSTM for sequential data. Mapped Outcomes and Bloom's Level: CO5, CO6 – Apply / Create	
TOTAL		30Hrs.
Text Books:		
1. S. K. Mitra, Digital Signal Processing: A Computer-Based Approach, 4th Edition, McGraw-Hill Education. 2. Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, 2nd Edition, California Technical Publishing. 3. Richard G. Lyons, Understanding Digital Signal Processing, 3rd Edition, Pearson Education. 4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 3rd Edition, O'Reilly Media (for the ML/DL portions applied to signals).		
Reference Books:		
1. A. V. Oppenheim and R. W. Schaffer, Discrete-Time Signal Processing, 3rd Edition, Pearson. 2. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Edition, Pearson. 3. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson (for the image-as-signal unit). 4. Zheng Rong Yang, Machine Learning Approaches to Bioinformatics / Biomedical Signal Processing literature and IEEE journal articles as prescribed by the course instructor. 5. Selected research papers and open-source documentation for Librosa, SciPy, PyTorch and TensorFlow, updated each offering.		
<u>E-Resources: MOOC / NPTEL / YouTube</u>		
1. NPTEL – Optimization Techniques: https://nptel.ac.in/courses/106106224 2. NPTEL – Evolutionary Computation for Engineering Optimization: https://nptel.ac.in/courses/127106022		
<u>Mini Project / Capstone Domains:</u>		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

1. Human Activity Recognition

Accelerometer data → Signal preprocessing → Feature extraction → ML/DL → Activity classification

2. Speech Emotion Recognition

Audio → Noise removal → MFCC/Spectrogram → CNN → Emotion classification

3. Predictive Maintenance

Machine vibration signal → Filtering → Feature extraction → ML model → Failure prediction

4. ECG Anomaly Detection

ECG signal → Denoising → Feature extraction → Anomaly detection → Abnormal/normal classification

Industry Skills Expected at Course Completion:

Use Python and NumPy for basic signal handling; understand continuous and discrete signals and sampling; perform basic signal visualization and preprocessing; handle noise and common signal-quality issues; apply basic filtering and smoothing techniques; analyze signals in the time and frequency domains; use Fourier Transform and FFT for frequency analysis; extract basic statistical, temporal and frequency-domain features; understand convolution and correlation for signal analysis; apply basic signal processing techniques to real-world data such as audio, sensor and time-series signals; select appropriate preprocessing and filtering methods based on the application; use signal features for basic machine learning tasks; evaluate and interpret processed signals and extracted features; implement basic signal-processing workflows using Python libraries such as NumPy, SciPy and Matplotlib; explain assumptions, limitations and practical trade-offs of signal-processing methods; follow basic data-quality, privacy and responsible data-use practices.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)	Semester: V
Course: Signal Processing for Artificial Intelligence Lab	Code: ADPE501DP

Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	-	50	50

Prerequisites: Linear Algebra, Calculus, Probability & Statistics, Python, Machine Learning.

Course Objectives:

1. To understand fundamental concepts of continuous and discrete signals.
2. To analyze signals in both time and frequency domains.
3. To apply sampling, convolution, Fourier transforms and filtering techniques.
4. To extract meaningful features from real-world signals for AI applications.
5. To apply machine learning and deep learning techniques to signal data.
6. To develop AI solutions for audio, speech, sensor, biomedical and other signal-based applications.

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

CO	Course Outcome	Bloom's Taxonomy Level
CO1	Analyze continuous and discrete signals using appropriate mathematical representations.	BL4 – Analyze
CO2	Apply sampling, convolution and Fourier-transform techniques to analyze signals.	BL2 – Apply
CO3	Design basic filtering and feature-extraction techniques for noisy real-world signals.	BL3 – Create
CO4	Generate time-frequency representations such as spectrograms and apply them to AI problems.	BL6 – Create
CO5	Apply machine learning and deep learning techniques to signal classification and prediction.	BL3 – Apply
CO6	Develop an AI-based solution for a real-world signal-processing application.	BL5 – Create

LIST OF EXPERIMENTS (Out of 14 Experiments, 10 Experiments are mandatory)

1. **Signal Generation and Visualization:** Generate and visualize continuous and discrete signals using Python.
2. **Sampling and Aliasing:** Demonstrate sampling and aliasing.
3. **Discrete Convolution:** Implement discrete convolution.
4. **Correlation vs Convolution:** Implement correlation and compare correlation with convolution.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

5. **DFT Computation:** Compute the Discrete Fourier Transform (DFT) using Python.
6. **FFT vs DFT:** Implement the FFT and compare it with the DFT.
7. **Time and Frequency Domain Analysis:** Analyze a real-world signal in the time and frequency domains.
8. **Filter Design:** Design and implement low-pass/high-pass filtering.
9. **Noise Removal / Denoising:** Remove noise from a real-world signal using filtering/denoising.
10. **Feature Extraction:** Extract statistical and frequency-domain features from a signal.
11. **Spectrogram using STFT:** Generate and analyze a spectrogram using the Short-Time Fourier Transform (STFT).
12. **MFCC Feature Extraction:** Extract MFCC features from an audio signal.
13. **Signal Classification:** Classify signals using a machine-learning model.
14. **1D CNN for Signal Classification:** Build a 1D CNN for signal classification.

Text Books:

1. S. K. Mitra, Digital Signal Processing: A Computer-Based Approach, 4th Edition, McGraw-Hill Education.
2. Steven W. Smith, The Scientist and Engineer's Guide to Digital Signal Processing, 2nd Edition, California Technical Publishing.
3. Richard G. Lyons, Understanding Digital Signal Processing, 3rd Edition, Pearson Education.
4. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras & TensorFlow, 3rd Edition, O'Reilly Media.

Reference Books:

1. A. V. Oppenheim and R. W. Schaffer, Discrete-Time Signal Processing, 3rd Edition, Pearson.
2. John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, 4th Edition, Pearson.
3. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson.

E-Resources: MOOC / NPTEL / YouTube

1. NPTEL – Digital Signal Processing <https://nptel.ac.in/courses/117105143>
2. Coursera – Audio Signal Processing for Music Applications <https://www.coursera.org/learn/audio-signal-processing>

Mini-Projects (Out of 3 Mini-Projects, 1 is mandatory):

1. Speech Emotion Recognition using MFCC/Spectrogram
2. Machine Predictive Maintenance using Vibration Signals
3. IoT Sensor Anomaly Detection



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Industry Skills Expected at Course Completion:

Use Python and NumPy for basic signal handling; understand continuous and discrete signals and sampling; perform basic signal visualization and preprocessing; handle noise and common signal-quality issues; apply basic filtering and smoothing techniques; analyze signals in the time and frequency domains; use the Fourier Transform and FFT for frequency analysis; extract basic statistical, temporal and frequency-domain features; understand convolution and correlation for signal analysis; apply basic signal-processing techniques to real-world data such as audio, sensor and time-series signals; use signal features for basic machine-learning tasks; implement basic signal-processing.

[**Back to Structure**](#)



Open Elective Course - III



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Data Analytics							Code: ALOE503A		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
02	-	-	02	-	-	50	-	50	100
Prerequisites:									
• Basic knowledge of Mathematics and Statistics • Fundamentals of Computer Science									
Course Objectives:									
1. To introduce the types and applications of data analytics across domains. 2. To apply descriptive statistics and visualization techniques to summarize data. 3. To apply inferential statistics and hypothesis testing for decision-making. 4. To analyze relationships in data using correlation, regression, and ANOVA. 5. To build predictive models using classification and clustering techniques. 6. To familiarize students with prescriptive analytics and Big Data concepts.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Explain the types of data analytics and their applications across domains. BL2 – Understand								BL2 – Understand
CO2	Apply descriptive statistics and visualization techniques to summarize data. BL3 – Apply								BL3 – Apply
CO3	Analyze data using inferential statistics and hypothesis testing methods. BL4 – Analyze.								BL4 – Analyze
CO4	Apply correlation, regression, and ANOVA techniques for data-driven decisions. BL3 – Apply								BL3 – Apply
CO5	Design predictive models using classification and clustering approaches. BL6 – Create								BL6 – Create
CO6	Evaluate prescriptive analytics approaches and Big Data platforms for applications.								BL5 – Evaluate
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Introduction to Data Analytics Types of analytics — descriptive, diagnostic, predictive, and prescriptive; Analytics vs. reporting; Key applications across domains: business, healthcare, finance, and marketing; Overview of analytics tools landscape: Excel, Python, R, and Power BI (comparative overview); KPIs and metrics for decision-making. Mapped Outcomes and Bloom's Level: CO1 – Understand								05 Hrs.



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Unit II: Descriptive Analytics		
2.	Frequency distributions, outliers; Measures of central tendency and dispersion; Interquartile range; Skewness and kurtosis; Normal distribution and z-scores; Data visualization principles: bar chart, histogram, box plot, scatter plot, and heat map. Mapped Outcomes and Bloom's Level: CO2 – Apply	05Hrs.
Unit III: Inferential Statistics		
3.	Population vs. sample, random sampling; Sampling distribution, standard error; Hypothesis testing: null and alternate hypothesis, z-test, t-test; One-tailed and two-tailed tests; Confidence intervals and level of confidence; Type I and Type II errors. Mapped Outcomes and Bloom's Level: CO3 – Analyze	05 Hrs.
Unit IV: Correlation, Regression & ANOVA		
4.	Correlation and scatter plots; Simple linear regression, least squares method; Multiple regression; Coefficient of determination (R^2); One-way and two-way ANOVA; Chi-square test of independence. Mapped Outcomes and Bloom's Level: CO4 – Apply	04 Hrs.
Unit V: Predictive Analytics		
5.	Introduction to predictive modeling; Classification techniques: logistic regression, decision trees; Clustering: k-means; Model evaluation: accuracy, confusion matrix; Time series analysis basics: moving averages, trend analysis. Mapped Outcomes and Bloom's Level: CO5 – Create	05 Hrs.
Unit VI: Prescriptive & Big Data Analytics		
6.	Prescriptive analytics: optimization and simulation for decision-making; Introduction to Big Data: the 5 V's, sources of big data; Overview of the Big Data ecosystem: Hadoop, Spark (conceptual only); Applications: business analytics, web analytics, and social media analytics. Mapped Outcomes and Bloom's Level: CO6 – Evaluate	05 Hrs.
TOTAL		30Hrs
Textbooks		
1. Anil Maheshwari, Data Analytics, 2nd Edition, McGraw Hill Education, 2023. 2. Robert S. Witte and John S. Witte, Statistics, 11th Edition, Wiley Publications, 2017. 3. U. Dinesh Kumar, Business Analytics: The Science of Data-Driven Decision Making, Wiley India 2017		
Reference Books:		
1. Seema Acharya and Subhashini Chellappan, Big Data and Analytics, 2nd Edition, Wiley India, 2019. 2. Allen B. Downey, Think Stats: Exploratory Data Analysis in Python, Green Tea Press, 2014.		
E-Resources:		
MOOC / NPTEL / YouTube Link		
1. NPTEL Course on "Introduction to Data Analytics" (IIT Madras Track) Link: nptel.ac.in 2. NPTEL Course on "Data Analytics with Python" (IIT Roorkee Track) Link: https://nptel.ac.in/courses/106107220		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

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| <ol style="list-style-type: none">3. NPTEL Course on "Business Intelligence & Analytics" (IIT Madras Track)
Link: https://onlinecourses.nptel.ac.in/noc25_cs09/preview4. NPTEL Course on "Business Analytics for Management Decision" (IIT Kharagpur Track)
Link: https://nptel.ac.in/courses/1101050895. Coursera: "Google Data Analytics Professional Certificate"
Link: coursera.org6. edX: "Data Science: Statistics and Machine Learning" by Harvard University
Link: edx.org |
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EBook

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| <ol style="list-style-type: none">1. Allen B. Downey – Think Stats: Exploratory Data Analysis in Python (Open Access)
Link: greenteapress.com2. EMC Education Services – Data Science and Big Data Analytics (Open Academic Archive)
Link: archive.org |
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[**Back to Structure**](#)



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DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Open Elective – III (Green Building)							Code: ALOE503B		
Teaching Scheme (Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
02	-	-	02	-	-	50		50	100
Prerequisites:									
Basic environmental engineering, building materials & construction, engineering chemistry/ environmental science, basic knowledge of energy and sustainability concepts									
Course Objectives:									
1. To equip students with the principles of sustainable building design, resource-efficient construction, and green building practices. 2. To provide students with knowledge of energy-efficient technologies, water and waste management, sustainable materials, and green building rating systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the concepts, principles, benefits, and environmental impacts associated with green buildings and sustainable development.								
CO2	Assess building orientation, climate-responsive planning, landscaping, green roofs, and green walls for improving environmental performance.								
CO3	Evaluate building energy consumption and recommend energy-efficient strategies, HVAC optimization, renewable energy systems, and conservation measures.								
CO4	Design suitable water conservation, rainwater harvesting, greywater recycling, waste management, and sustainable drainage solutions for buildings.								
CO5	Select appropriate sustainable building materials and assess indoor environmental quality based on thermal comfort, indoor air quality, lighting, and acoustics.								
CO6	Compare major green building rating systems such as IGBC, GRIHA, and LEED and apply their principles to assess building sustainability.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Green Buildings: Definition, concept, and need of green buildings, Sustainable development principles, Environmental impacts of conventional buildings, Benefits of green buildings.								05
2.	Sustainable Planning & Architecture: Sustainable planning, Orientation and climate-responsive design, Landscape planning, Green roofs and walls.								05
3.	Energy Efficiency in Buildings:								04



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Energy consumption in buildings, Energy-efficient building design, HVAC optimization, Renewable energy systems (solar, wind), Energy audit and conservation techniques.	
4.	Water & Waste Management: Water conservation techniques, Rainwater harvesting systems, Greywater recycling, Waste management in buildings, Sustainable drainage systems.	04
5.	Sustainable Materials & Indoor Environmental Quality: Eco-friendly building materials, Low embodied energy materials, Recycled and locally available materials, Indoor air quality (IAQ), Thermal comfort, lighting, and acoustics.	04
6.	Green Building Rating Systems & Regulations: Overview of rating systems: Indian Green Building Council (IGBC) Green Rating for Integrated Habitat Assessment (GRIHA) Leadership in Energy and Environmental Design (LEED)	04
TOTAL		26

Teamwork : (Any 10)

1. Study any IGBC/GRIHA certified building and identify the sustainable features adopted.
2. Study how sustainable development principles have been implemented in any residential, commercial, or institutional building.
3. Study a construction project and identify its environmental impacts. Suggest green alternatives to reduce these impacts.
4. Analyze building designed using passive architectural principles.
5. Study the site planning of a green campus, township, or commercial complex.
6. Study an existing building incorporating green roofs or vertical gardens.
7. Study an energy-efficient building and identify passive design strategies adopted.
8. Study a building utilizing renewable energy systems and evaluate their benefits.
9. Analyze an energy audit report (or published case study) and summarize the recommended energy-saving measures.
10. Study water conservation measures implemented in any green building.
11. Study a residential or institutional building with rainwater harvesting and grey water reuse systems.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

12. Study the waste management practices of a smart city, residential township, or institutional campus.
13. Study a building that has extensively used sustainable building materials.
14. Perform a literature review on the life cycle assessment of one construction material.
15. Study an office, hospital, educational building, or green building focusing on indoor environmental quality improvements.
16. Compare two certified buildings, each evaluated under different rating systems (e.g., IGBC vs LEED or GRIHA vs IGBC).

Study the certification journey of an IGBC or GRIHA certified building.

1. K.S. Jagadeesh, "Alternative Building Materials and Technologies", New Age International.
2. C.J. Kibert, "Sustainable Construction: Green Building Design and Delivery", Wiley.

Charles J. Kibert, "Green Buildings: Principles and Practices", Island Press.

3. Environmental Legislations & Standards:

Indian Regulations

1. Environment (Protection) Act, 1986
2. Energy Conservation Act, 2001
3. National Building Code (NBC) of India
4. Eco-Niwas Samhita (Energy Conservation Building Code – Residential)

Standards & Guidelines

1. Energy Conservation Building Code (ECBC)
2. GRIHA & IGBC rating guidelines
3. LEED certification standards
4. Bureau of Energy Efficiency (BEE) norms

Reference Books:

1. O.H. Koenigsberger, "Manual of Tropical Housing and Building", Orient BlackSwan
2. G.Z. Brown and Mark DeKay, "Sun, Wind & Light", Wiley
3. Laurie Baker, "Building with Earth", Centre for Science and Environment



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

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| 4. Indian Green Building Council, "IGBC Manuals and Guidelines", CII – Indian Green Building Council |
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E-Resources:

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| <div>1. Indian Green Building Council - https://igbc.in</div> <div>2. Green Rating for Integrated Habitat Assessment - https://grihaindia.org</div> <div>3. U.S. Green Building Council - https://usgbc.org</div> <div>4. NPTEL Green Building courses - https://nptel.ac.in</div> <div>5. Ministry of Environment, Forest and Climate Change - https://moef.gov.in</div> |
| <div>6. Indian Green Building Council - https://igbc.in</div> <div>7. Green Rating for Integrated Habitat Assessment - https://grihaindia.org</div> <div>8. U.S. Green Building Council - https://usgbc.org</div> <div>9. NPTEL Green Building courses - https://nptel.ac.in</div> <div>10. Ministry of Environment, Forest and Climate Change - https://moef.gov.in</div> |

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Open Elective – III (Electrical Mobility)							Code: ALOE503C		
Teaching Scheme (Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
02	-	-	02	-	-	50	-	50	100
Prerequisites:									
Basic Electrical and Electronics Engineering.									
Course Objectives:									
1. To apply fundamental principles of electric mobility to interpret EV architectures, components and applications. 2. To utilize energy storage and battery management concepts to evaluate battery performance, charging, and safety. 3. To implement basic concepts of EV powertrains, electric drives, regenerative braking, and charging infrastructure. 4. To integrate smart charging, vehicle-to-grid, IoT, and emerging technologies for sustainable electric mobility.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the concepts, architecture, and applications of Electric and Hybrid Electric Vehicles.								
CO2	Identify the suitable energy storage systems used in electric vehicles.								
CO3	Illustrate battery charging methods, battery management systems, and SoC estimation techniques.								
CO4	Interpret hybrid powertrain configurations, operating modes, and regenerative braking.								
CO5	Demonstrate the use of electric drives, charging levels, charging standards, and EV charging equipment.								
CO6	Describe EV charging technologies and grid integration concepts such as G2V, V2G, V2H, V2B, and V2V.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Electric Mobility: Need for electric mobility, evolution of EVs, advantages and challenges, environmental and economic aspects, EV vs conventional vehicles, types of EVs: BEV, HEV, PHEV and fuel-cell vehicles, basic EV architecture and major components.								04
2.	Energy Storage Systems: Energy storage requirements, battery terminology and specifications, Li-ion batteries and their types, basic battery characteristics, battery alternatives: solid-state, Aluminium-air, fuel cell and supercapacitor, battery–supercapacitor hybrid system, selection of energy storage system.								04



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DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

3.	Battery Charging and Management: EV charging basics, AC and DC charging, charging methods and levels, charging time and factors affecting charging, Battery Management System (BMS), functions of BMS, State of Charge (SoC), State of Health (SoH), State of Power (SoP), cell balancing, battery thermal management and safety.	05
4.	EV Powertrain and Electric Drives: EV powertrain architecture, energy flow in EVs, vehicle performance and basic tractive effort, electric motors used in EVs: BLDC and PMSM, motor selection, basic drive control, regenerative braking and its benefits.	04
5.	EV Charging Infrastructure: EV charging infrastructure, charging levels, AC/DC chargers, EVSE, charging connectors and standards: CCS, CHAdeMO, SAE J1772, Bharat AC/DC, basic charging station components, installation and safety considerations.	04
6.	Smart and Emerging Electric Mobility: Grid-to-Vehicle (G2V), Vehicle-to-Grid (V2G), Vehicle-to-Home (V2H), Vehicle-to-Building (V2B), Vehicle-to-Vehicle (V2V), smart charging, wireless charging, battery swapping, energy management, IoT and digital technologies in EVs, future trends and challenges.	05
TOTAL		26
Teamwork :		
1. Study the architecture of an Electric Vehicle (EV) and identify the functions of major components such as battery, BMS, motor, inverter, charger, controller and sensors. 2. Compare 3–5 EVs available in India based on battery capacity, motor power, driving range, charging time, efficiency, cost and other key specifications. 3. Study and compare different energy storage technologies such as Li-ion batteries, solid-state batteries, fuel cells and supercapacitors based on energy density, charging time, life, cost, safety and applications. 4. Visit an EV charging station and study the charger type, AC/DC charging, charging level, connector/standard, power rating, and charging time and safety provisions. 5. Prepare a basic layout of an EV charging station showing charging points, power supply, protection system, parking area, cable routing, safety provisions and user facilities. 6. Study smart EV charging and Vehicle-to-Grid (V2G) concepts, including G2V, V2G, V2H and V2B, and identify their applications in smart grids and buildings. 7. Collect and analyze EV performance or charging data using Excel/Python/MATLAB and study parameters such as battery capacity, range, charging time and energy consumption. 8. Design a conceptual IoT-based EV monitoring system showing sensors, communication network, cloud platform and user interface for monitoring SoC, temperature, charging status and energy consumption. 9. Study regenerative braking in EVs and prepare an energy-flow diagram. Analyze energy recovery under different braking conditions using numerical calculations or simulation. 10. Study an emerging EV technology such as battery swapping, wireless charging, solid-state		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

batteries, autonomous EVs, solar charging or second-life batteries and evaluate its technical, economic and environmental benefits.

Text Books:

1. James Larminie and John Lowry, "Electric Vehicle", John Wiley & Sons, 2012.
2. Ronald K. Jurgen, "Electric and Hybrid-Electric Vehicles", SAE International.
3. K. T. Chau, "Energy Systems for Electric and Hybrid Vehicles", The Institution of Engineering and Technology.
4. D. A. J. Rand, R. Woods, and R. M. Dell, "Batteries for Electric Vehicles", Research Studies Press Ltd., New York, John Wiley & Sons.
5. "Electric & Hybrid Vehicles – Design Fundamentals", CRC Press.

Reference Books:

1. Mehrdad Ehsani, Yimin Gao, and Ali Emadi, "Modern Electrical Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design", CRC Press, 2009.
2. Junwei Lu and Jahangir Hossain et al. (Eds.), "Vehicle-to-Grid: Linking Electric Vehicles to the Smart Grid", IET Digital Library.
3. Tom Denton, "Automobile Electrical and Electronic Systems", SAE International Publications.
4. C. Mi, M. A. Masrur, and D. W. Gao, "Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives", John Wiley & Sons, 2011.
5. Mark Warner, "The Electric Vehicle Conversion Handbook", HP Books, 2011.

E-Resources:

1. <https://www.theiet.org/resources/books/transport/vehicle2grid.cfm>
2. <https://www.sae.org/publications/books/content/pt-143.set/>
3. <http://nptel.ac.in/courses/108103009/>

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Introduction to Stock Market							Code: ALOE503D		
Teaching Scheme (4 Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
02	-	-	02	-	-	50	-	50	100
Prerequisites:									
- Basic knowledge of economics and financial systems. - Familiarity with percentage calculations and simple mathematics. - Interest in investing and financial markets.									
Course Objectives:									
- To understand the structure and functioning of financial and stock markets along with investor psychology. - To apply candlestick patterns and indicators for identifying market trends. - To understand the fundamentals of option trading and option pricing concepts. - To develop short-term and long-term investment strategies using fundamental and technical analysis.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Explain the functioning of financial markets using fundamental analysis								BL2
CO2	Analyze stock price movements using candlestick patterns for trading decisions.								BL4
CO3	Analyze stock price movements using technical indicators for trading decisions.								BL4
CO4	Describe the concepts of derivatives and option trading.								BL4
CO5	Apply the strategies for option trading.								BL3
CO6	Apply investment strategies based on market analysis.								BL3
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit 1: Fundamental Analysis and Investor Psychology Introduction to Financial Markets, Primary and Secondary Markets, Market Participants, Stock Exchanges, SEBI and Regulatory Framework, Investment vs Trading, Understanding Business Models, Reading Financial Statements (Balance Sheet, Profit & Loss Account, Cash Flow Statement), Fundamental Ratios (EPS, PE Ratio, PB Ratio, ROE, ROCE, Debt-Equity Ratio), Sector Analysis, Economic Indicators, Investor Psychology, Market Emotions (Fear & Greed), Behavioral Biases, Risk Management Principles.								06
2.	Unit 2: Technical Analysis using Candlestick Charts Introduction to Technical Analysis, Dow Theory, Support and Resistance, Trend Analysis, Price Action Concepts Candlestick Anatomy : Single Candlestick Patterns (Doji, Hammer, Shooting Star, Marubozu, Spinning Top), Double Candlestick Patterns (Bullish & Bearish Engulfing, Harami, Piercing Pattern, Dark Cloud Cover), Triple Candlestick Patterns (Morning Star, Evening Star, Three								04



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	White Soldiers, Three Black Crows), Gap Analysis, Trend Reversal and Continuation Patterns.	
3.	Unit 3: Technical Analysis using Indicators Technical Indicators : Moving Averages (SMA, EMA), MACD, RSI, Stochastic Oscillator, Bollinger Bands, VWAP, ADX, ATR, Volume Analysis, Fibonacci Retracement, Pivot Points, Trend Confirmation, Indicator-Based Trading Strategies, Combining Multiple Indicators, Entry and Exit Rules, Backtesting Concepts.	04
4.	Unit 4: Introduction to Derivatives and FNO Introduction to Derivatives, Futures and Options, Types of Options (Call and Put), Option Terminology (Strike Price, Expiry, Premium, Lot Size, Open Interest), Intrinsic and Time Value, ITM, ATM, OTM Options, Option Chain Analysis, Greeks (Delta, Gamma, Theta, Vega, Rho - Basic Concepts), Option Pricing Factors, Option Expiry and Settlement Process.	04
5.	Unit 5: Introduction to Option Trading Strategies Option Buying vs Option Selling, Risk and Reward Analysis, Long Call, Long Put, Covered Call, Cash Secured Put, Bull Call Spread, Bear Put Spread, Bull Put Spread, Bear Call Spread, Iron Condor (Basic Concept), Straddle and Strangle (Introduction), Position Sizing, Stop Loss Techniques, Capital Management, Risk Management in Options Trading.	04
6.	Unit 6: Short-Term and Long-Term Trading & Investment Strategies Swing Trading, Positional Trading, Intraday Trading (Overview), Momentum Trading, Breakout Trading, Trend Following Strategies, Portfolio Building, Value Investing, Growth Investing, Dividend Investing, SIP in Equity, Asset Allocation, Diversification, Trading Plan Development, Trading Journal, Performance Evaluation, Common Mistakes Made by Traders and Investors, Ethics in Financial Markets.	04
Total		26

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Open Elective – III (Patent Law for Engineers and Scientists)							Code: ALOE503E		
Teaching Scheme (Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
02	-	-	02	-	-	50		50	100
Prerequisites:									
Basic understanding of engineering/scientific concepts and technological innovation, Basic skills in technical reading, documentation, and report writing.									
Course Objectives:									
1. To understand the importance of Intellectual Property Rights (IPR) and patents.									
2. To identify patentable and non-patentable inventions based on patentability criteria.									
3. To conduct prior-art and patent searches using public patent databases.									
4. To draft a basic patent specification, including claims and abstract.									
5. To understand and apply the complete patent filing, examination, and granting process in India.									
6. To analyze engineering case studies involving patents, innovation, and commercialization.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Apply the provisions of the Indian Patent Law to engineering inventions.								
CO2	Perform prior-art and patent searches using standard patent databases.								
CO3	Analyze the patentability, filing, examination, and grant process under the Indian Patent Act.								
CO4	Evaluate patent infringement, licensing, technology transfer, and commercialization issues.								
CO5	Draft a patent specification, including claims and abstract, in compliance with patent law.								
CO6	Develop a patent application for an innovative engineering solution following legal and procedural requirements.								
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Introduction to Intellectual Property Rights and Patents: Introduction to Intellectual Property Rights (IPR), significance of IPR in engineering, innovation and entrepreneurship, types of IPR, concept and objectives of patents, patentability criteria (novelty, inventive step and industrial applicability), patentable and non-patentable inventions under the Indian Patent Act, 1970, patents versus research publications and products, role of patents in technology commercialization and startup ecosystem. Case Study: Patentability analysis of a simple engineering innovation.								05



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

2.	Indian Patent Law and Prior-Art Search: Overview of the Indian Patent Act, 1970 and its amendments, objectives and scope of patent law, rights and duties of inventors, overview of WIPO, Patent Cooperation Treaty (PCT) and international patent systems, prior-art search techniques, patent classification systems, patent search using Google Patents, InPASS, Espacenet, and WIPO PATENTSCOPE novelty assessment and patent landscape analysis. Case Study: Prior-art search and novelty analysis of an engineering invention.	04
3.	Patent Drafting: Structure and components of a patent specification including title, field of invention, background, prior art, problem statement, objectives, summary of invention, brief description of drawings, detailed description, claims, abstract, and drawings. Principles of claim drafting, dependent and independent claims, patent drafting guidelines, common drafting errors, and patent documentation for engineering innovations. Case Study: Drafting of a patent specification for a smart engineering product.	05
4.	Patent Filing, Examination and Grant: Patent filing procedure in India, provisional and complete specification, online filing process, statutory forms, publication of patent application, request for examination, First Examination Report (FER), response to objections, hearing process, patent grant, renewal, restoration, opposition, and maintenance of patents under the Indian Patent Act. Case Study: Patent filing and grant timeline of an Indian engineering patent.	04
5.	Patent Commercialization and Legal Issues: Patent ownership, licensing, assignment, technology transfer, patent valuation, startup and university patents, patent infringement, remedies and dispute resolution, freedom-to-operate (FTO), patent analytics, commercialization strategies, and ethical issues in patent protection. Case Study: Commercialization of a patented engineering innovation.	04
6.	Emerging Technologies and Patent Case Studies: Patents in Artificial Intelligence, Machine Learning, Internet of Things (IoT), Robotics, Semiconductor Technology, Biotechnology, Software, Green Technologies, and Industry 4.0, AI-generated inventions, recent developments in patent law, international patent trends, patent portfolio management, and innovation-driven entrepreneurship. Case Study: Analysis of landmark patent disputes such as Apple vs Samsung or an Indian engineering innovation, along with preparation of a basic patent draft for an engineering solution.	04



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Total		26
Term Work:		
Students shall complete the following practical, activity-oriented assignments based on a selected engineering innovation/project:		
1. Identify suitable IP protection for an engineering innovation and assess basic patentability criteria. 2. Conduct patent searches using Google Patents, IP India, WIPO PATENTSCOPE and Espacenet and analyze the novelty of the selected innovation. 3. Identify a copyrightable work such as software, technical content or digital work and prepare/undertake the copyright registration process. 4. Develop a product/start-up brand, conduct trademark search, identify the appropriate class and prepare a basic trademark application. 5. Identify protectable visual features of an engineering product, conduct design search and prepare a basic design registration application. 6. Prepare a basic patent specification including title, background, objectives, description, drawings, abstract and claims for an engineering innovation. 7. Prepare a mock provisional/complete patent application and study the filing, publication, examination, FER, response and grant process in India. 8. Study the PCT route and prepare a mock PCT application based on the selected engineering invention. 9. Analyze patents in a selected emerging technology area and identify major patent holders, technology trends and basic FTO considerations. 10. Develop an IP portfolio for the selected innovation covering patent, copyright, trademark/design and propose a basic commercialization strategy.		
Text Books:		
1. P. Narayanan, "Patent Law", Eastern Law House. 2. Prabuddha Ganguli, "Intellectual Property Rights: Unleashing the Knowledge Economy", McGraw-Hill. 3. N. S. Gopalakrishnan and T. G. Agitha, "Principles of Intellectual Property", Eastern Book Company. 4. Government of India, "The Patents Act, 1970 (as amended) and The Patents Rules, 2003 (as amended)", Government of India.		
Reference Books:		
1. David Pressman, "Patent It Yourself", NOLO Publications. 2. WIPO, "WIPO Intellectual Property Handbook: Policy, Law and Use", World Intellectual Property Organization.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

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| 3. Indian Patent Office, "Manual of Patent Office Practice and Procedure", Office of the Controller General of Patents, Designs & Trade Marks (CGPDTM), Government of India. |
| 4. Alexander I. Poltorak and Paul J. Lerner, "Essentials of Intellectual Property", John Wiley & Sons. |

E-Resources:

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| 1. Patent Law for Engineers and Scientists – NPTEL (IIT Madras):
https://nptel.ac.in/courses/110106081 |
| 1. Intellectual Property – NPTEL (IIT Madras): https://nptel.ac.in/courses/109106137 |

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: V			
Course: Statistical Methods for Data Modelling						Code: ADMD503			
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
1	2	-	02	-	-	50	-	-	50
Prerequisites: Basic Mathematics, Programming Fundamentals, and Fundamentals of Data Handling									
Course Objectives:									
1. To understand the fundamental concepts of descriptive and inferential statistics, including measures of central tendency, dispersion, skewness, probability distributions, and sampling. 2. To develop practical skills in exploratory data analysis (EDA) and statistical visualization using tools such as Python, R, and Microsoft Excel. 3. To apply appropriate parametric and non-parametric hypothesis testing techniques for analyzing and interpreting real-world datasets. 4. To understand and apply correlation and linear regression techniques for analyzing relationships between variables and evaluating model performance. 5. To perform regression diagnostics and validation using techniques such as multicollinearity analysis, residual analysis, and goodness-of-fit measures. 6. To apply basic time-series analysis and forecasting techniques, including decomposition, moving averages, and exponential smoothing, for data-driven decision-making.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze structured datasets using descriptive statistics, measures of central tendency and dispersion, skewness, and appropriate statistical visualizations.								BL4 – Analyze
CO2	Apply sampling and probability concepts, including the Central Limit Theorem, to understand sampling distributions and statistical inference.								BL3 – Apply
CO3	Apply appropriate parametric and non-parametric hypothesis testing techniques to analyze and interpret relationships and differences in datasets.								BL3 – Apply
CO4	Analyze relationships among variables using correlation and linear regression techniques and interpret model fit and regression results.								BL4 – Analyze
CO5	Evaluate regression models using diagnostic and validation techniques, including multicollinearity analysis, residual analysis, and goodness-of-fit measures.								BL5 – Evaluate
CO6	Apply basic time-series analysis and forecasting techniques such as								BL3 – Apply



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	decomposition, moving averages, and exponential smoothing to support data-driven decision-making.	
Course Contents:		
Unit	Description	Duration (Hrs.)
1.	Unit 1: Data Exploration & Descriptive Statistics Introduction to statistics and data, population and sample, mean, median, mode, range, variance and standard deviation, basic skewness, exploratory data analysis, histograms and box plots.	03 Hrs.
2.	Unit 2: Probability & Sampling Basic probability concepts, random variables and probability distributions, sampling methods, sampling distribution, Central Limit Theorem, interpretation of sample means.	03 Hrs.
3.	Unit 3: Hypothesis Testing Introduction to hypothesis testing, null and alternative hypotheses, significance level and p-value, Type I and Type II errors, one-sample and two-sample t-tests, Chi-Square test of independence, interpretation of results.	03 Hrs.
4.	Unit 4: Correlation & Linear Regression Relationship between variables, Pearson and Spearman correlation, simple linear regression, regression equation and coefficients, R^2 , regression line, interpretation of regression results.	03 Hrs.
5.	Unit 5: Regression Analysis & Diagnostics Multiple linear regression, basic regression assumptions, multicollinearity, Variance Inflation Factor (VIF), residual analysis, residual plots and Q-Q plots, basic model validation.	02 Hrs.
6.	Unit 6: Time Series & Forecasting Introduction to time-series data, trend and seasonality, basic time-series decomposition, moving average, exponential smoothing, simple forecasting and interpretation.	02 Hrs.
TOTAL		16 Hrs
Text Books:		
1. Peter Bruce, Andrew Bruce, and Peter Gedeck, "Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python", O'Reilly Media, 2nd Edition, 2020.		
2. Douglas C. Montgomery, Elizabeth A. Peck, and G. Geoffrey Vining, "Introduction to Linear Regression Analysis", Wiley, 6th Edition (Indian Adaptation), 2021.		
3. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Jupyter", O'Reilly		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Media, 3rd Edition, 2022.

4. Richard D. De Veaux, Paul F. Velleman, and David E. Bock, "Stats: Data and Models", Pearson Education, 5th Edition, 2020.

Reference Books:

1. Jake VanderPlas, "Python Data Science Handbook: Essential Tools for Working with Data", O'Reilly Media, 2nd Edition, 2022.

2. Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, "An Introduction to Statistical Learning: with Applications in Python", Springer, 1st Edition, 2023.

3. Sheldon M. Ross, "Introduction to Probability and Statistics for Engineers and Scientists", Academic Press, 6th Edition, 2020.

4. Rob J. Hyndman and George Athanasopoulos, "Forecasting: Principles and Practice", OTexts, 3rd Edition, 2021.

E-Resources:

MOOC / NPTEL / YouTube Links

1. NPTEL Course: "Introduction to Probability and Statistics" - IIT Madras (<https://nptel.ac.in>)

2. NPTEL Course: "Applied Statistics and Econometrics" - IIT Kanpur (<https://nptel.ac.in>)

3. YouTube Playlist: "StatQuest with Josh Starmer" - Statistics Fundamentals, Regression and Analytics (<https://youtube.com>)

LIST OF EXPERIMENTS (Any 10 out of 11 to be performed)

Experiment 1: Data Exploration & Descriptive Statistics: Perform Exploratory Data Analysis (EDA) on a structured dataset; calculate mean, median, mode, range, variance and standard deviation; visualize the data using histograms and box plots.

(Tools: Python – Pandas, NumPy, Matplotlib, Seaborn)

Experiment 2: Sampling & Central Limit Theorem: Generate random samples from a dataset or probability distribution and observe the distribution of sample means to understand the Central Limit Theorem.

(Tools: Python – NumPy, Pandas, Matplotlib)

Experiment 3: Hypothesis Testing using T-Test: Perform one-sample and two-sample t-tests on suitable datasets and interpret the p-value and statistical significance.

(Tools: Python – SciPy, Pandas)

Experiment 4: Chi-Square Test: Apply the Chi-Square test of independence on categorical data to determine whether two variables are statistically related.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

(Tools: Python – SciPy, Pandas)

Experiment 5: Correlation Analysis: Calculate Pearson and Spearman correlation coefficients and visualize relationships between variables using a correlation heatmap.

(Tools: Python – Pandas, SciPy, Seaborn, Matplotlib)

Experiment 6: Simple Linear Regression: Build a Simple Linear Regression model, plot the regression line, calculate R^2 , and interpret the regression coefficients and model fit.

(Tools: Python – Pandas, Scikit-learn, Matplotlib)

Experiment 7: Multiple Linear Regression: Build a Multiple Linear Regression model using multiple input variables and evaluate its performance using suitable regression metrics.

(Tools: Python – Pandas, Scikit-learn)

Experiment 8: Regression Diagnostics: Analyze regression residuals and check basic assumptions using residual plots, Q-Q plots, and Variance Inflation Factor (VIF).

(Tools: Python – Statsmodels, Pandas, Matplotlib, Seaborn)

Experiment 9: Time-Series Analysis: Analyze a time-series dataset to identify and visualize basic trend and seasonal patterns using time-series decomposition.

(Tools: Python – Pandas, Matplotlib, Statsmodels)

Experiment 10: Basic Time-Series Forecasting: Implement Moving Average and Exponential Smoothing methods to forecast future values of a time-series dataset and interpret the results.

(Tools: Python – Pandas, Statsmodels, Matplotlib)

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: V		
Course: Internship – IV							Code: ADIN504		
Teaching Scheme (Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	-	-	02	-	-	25	-	-	25
Preamble:									
Internships serve as vital educational and career development experiences, offering practical exposure in a specific field. Employers seek individuals who possess the necessary skills and an understanding of industry environments, practices, and cultures. This internship is designed as a structured, short-term, supervised training program, often centered on specific tasks or projects with clear timelines. The primary goal is to immerse technical students in an industrial setting, providing experiences that cannot be replicated in the classroom. This exposure aims to develop competent professionals who understand the social, economic, and administrative factors influencing the operations of industrial organizations.									
Course Objectives:									
1. Exposure to students to the industrial environment, which cannot be provided in the classroom and hence creating deployable professionals for the industry.									
2. Learn to implement the technical knowledge in real industrial situations.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Gain exposure to industry practices and understand how academic concepts are applied in professional settings.								
CO2	Develop and demonstrate effective communication and teamwork skills within a work environment.								
CO3	Improve your problem-solving and time management skills by working in real-world industry settings.								
Internship Requirements									
1. Internship Duration: It is mandatory for all students to undergo an internship after every semester during vacations for the duration of 3 to 5 weeks. Internships completed during this period will be considered for the assessment of Term Work (TW).									
2. Internship Opportunities: Students can explore various opportunities for internships at:									
a. Industries									
b. Research labs or organizations									
c. Collegiate clubs									
d. In-house research projects									
e. Online internships									
3. Support and Assistance: Students can seek assistance for securing internships from:									
a. The Training and Placement cell, along with departmental coordinators									
b. Department or institute faculty members									
c. Personal contacts									
d. Directly connecting with industries or organizations									
4. Request Letter: Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.

5. **Confirmation Letter:** Students must submit the confirmation letter from the industry, research organization, or collegiate club to the Internship Coordinator and the Head of Department (HOD) office.
6. **Joining Report:** Upon commencing the internship, students must submit the joining report, joining letter, or a copy of the confirmation email to the Internship Coordinator and the HOD office.
7. **Faculty Mentor:** A faculty member will be assigned as a mentor to a group of students. The mentor will be responsible for monitoring, evaluating, and assessing student internship activities. The faculty mentor is also required to visit the internship location and submit formal feedback to the Internship Coordinator.
8. **Faculty Visits:** Faculty members are advised to visit the internship site once or twice during the internship period to monitor progress.
9. **Progress Report:** Students must submit progress report fortnightly to their faculty guide and the final internship report to the Internship Coordinator and department office.
10. **Evaluation Report:** After the completion of the internship, the mentor, along with the assessment panel members, should submit the evaluation report of the students to the department office and the Internship Coordinator.
11. **Internship Certificate:** Students must receive the Internship Certificate from the industry and submit it to the Internship Coordinator and department office.
12. **Presentation and Assessment:** Students are required to give a presentation on their internship work as part of the term work. The internship diary and report will also be verified and assessed.

[**Back to Structure**](#)



SYLLABUS

SEMESTER - VI



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: Deep Learning						Code: ADPC611			
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems, and Database Management Systems									
Course Objectives:									
1. Explain the mathematical and algorithmic foundations of deep learning, including neural computation, loss optimization, and generalization principles. 2. Build and train feedforward deep neural networks using appropriate activation functions, regularization methods, and optimization algorithms. 3. Analyze and apply convolutional neural networks for image-related learning tasks such as classification and feature extraction. 4. Design recurrent and sequence-based deep learning models for temporal, textual, and sequential data processing. 5. Evaluate representation learning, autoencoders, and transfer learning methods for real-world AI applications. 6. Develop and assess deep learning solutions using modern software frameworks and performance metrics for practical AI systems									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze the fundamental concepts, architectures, and mathematical principles that underpin deep learning models.								BL4 – Analyze
CO2	Apply optimization, regularization, and hyperparameter tuning techniques to train robust deep neural networks.								BL3 – Apply
CO3	Design and evaluate feedforward and convolutional neural networks for supervised learning tasks.								BL2 – Understand
CO4	Develop sequence models using recurrent networks and attention-based ideas for temporal and language data.								BL3 – Apply
CO5	Evaluate representation learning, autoencoders, and transfer learning approaches for problem-specific model selection.								BL5 – Evaluate



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

CO6	Create end-to-end deep learning workflows using standard frameworks, datasets, and performance measures.	BL4 – Analyze
Course Contents:		
Unit	Description	Duration (Hrs.)
1.	Unit I: Foundations of Deep Learning Overview of Deep Learning, AI vs Machine Learning vs Deep Learning, evolution and applications of Deep Learning, brief overview of ANN and MLP as prerequisites, limitations of shallow networks, concept of deep networks and representation learning, loss functions overview, training validation and test data, underfitting and overfitting, bias-variance concept, model generalization. Mapped Outcomes and Bloom's Level: CO1 - Analyze; CO2 - Apply	05 Hrs.
2.	Unit II: Training Deep Neural Networks Overview of forward propagation and backpropagation, activation functions overview including ReLU sigmoid and tanh, gradient descent and its variants, mini-batch training, Adam optimizer, learning rate, weight initialization, regularization, dropout, batch normalization, vanishing and exploding gradient problems. Mapped Outcomes and Bloom's Level: CO2 - Apply; CO3 - Create /Evaluate.	05 Hrs.
3.	Unit III: Convolutional Neural Networks Introduction to CNNs, convolution operation, filters and feature maps, padding and stride, pooling, receptive field, basic CNN architecture, image classification using CNNs, overview of popular architectures such as LeNet, AlexNet and ResNet, data augmentation, transfer learning overview. Mapped Outcomes and Bloom's Level: CO3 - Create / Evaluate; CO6 –Create	05 Hrs.
4.	Unit IV: Sequence Models and Attention Introduction to sequential data, overview of Recurrent Neural Networks (RNN), basic idea of LSTM and GRU, sequence classification, introduction to attention mechanism, overview of Transformers. Mapped Outcomes and Bloom's Level: CO4 - Create; CO6 - Create.	05 Hrs.
5.	Unit V: Representation Learning and Generative Models Introduction to representation learning, autoencoders, denoising autoencoders, latent representations, introduction to generative AI, overview of Variational Autoencoders (VAE) and Generative Adversarial Networks (GAN), transfer learning and fine-tuning, use of pretrained models. Mapped Outcomes and Bloom's Level: CO5 - Evaluate; CO6 - Create	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

6.	Unit VI: Deep Learning Practice and Applications Deep learning workflow using Python and a deep learning framework, dataset preparation and preprocessing, model training and evaluation, confusion matrix, precision, recall and F1-score, basic model improvement and error analysis, overview of deployment considerations, responsible and ethical use of AI, applications in computer vision NLP healthcare and recommendation systems, simple case study or mini-project. Mapped Outcomes and Bloom's Level: CO1 - Analyze; CO5 - Evaluate; CO6 - Create.	05 Hrs.
TOTAL		30 Hrs
Text Books:		
1. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, MIT Press, 2016. 2. Francois Chollet, Deep Learning with Python, 2nd Edition, Manning Publications, 2021. 3. Charu C. Aggarwal, Neural Networks and Deep Learning: A Textbook, 2nd Edition, Springer, 2023. 4. Simon J.D. Prince, Understanding Deep Learning, MIT Press, 2023. 5. Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola, Dive into Deep Learning, Cambridge University Press, 2023		
Reference Books:		
1. Nikhil Buduma and Nicholas Locascio, Fundamentals of Deep Learning, 2nd Edition, O'Reilly Media, 2021. 2. Josh Patterson and Adam Gibson, Deep Learning: A Practitioner's Approach, 2nd Edition, O'Reilly Media, 2021. 3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, 3rd Edition, O'Reilly Media, 2022. 4. Umberto Michelucci, Applied Deep Learning: A Case-Based Approach to Understanding Deep Neural Networks, Apress, 2022. 5. Mark Ryan, In Deep: How to Build Neural Networks and Shape the Future of AI, Manning Publications, 2020.		
E-Resources:		
MOOC / NPTEL / YouTube Links		
• <u>1NPTEL: Deep Learning</u> - An NPTEL course covering feedforward networks, convolutional networks, recurrent networks, attention mechanisms, and optimization methods.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

- [NPTEL Preview: Deep Learning](#) - Course outline describing deep learning applications in computer vision and natural language processing.
- [NPTEL: Foundations of Deep Learning: Concepts and Applications](#) - Introductory-to-advanced course emphasizing implementation using Python and Google Colab.
- [Deep Learning Book](#) - Open online version of the standard MIT Press textbook by Goodfellow, Bengio, and Courville.
- [Coursera: Deep Learning Specialization](#) - Structured academic pathway for neural networks, CNNs, sequence models, and attention.
- [MIT Open Learning Library](#) - Open academic learning resources useful for mathematical foundations and AI-related study.
- [GitHub: Dive into Deep Learning](#) - Open-source book, code, and notebooks for hands-on deep learning practice.
- [YouTube: NPTEL Deep Learning Lectures](#) - Lecture videos aligned with the NPTEL deep learning curriculum.
- [PyTorch Tutorials](#) - Official tutorials for model building, training, and deployment.

[TensorFlow Tutorials](#) - Official tutorials for deep learning workflows and implementation

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: Deep Learning Lab						Code: ADPC611P			
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems, and Database Management Systems									
Course Objectives:									
1. Explain the mathematical and algorithmic foundations of deep learning, including neural computation, loss optimization, and generalization principles. 2. Build and train feedforward deep neural networks using appropriate activation functions, regularization methods, and optimization algorithms. 3. Analyze and apply convolutional neural networks for image-related learning tasks such as classification and feature extraction. 4. Design recurrent and sequence-based deep learning models for temporal, textual, and sequential data processing. 5. Evaluate representation learning, autoencoders, and transfer learning methods for real-world AI applications. 6. Develop and assess deep learning solutions using modern software frameworks and performance metrics for practical AI systems									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Analyze the fundamental concepts, architectures, and mathematical principles that underpin deep learning models.								
CO2	Apply optimization, regularization, and hyperparameter tuning techniques to train robust deep neural networks.								
CO3	Design and evaluate feedforward and convolutional neural networks for supervised learning tasks.								
CO4	Develop sequence models using recurrent networks and attention-based ideas for temporal and language data.								
CO5	Evaluate representation learning, autoencoders, and transfer learning approaches for problem-specific model selection.								
CO6	Create end-to-end deep learning workflows using standard frameworks, datasets, and								



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

performance measures.

LIST OF EXPERIMENTS

The following tools should be treated as the minimum common toolset for the practical course: **Python, Jupyter Notebook/Google Colab, NumPy, Pandas, Matplotlib, Seaborn, Scikit-learn, TensorFlow/Keras or PyTorch, Hugging Face Transformers, VS Code, and Git/GitHub** for basic project and version-control practice.

Minimum Mandatory Experiments: 8

1. **Build and Train a Basic Deep Neural Network:** Build a simple neural network for classification using a standard dataset, train the model, observe training and validation loss, and evaluate its performance. (Tools: Python, Jupyter Notebook/Google Colab, TensorFlow/Keras or PyTorch, NumPy, Pandas, Scikit-learn)
2. **Compare Activation Functions and Learning Performance:** Implement a simple neural network using ReLU, sigmoid and tanh activation functions, compare training behavior and performance, and observe the effect of different learning rates. (Tools: Python, Google Colab/Jupyter Notebook, TensorFlow/Keras or PyTorch, Matplotlib)
3. **Study Regularization and Overfitting:** Train a neural network with and without dropout and L2 regularization, compare training and validation performance, and observe the effect of overfitting. (Tools: Python, TensorFlow/Keras or PyTorch, Matplotlib, Scikit-learn)
4. **Implement a Convolutional Neural Network for Image Classification:** Build a basic CNN for image classification using MNIST or Fashion-MNIST, evaluate accuracy and loss, generate a confusion matrix, and examine prediction errors. (Tools: Python, Jupyter Notebook/Google Colab, TensorFlow/Keras or PyTorch, NumPy, Matplotlib, Scikit-learn)
5. **Apply Data Augmentation and Transfer Learning:** Use data augmentation and a pre-trained CNN such as MobileNet or ResNet for classification on a small image dataset, and compare transfer learning performance with a basic CNN. (Tools: Python, Google Colab, TensorFlow/Keras or PyTorch, Matplotlib)
6. **Build an RNN/LSTM for Sequential Data:** Implement a simple RNN or LSTM model for time-series prediction or sequence classification, and evaluate its performance on a suitable dataset. (Tools: Python, Jupyter Notebook/Google Colab, TensorFlow/Keras or PyTorch, Pandas, Matplotlib)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

7. **Sentiment Analysis using Deep Learning:** Perform text preprocessing and build a simple sentiment classification model using word embeddings, evaluate the model using accuracy, precision, recall and F1-score, and analyze incorrect predictions. **(Tools: Python, Google Colab/Jupyter Notebook, TensorFlow/Keras or PyTorch, Pandas, Scikit-learn)**
8. **Introduction to Attention and Transformer Models:** Use a pre-trained Transformer model for a simple NLP task such as text classification or sentiment analysis, and understand the basic role of attention and pretrained models. **(Tools: Python, Google Colab/Jupyter Notebook, Hugging Face Transformers, TensorFlow/PyTorch)**
9. **Deep Learning Model Evaluation and Error Analysis:** Evaluate a trained deep learning model using confusion matrix, accuracy, precision, recall and F1-score, visualize training/validation curves, and identify common prediction errors. **(Tools: Python, Scikit-learn, Matplotlib, Seaborn, TensorFlow/Keras or PyTorch)**
10. **Mini Project – Deep Learning Application:** Develop a simple deep learning application for an image, text, audio or time-series problem, covering dataset preparation, model training or transfer learning, evaluation, and basic visualization. **(Tools: Python, Google Colab/Jupyter Notebook, TensorFlow/Keras or PyTorch, Scikit-learn, Matplotlib/Seaborn, VS Code, Git/GitHub)**

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: Natural Language Processing						Code: ADPC612			
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems, and Database Management Systems									
Course Objectives:									
1. Explain the linguistic and computational foundations of NLP, including tokenization, morphology, syntax, and semantics. 2. Apply classical NLP techniques such as n-gram language models, HMMs, CRFs, and parsing algorithms to text processing tasks. 3. Design neural sequence models (RNNs, LSTMs, GRUs) and word embeddings for representation and modeling of textual data. 4. Analyze and implement transformer architectures, attention mechanisms, and pre-trained language models for NLP applications. 5. Evaluate NLP systems using appropriate metrics and datasets for tasks such as classification, extraction, summarization, and generation. 6. Develop end-to-end NLP pipelines using modern libraries (NLTK, spaCy, Hugging Face Transformers) and deploy them in practical scenarios.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze linguistic structures and computational models underlying natural language understanding and generation.								Analyze
CO2	Apply statistical and neural methods for text preprocessing, language modeling, and sequence labeling.								Apply
CO3	Design and implement sequence-to-sequence models and attention-based architectures for core NLP tasks.								Create
CO4	Evaluate transformer-based models and pre-trained language models for domain-specific NLP applications.								Evaluate
CO5	Assess performance, bias, and ethical implications of NLP systems using standard metrics and benchmarks.								Evaluate
CO6	Create end-to-end NLP solutions using modern frameworks, integrating								Create



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	preprocessing, modeling, and deployment components.	
Course Contents:		
Unit	Description	Duration (Hrs.)
1.	Unit I: Introduction to NLP and Text Processing Introduction to NLP, motivation and applications; challenges in processing human language; characteristics of natural language and ambiguity; basic levels of language analysis; text representation and encoding; text preprocessing: sentence segmentation, tokenization, normalization, stemming, lemmatization and stop-word removal; regular expressions for text processing; introduction to corpora and lexical resources; basic NLP tools and libraries such as NLTK and spaCy. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	05 Hrs.
2.	Unit II: Basic Statistical NLP and Text Classification Introduction to language models; n-gram language models; basic smoothing techniques; evaluation using perplexity; spelling correction and edit distance; introduction to Part-of-Speech tagging; Hidden Markov Models and Viterbi algorithm; Named Entity Recognition and chunking; text representation using Bag-of-Words and TF-IDF; basic text classification using Naive Bayes, Logistic Regression and SVM; evaluation metrics: accuracy, precision, recall and F1-score. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply; CO5 – Evaluate	05 Hrs.
3.	Unit III: Neural Networks and Word Representations Introduction to neural networks for NLP; word representations and embeddings; Word2Vec, GloVe and FastText; Recurrent Neural Networks; LSTM and GRU for sequence data; basic encoder-decoder architecture; introduction to attention mechanism; neural approaches for text classification and sentiment analysis; basic sequence labeling; common training issues such as overfitting, vanishing gradients and dropout; introduction to transfer learning. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO3 – Create; CO5 – Evaluate	05 Hrs.
4.	Unit IV: Transformers and Pre-trained Language Models Introduction to attention and self-attention; scaled dot-product attention; basic Transformer architecture; multi-head attention and positional encoding; encoder and decoder concepts; introduction to BERT and GPT; pre-training and fine-tuning; prompt-based learning; introduction to large language models; using Hugging Face Transformers for model loading and inference; basic applications of pre-trained language models; ethical considerations in language models.	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Mapped Outcomes and Bloom's Level: CO3 – Create; CO4 – Evaluate; CO5 – Evaluate	
5.	Unit V: NLP Applications Text classification and sentiment analysis; information extraction; Named Entity Recognition and relation extraction; question answering systems; text summarization; chatbots and conversational systems; machine translation; introduction to topic modeling; multilingual and low-resource NLP; NLP applications in healthcare, finance, education, social media and other domains; introduction to real-world NLP datasets and case studies. Mapped Outcomes and Bloom's Level: CO3 – Create; CO4 – Evaluate; CO6 – Create	05 Hrs.
6.	NLP Systems, Responsible AI and Mini Project End-to-end NLP workflow: data collection, preprocessing, model building, evaluation and deployment; model evaluation and error analysis; basic model interpretability; bias, fairness and privacy in NLP; responsible use of language technologies; introduction to current NLP trends such as Retrieval-Augmented Generation (RAG), conversational AI and multimodal NLP; use of modern NLP libraries and APIs; mini-project based on an NLP application such as sentiment analysis, text classification, question answering, summarization or chatbot. Mapped Outcomes and Bloom's Level: CO4 – Evaluate; CO5 – Evaluate; CO6 – Create	05 Hrs.
TOTAL		30 Hrs
Text Books:		
1. Daniel Jurafsky and James H. Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 2nd Edition, Pearson Education, 2008. 2. Christopher D. Manning and Hinrich Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999 (available online via Stanford NLP). 3. Stephan Raaijmakers, Deep Learning for Natural Language Processing, Manning Publications, 2022. 4. Hobson Lane and Maria Dyshel, Natural Language Processing in Action, 2nd Edition, Manning Publications, 2025. 5. Akshi Kumar, Language Intelligence: Expanding Frontiers in Natural Language Processing, 2025.		
Reference Books:		
1. Steven Bird, Ewan Klein, and Edward Loper, Natural Language Processing with Python, O'Reilly Media, 2009. 2. Masato Hagiwara, Real-World Natural Language Processing, Manning Publications, 2021.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

3. Paul Azunre, Transfer Learning for Natural Language Processing, Manning Publications, 2021.
4. Ekaterina Kochmar, Getting Started with Natural Language Processing, Manning Publications, 2022.
5. Philipp Koehn, Statistical Machine Translation, Cambridge University Press, 2010.

E-Resources:

MOOC / NPTEL / YouTube Links

- NPTEL: Natural Language Processing (IIT Kharagpur) –
https://onlinecourses.nptel.ac.in/noc26_cs45/preview
- NPTEL: Applied Natural Language Processing –
https://archive.nptel.ac.in/content/syllabus_pdf/106106211.pdf
- NPTEL: Deep Learning for Natural Language Processing – https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs181
- Stanford CS224N: NLP with Deep Learning –
<https://web.stanford.edu/class/archive/cs/cs224n/cs224n.1142/textbook.html>
- Coursera: Natural Language Processing Specialization (DeepLearning.AI) –
<https://www.coursera.org/specializations/natural-language-processing>
- Hugging Face Course: Transformers and NLP – <https://huggingface.co/learn/llm-course/en/chapter1/1>
- Heidelberg University: NLP using Transformers – <https://ds.ifi.uni-heidelberg.de/teaching/nlp-using-transformers>
- Coursera: Deep Learning Specialization - Structured academic pathway for neural networks, CNNs, sequence models, and attention.
- MIT Open Learning Library - Open academic learning resources useful for mathematical foundations and AI-related study.
- GitHub: Dive into Deep Learning - Open-source book, code, and notebooks for hands-on deep learning practice.
- YouTube: NPTEL Deep Learning Lectures - Lecture videos aligned with the NPTEL deep learning curriculum.
- PyTorch Tutorials - Official tutorials for model building, training, and deployment.
- TensorFlow Tutorials - Official tutorials for deep learning workflows and implementation.
- GitHub: Transformers Course – <https://github.com/s-nlp/transformers-course>



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

- **YouTube: NPTEL NLP Lectures –**
https://www.youtube.com/results?search_query=NPTEL+Natural+Language+Processing
- NLTK Book and Tutorials – <https://www.nltk.org/book/>
- spaCy Documentation – <https://spacy.io/>
- Hugging Face Transformers Documentation – <https://huggingface.co/docs/transformers>.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: Natural Language Processing Lab						Code: ADPC612P			
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	25	-	25
Prerequisites: Programming Fundamentals, Computer Networks, Operating Systems,									
Course Objectives:									
1. Explain the linguistic and computational foundations of NLP, including tokenization, morphology, syntax, and semantics.									
2. Apply classical NLP techniques such as n-gram language models, HMMs, CRFs, and parsing algorithms to text processing tasks.									
3. Design neural sequence models (RNNs, LSTMs, GRUs) and word embeddings for representation and modeling of textual data.									
4. Analyze and implement transformer architectures, attention mechanisms, and pre-trained language models for NLP applications.									
5. Evaluate NLP systems using appropriate metrics and datasets for tasks such as classification, extraction, summarization, and generation.									
6. Develop end-to-end NLP pipelines using modern libraries (NLTK, spaCy, Hugging Face Transformers) and deploy them in practical scenarios.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Analyze linguistic structures and computational models underlying natural language understanding and generation.								
CO2	Apply statistical and neural methods for text preprocessing, language modeling, and sequence labeling								
CO3	Design and implement sequence-to-sequence models and attention-based architectures for core NLP tasks.								
CO4	Evaluate transformer-based models and pre-trained language models for domain-specific NLP applications.								
CO5	Assess performance, bias, and ethical implications of NLP systems using standard metrics and benchmarks.								
CO6	Create end-to-end NLP solutions using modern frameworks, integrating preprocessing, modeling, and deployment components.								
LIST OF EXPERIMENTS									
1. Text Preprocessing									



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Implement a basic text preprocessing pipeline including sentence splitting, tokenization, case conversion, stop-word removal, stemming, lemmatization, and edit distance.

2. Text Representation

Implement Bag-of-Words, one-hot encoding, and TF-IDF to represent and vectorize text documents.

3. N-gram Language Model

Implement unigram, bigram, and trigram language models and calculate basic language-model probabilities and perplexity.

4. Part-of-Speech Tagging

Perform Part-of-Speech tagging using a pre-trained NLP library and implement a basic Hidden Markov Model-based tagging approach.

5. Text Classification

Build a text classification model using Naive Bayes or Logistic Regression with TF-IDF features and evaluate its performance using accuracy, precision, recall, and F1-score.

6. Word Embeddings

Use pre-trained Word2Vec, GloVe, or FastText embeddings to find word similarities and represent text for a simple NLP task.

7. Named Entity Recognition and Information Extraction

Perform Named Entity Recognition using spaCy or NLTK and extract entities such as persons, organizations, locations, and dates from text.

8. Sentiment Analysis

Build a sentiment analysis system using traditional machine learning and/or a simple neural network model and evaluate its performance.

9. Text Summarization or Question Answering

Implement a basic text summarization or question-answering application using a pre-trained NLP model or library.

10. Transformer-based NLP Application

Use a pre-trained Transformer model such as BERT or a similar model through Hugging Face Transformers for a simple task such as text classification, sentiment analysis, or question answering.

GitHub / Example Resources

- [Natural Language Processing Lab Experiments](#) — covers preprocessing, bag of words, TF-IDF, POS tagging, chunking, NER, and embeddings.[github](#)
- [NLP examples with Python](#) — Jupyter notebooks for statistical and neural NLP examples.[github](#)
- [NLP projects and examples](#) — sentiment analysis, topic modeling, keyword extraction, next-word prediction, spelling correction, and more.[github](#)
- [NLP Projects](#) — project-style examples including text classification and chatbots.[github](#)
- [Simple NLP Projects](#) — a smaller collection of classic NLP programs.[github](#)
- [Natural Language Processing virtual lab experiments](#) — structured experiment list for word analysis, n-



Program Elective Course - II



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Big Data Analytics							Code: ADPE602A		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1. Understand the characteristics, challenges, and architectural paradigms of big data systems.									
2. Apply distributed storage and processing frameworks such as Hadoop, HDFS, and Map Reduce for batch analytics.									
3. Design scalable data processing pipelines using Apache Spark and its libraries for large-scale analytics.									
4. Implement NoSQL databases and streaming platforms for real-time data ingestion and analysis.									
5. Evaluate and apply big data analytics algorithms for classification, clustering, and pattern mining on distributed data.									
6. Develop end-to-end big data solutions integrating storage, processing, and analytics components using modern tools.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze the characteristics, challenges, and architectural paradigms of big data systems.								Analyze
CO2	Apply distributed storage and processing frameworks (Hadoop, HDFS, MapReduce) for batch data analytics.								Apply
CO3	Design scalable data processing pipelines using Apache Spark and its libraries for large-scale analytics.								Create
CO4	Implement NoSQL databases and streaming platforms for real-time data ingestion and analysis.								Create
CO5	Evaluate big data analytics algorithms for classification, clustering, and pattern mining on distributed data.								Evaluate
CO6	Develop end-to-end big data solutions integrating storage, processing, and analytics components using modern tools.								Create
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Introduction to Big Data Big data characteristics: volume, velocity, variety, veracity, value;Sources and types of big data: structured, semi-structured, unstructured;Challenges in big data: storage,								05 Hrs.



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	processing, privacy, security; Big data architecture patterns: batch, real-time, lambda, and kappa architectures; Big data ecosystem overview: Hadoop, Spark, NoSQL databases, streaming platforms; Applications of big data analytics in industry, healthcare, finance, social media, and IoT. Mapped Outcomes and Bloom's Level: CO1 – Analyze	
2.	Unit II: Distributed Storage and Batch Processing Hadoop ecosystem: HDFS architecture, design, read/write operations, commands; Hadoop cluster components: NameNode, Data Node, ResourceManager, Node Manager; MapReduce programming model: map, shuffle, sort, reduce phases; MapReduce on YARN: resource management, job scheduling, and workflow; Writing MapReduce applications for word count, log analysis, and aggregation; Data serialization formats: Avro, Parquet, ORC, sequence files; Hive for SQL-like querying on big data: architecture, partitioning, optimization; Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	05 Hrs.
3.	Unit III: In-Memory Processing with Apache Spark Spark architecture: driver, executors, cluster managers, SparkContext; Resilient Distributed Datasets (RDDs): transformations, actions, caching; Spark SQL: DataFrames, DataSets, schema inference, query optimization; Spark libraries: MLlib for machine learning, GraphX for graph processing; Spark Streaming: DStreams, micro-batch processing, window operations; Structured Streaming: event-time processing, watermarking, stateful operations; Running Spark on YARN/Kubernetes; performance tuning and best practices. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO3 – Create	05 Hrs.
4.	Unit IV: NoSQL Databases and Real-Time Streaming NoSQL database categories: key-value, document, column-family, graph; CAP theorem and consistency models in distributed databases; HBase: architecture, data model, DDL/DML commands, use cases; Cassandra: architecture, CQL, data modeling, replication, consistency tuning; MongoDB: document model, indexing, aggregation framework; Apache Kafka: architecture, topics, partitions, producers, consumers, stream processing; Integrating Kafka with Spark for real-time analytics pipelines. Mapped Outcomes and Bloom's Level: CO3 – Create; CO4 – Create	05 Hrs.
5.	Unit V: Big Data Analytics Algorithms Parallel frequent pattern mining: SON algorithm, FP-Growth on distributed data; Classification on big data: Naive Bayes, decision trees, random forests; Clustering on large datasets: parallel K-Means, BFR algorithm, DBSCAN variants; Recommendation systems: collaborative filtering, matrix factorization on Spark MLlib; Anomaly detection, time-series analysis, and predictive analytics at scale; Evaluation metrics for big data models: accuracy, precision, recall, AUC, throughput, latency. Mapped Outcomes and Bloom's Level: CO4 – Create; CO5 – Evaluate	05 Hrs.
6.	Unit VI: Advanced Topics and Project Work	05 Hrs.



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	Graph analytics: PageRank, connected components, community detection using Spark GraphX; Data lakes and modern data architectures: Delta Lake, Hudi, Iceberg; Cloud-based big data platforms: AWS EMR, Google Dataproc, Azure HDInsight; Security, privacy, and governance in big data systems; MLOps for big data: model training, deployment, monitoring pipelines; Mini-project: Design and implement a big data analytics solution using Hadoop/Spark, NoSQL, and streaming tools on a real-world dataset. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Create	
	TOTAL	30 Hrs
Text Books: 1. Tom White, Doug Cutting, and Ted Dunning, Hadoop: The Definitive Guide, 4th Edition, O'Reilly Media, 2015. 2. Holden Karau, Konstantin Boudnik, Barry Brum, and Patrick Wendell, Learning Spark: Lightning-Fast Big Data Analysis, 2nd Edition, O'Reilly Media, 2017. 3. Jebunnessa Chapola and T. Palanisamy, Big Data Analytics: Using Hadoop, Spark, and NoSQL Databases, 1st Edition, CRC Press, 2022. 4. Venkat Ankam, Big Data Analytics with Spark and Hadoop, 1st Edition, Packt Publishing, 2016. 5. Diego Rodrigues, Fundamentals of Big Data: With Hadoop and Spark – 2024 Edition, 2024		
Reference Books: 1. Alex DeBrie, NoSQL with Apache Cassandra, 2nd Edition, Manning Publications, 2021. 2. Gwen Shapira, Todd Palino, Rajini Sivaram, and Flavio Junqueira, Kafka: The Definitive Guide, 2nd Edition, O'Reilly Media, 2021. 3. Jesse Anderson, Data Science at Scale with Python and Spark, 1st Edition, Manning Publications, 2023. 4. Neha Narkhede, Gwen Shapira, and Todd Palino, Kafka: The Definitive Guide, 1st Edition, O'Reilly Media, 2017 5. Raj Kamal and Preethi Saxena, Big Data Analytics, 1st Edition, Pearson Education, 2017.		
E-Resources: <u>MOOC / NPTEL Links</u> 1. NPTEL: Big Data Computing – https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cs131 2. NPTEL: Statistical Foundation for Big Data Analysis – https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs09		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

3. NPTEL: Big Data Analytics (Video Lectures) –
<http://www.digimat.in/nptel/courses/video/106104189/106104189.html>
4. MIT OpenCourseWare: The Analytics Edge – <https://ocw.mit.edu/courses/15-071-the-analytics-edge-spring-2017/>
5. MIT OpenCourseWare: Mathematics of Big Data and Machine Learning –
<https://ocw.mit.edu/courses/res-ll-005-mathematics-of-big-data-and-machine-learning-january-iap-2020/>
6. Coursera: Big Data Specialization (UC San Diego) – <https://www.coursera.org/specializations/big-data>
7. edX: Big Data Analysis with Spark (UC Berkeley) – <https://www.edx.org/professional-certificate/uc-berkeleyx-big-data-analysis-with-spark>
8. Apache Spark Documentation – <https://spark.apache.org/docs/latest/>
9. Hadoop Documentation – <https://hadoop.apache.org/docs/current/>
10. Kafka Documentation – <https://kafka.apache.org/documentation/>
11. GitHub: Spark Examples – <https://github.com/apache/spark/tree/master/examples>
12. YouTube: NPTEL Big Data Lectures –
https://www.youtube.com/results?search_query=NPTEL+Big+Data

E-Books

1. Ronald J. Brachman and Hector J. Levesque - Knowledge Representation and Reasoning (digital lending copy) — Link: archive.org/details/knowledgereprese0000brac

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: Big Data Analytics Lab						Code: ADPE602AP			
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	-	25	25
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1.Understand the characteristics, challenges, and architectural paradigms of big data systems. 2.Apply distributed storage and processing frameworks such as Hadoop, HDFS, and Map Reduce for batch analytics. 3.Design scalable data processing pipelines using Apache Spark and its libraries for large-scale analytics. 4.Implement NoSQL databases and streaming platforms for real-time data ingestion and analysis. 5. Evaluate and apply big data analytics algorithms for classification, clustering, and pattern mining on distributed data. 6. Develop end-to-end big data solutions integrating storage, processing, and analytics components using modern tools.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Analyze the characteristics, challenges, and architectural paradigms of big data systems								
CO2	Apply distributed storage and processing frameworks (Hadoop, HDFS, MapReduce) for batch data analytics								
CO3	Design scalable data processing pipelines using Apache Spark and its libraries for large-scale analytics.								
CO4	Implement NoSQL databases and streaming platforms for real-time data ingestion and analysis.								
CO5	Evaluate big data analytics algorithms for classification, clustering, and pattern mining on distributed data.								
CO6	Develop end-to-end big data solutions integrating storage, processing, and analytics components using modern tools.								
LIST OF PRACTICALS									
1. Install and configure Hadoop in pseudo-distributed mode; perform HDFS file operations such as upload, download, list, and delete. GitHub example: Big Data Analytics Lab Practicalgithub 2. Implement Word Count using Hadoop MapReduce to understand mapper, reducer, shuffle, and sort phases. GitHub example: Big Data Analytics Lab Practicalgithub 3. Write MapReduce programs for aggregation tasks such as maximum, average, distinct count, and									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

duplicate removal on large integer datasets.

GitHub example: [Big Data Analytics Lab Practicalgithub](#)

4. **Perform matrix multiplication using Hadoop MapReduce** on distributed input files.

GitHub example: [Big Data Analytics Lab Practicalgithub](#)

5. **Implement K-means clustering using MapReduce or Spark** on a large dataset.

GitHub example: [Big-Data-Analyticsgithub](#)

6. **Install and use Hive to create tables and run descriptive analytics** with SQL-like queries on large datasets.

GitHub example: [BDA Lab Manual / Hive practice referencesgithub](#)

7. **Use Hive for advanced operations** such as joins, grouping, partitioning, and bucketing, and compare query performance.

GitHub example: [Big-Data-Analyticsgithub](#)

8. **Install and configure HBase or MongoDB for NoSQL data storage** and perform CRUD operations on semi-structured data.

GitHub example: [Big Data Analytics Lab Practicalgithub](#)

9. **Run Pig Latin scripts or Spark/PySpark jobs** for sorting, filtering, joining, and transforming data.

GitHub example: [Python Big Data resourcesgithub](#)

10. **Mini project: implement a real-world Big Data analytics pipeline** using Hadoop/Spark/Kafka/Hive for log analysis, recommendation, social media analytics, or streaming data processing.

GitHub example: [big-data-projects topicgithub](#).

Text Books:

1. Tom White, Doug Cutting, and Ted Dunning, Hadoop: The Definitive Guide, 4th Edition, O'Reilly Media, 2015.
2. Holden Karau, Konstantin Boudnik, Barry Brum, and Patrick Wendell, Learning Spark: Lightning-Fast Big Data Analysis, 2nd Edition, O'Reilly Media, 2017.
3. Jebunnessa Chapola and T. Palanisamy, Big Data Analytics: Using Hadoop, Spark, and NoSQL Databases, 1st Edition, CRC Press, 2022.
4. Venkat Ankam, Big Data Analytics with Spark and Hadoop, 1st Edition, Packt Publishing, 2016.
5. . Diego Rodrigues, Fundamentals of Big Data: With Hadoop and Spark – 2024 Edition, 2024

Reference Books:

1. Alex DeBrie, NoSQL with Apache Cassandra, 2nd Edition, Manning Publications, 2021.
2. Gwen Shapira, Todd Palino, Rajini Sivaram, and Flavio Junqueira, Kafka: The Definitive Guide, 2nd Edition, O'Reilly Media, 2021.
3. Jesse Anderson, Data Science at Scale with Python and Spark, 1st Edition, Manning Publications, 2023.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Neha Narkhede, Gwen Shapira, and Todd Palino, Kafka: The Definitive Guide, 1st Edition, O'Reilly Media, 2017

4. Raj Kamal and Preethi Saxena, Big Data Analytics, 1st Edition, Pearson Education, 2017.

E-Resources:

MOOC / NPTEL Links

1. NPTEL: Big Data Computing – https://onlinecourses.nptel.ac.in/e-learning/preview/noc25_cs131
2. NPTEL: Statistical Foundation for Big Data Analysis – https://onlinecourses.nptel.ac.in/e-learning/preview/noc26_cs09
3. NPTEL: Big Data Analytics (Video Lectures) – <http://www.digimat.in/nptel/courses/video/106104189/106104189.html>
4. MIT OpenCourseWare: The Analytics Edge – <https://ocw.mit.edu/courses/15-071-the-analytics-edge-spring-2017/>
5. MIT OpenCourseWare: Mathematics of Big Data and Machine Learning – <https://ocw.mit.edu/courses/res-ll-005-mathematics-of-big-data-and-machine-learning-january-iap-2020/>
6. Coursera: Big Data Specialization (UC San Diego) – <https://www.coursera.org/specializations/big-data>
7. edX: Big Data Analysis with Spark (UC Berkeley) – <https://www.edx.org/professional-certificate/uc-berkeleyx-big-data-analysis-with-spark>
8. Apache Spark Documentation – <https://spark.apache.org/docs/latest/>
9. Hadoop Documentation – <https://hadoop.apache.org/docs/current/>
10. Kafka Documentation – <https://kafka.apache.org/documentation/>
11. GitHub: Spark Examples – <https://github.com/apache/spark/tree/master/examples>
12. YouTube: NPTEL Big Data Lectures – https://www.youtube.com/results?search_query=NPTEL+Big+Data

E-Books

1. Ronald J. Brachman and Hector J. Levesque - Knowledge Representation and Reasoning (digital lending copy) — Link: archive.org/details/knowledgereprese0000brac

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Soft Computing							Code: ADPE602B		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1.Understand the fundamental concepts, characteristics, and application domains of soft computing.									
2.Apply artificial neural network architectures for supervised and unsupervised learning tasks.									
3.Design fuzzy logic systems including membership functions, inference mechanisms, and defuzzification methods.									
4.Implement evolutionary algorithms such as genetic algorithms for optimization and search problems.									
5.Evaluate swarm intelligence techniques including particle swarm optimization and ant colony optimization.									
6.Develop hybrid soft computing systems integrating neural networks, fuzzy logic, and evolutionary algorithms.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze the fundamental concepts, characteristics, and application domains of soft computing.								Analyze
CO2	Apply artificial neural network architectures for supervised and unsupervised learning tasks.								Apply
CO3	Design fuzzy logic systems including membership functions, inference mechanisms, and defuzzification methods.								Create
CO4	Implement evolutionary algorithms such as genetic algorithms for optimization and search problems.								Create
CO5	Evaluate swarm intelligence techniques including particle swarm optimization and ant colony optimization.								Evaluate
CO6	Develop hybrid soft computing systems integrating neural networks, fuzzy logic, and evolutionary algorithms.								Create
Course Contents:									
Unit	Description								Duration (Hrs.)



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1.	Unit I: Introduction to Soft Computing and Neural Networks Soft computing vs. hard computing: characteristics, tolerance for imprecision and uncertainty; Components of soft computing: neural networks, fuzzy logic, evolutionary computing, swarm intelligence; Applications in pattern recognition, optimization, control systems, and decision support; Biological neuron and artificial neuron models: perceptron, activation functions (sigmoid, ReLU, tanh); Neural network architectures: single-layer, multi-layer feedforward networks; Learning paradigms: supervised, unsupervised, reinforcement learning; Learning rules: Hebbian, delta rule, perceptron learning, competitive learning. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	05 Hrs.
2.	Unit II: Advanced Neural Network Models Multi-layer perceptron and backpropagation algorithm: gradient descent, weight updates; Radial Basis Function (RBF) networks: architecture, training, applications; Recurrent neural networks: Hopfield networks, associative memory, stability analysis; Self-Organizing Maps (SOM): Kohonen networks, competitive learning, feature mapping; Learning Vector Quantization (LVQ): codebook vectors, classification; Deep learning overview: CNNs, RNNs, LSTMs (introductory concepts); Neural network applications: classification, function approximation, time-series prediction. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO3 – Create	05 Hrs.
3.	Unit III: Fuzzy Logic and Fuzzy Systems Crisp sets vs. fuzzy sets: membership functions, operations (union, intersection, complement); Fuzzy relations: composition, tolerance, equivalence relations; Fuzzy propositions, fuzzy implications, and fuzzy inference rules; Fuzzy inference systems: Mamdani and Sugeno models; Fuzzification techniques: singleton, triangular, trapezoidal membership; Defuzzification methods: centroid, bisector, mean of maxima, smallest/largest of maxima; Fuzzy logic controllers: architecture, design steps, applications in control systems; Case studies: temperature control, washing machine, automotive systems. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO3 – Create	05 Hrs.
4.	Unit IV: Genetic Algorithms and Evolutionary Computing Introduction to evolutionary computing: biological inspiration, population-based search; Genetic algorithm components: encoding (binary, real-valued), fitness function, selection; Genetic operators: crossover (single-point, multi-point, uniform), mutation; GA parameters: population size, crossover rate, mutation rate, convergence criteria; Simple GA and advanced variants: elitism, steady-state GA, hybrid GA; Multi-objective genetic algorithms (MOGA): Pareto optimality, dominance; Applications: function optimization, scheduling, feature selection, parameter tuning. Comparison with other optimization techniques: gradient descent, simulated annealing.	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Mapped Outcomes and Bloom's Level: CO4 – Create; CO5 – Evaluate	
5.	Unit V: Swarm Intelligence and Other Techniques Swarm intelligence: principles, self-organization, emergence; Particle Swarm Optimization (PSO): particles, velocity updates, personal and global best; Ant Colony Optimization (ACO): pheromone trails, probabilistic path selection; Applications of PSO and ACO: routing, clustering, combinatorial optimization; Simulated annealing: cooling schedule, acceptance probability, global optimization; Tabu search: memory structures, neighborhood exploration; Differential evolution and harmony search (introductory concepts); Comparative study of soft computing techniques: strengths, limitations, suitability. Mapped Outcomes and Bloom's Level: CO4 – Create; CO5 – Evaluate	05 Hrs.
6.	Unit VI: Hybrid Systems and Applications Neuro-fuzzy systems: architecture, ANFIS (Adaptive Neuro-Fuzzy Inference System); Integration of neural networks and fuzzy logic: learning fuzzy rules from data; Genetic-neural systems: using GA for weight optimization and architecture design; Genetic-fuzzy systems: evolving membership functions and rule bases; Hybrid soft computing frameworks for complex problem solving; Applications: medical diagnosis, financial forecasting, image processing, robotics; Implementation tools: MATLAB, Python (scikit-fuzzy, DEAP, PyTorch); Mini-project: Design and implement a hybrid soft computing solution for a real-world problem. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Create	05 Hrs.
TOTAL		30 Hrs
Text Books: 1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, 2nd Edition, Wiley India, 2011 (reprinted 2024). 2. Jyh-Shing Roger Jang, Chuen-Tsai Sun, and Eiji Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, 1st Edition, Prentice Hall, 1997. 3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Soft Computing: Fundamentals, Techniques and Applications, 1st Edition, McGraw Hill Education, 2018. 4. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, 1st Edition, Pearson Education, 2011. 5. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley India, 2011.		
Reference Books:		
1. Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education, 2009. 2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, 1st Edition, Prentice Hall, 1995.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

3. David E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, 1st Edition, Addison-Wesley, 1989.
4. James Kennedy, Russell C. Eberhart, and Yuhui Shi, Swarm Intelligence, 1st Edition, Morgan Kaufmann, 2001.
5. K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, 1st Edition, Wiley, 2001.

E-Resources:

MOOC / NPTEL Links

- NPTEL: Introduction to Soft Computing – <https://nptel.ac.in/courses/106105173>
- NPTEL: Introduction to Soft Computing (Preview) – https://onlinecourses.nptel.ac.in/noc25_cs48/preview
- NPTEL: Soft Computing Syllabus PDF – https://archive.nptel.ac.in/content/syllabus_pdf/106105173.pdf
- Coursera: Neural Networks and Deep Learning ([deeplearning.ai](https://www.coursera.org/learn/neural-networks-deep-learning)) – <https://www.coursera.org/learn/neural-networks-deep-learning>
- Coursera: Fuzzy Logic and Neural Networks – <https://www.coursera.org/learn/fuzzy-logic-neural-networks>
- edX: Evolutionary Computing and Genetic Algorithms – <https://www.edx.org/learn/genetic-algorithms>
- MIT OpenCourseWare: Computational Intelligence – <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>
- YouTube: NPTEL Soft Computing Lectures – https://www.youtube.com/results?search_query=NPTEL+Soft+Computing
- GitHub: Soft Computing Examples (Neural Networks, Fuzzy, GA, PSO) – <https://github.com/topics/soft-computing>
- scikit-fuzzy Documentation – <https://scikit-fuzzy.github.io/scikit-fuzzy/>
- DEAP (Distributed Evolutionary Algorithms in Python) – <https://deap.readthedocs.io/>
- MATLAB Neural Network and Fuzzy Logic Toolboxes – <https://www.mathworks.com/products/neural-network.html>

E-Books

1. Ronald J. Brachman and Hector J. Levesque - Knowledge Representation and Reasoning (digital lending copy) — Link: archive.org/details/knowledge-representation-and-reasoning-0000-brachman-and-levesque

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Soft Computing Lab							Code: ADPE602BP		
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	-	25	25
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1.Understand the fundamental concepts, characteristics, and application domains of soft computing. 2.Apply artificial neural network architectures for supervised and unsupervised learning tasks. 3.Design fuzzy logic systems including membership functions, inference mechanisms, and defuzzification methods. 4.Implement evolutionary algorithms such as genetic algorithms for optimization and search problems. 5.Evaluate swarm intelligence techniques including particle swarm optimization and ant colony optimization. 6.Develop hybrid soft computing systems integrating neural networks, fuzzy logic, and evolutionary algorithms.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Analyze the fundamental concepts, characteristics, and application domains of soft computing.								
CO2	Apply artificial neural network architectures for supervised and unsupervised learning tasks.								
CO3	Design fuzzy logic systems including membership functions, inference mechanisms, and de fuzzification methods								
CO4	Implement evolutionary algorithms such as genetic algorithms for optimization and search problems.								
CO5	Evaluate swarm intelligence techniques including particle swarm optimization and ant colony optimization								
CO6	Develop hybrid soft computing systems integrating neural networks, fuzzy logic, and evolutionary algorithms.								
LIST OF PRACTICALS									
1. Implement McCulloch-Pitts neuron for basic logic gates such as AND, OR, NOT, and XOR. Example code: GitHub - Soft-Computinggithub 2. Implement a perceptron model to solve linearly separable problems and realize AND/OR classification. Example code: GitHub - Soft-Computing-Labgithub 3. Implement ADALINE network using the delta learning rule and evaluate convergence. Example code: GitHub - Soft-Computing-Lab-2024github 4. Train a backpropagation neural network for function approximation or binary classification. Example code: GitHub - Soft-Computing-Labgithub									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

5. **Implement self-organizing map (Kohonen network)** for clustering or pattern mapping.
Example code: [GitHub - Soft-Computinggithub](#)
6. **Perform fuzzy set operations:** union, intersection, complement, difference, Cartesian product, and composition.
Example code: [GitHub - Soft-Computinggithub](#)
7. **Design a fuzzy inference system** for a control problem such as air conditioner, temperature, or washing machine control.
Example code: [Virtual Labs - Soft Computing Tools in Engineering Labscte-iitkgp.vlabs.ac](#)
8. **Implement defuzzification methods** such as centroid, mean of maxima, and weighted average for fuzzy outputs.
Example code: [GitHub - Soft-Computinggithub](#)
9. **Apply genetic algorithm for optimization** problems such as maximizing a function or minimizing an error function.
Example code: [GitHub - Soft-Computing-Labgithub](#)
10. **Solve Travelling Salesman Problem (TSP) using genetic algorithm** and compare fitness across generations.
Example code: [GitHub - Soft-Computing-Lab-2024github](#)

Text Books:

1. S. N. Sivanandam and S. N. Deepa, Principles of Soft Computing, 2nd Edition, Wiley India, 2011 (reprinted 2024).
2. Jyh-Shing Roger Jang, Chuen-Tsai Sun, and Eiji Mizutani, Neuro-Fuzzy and Soft Computing: A Computational Approach to Learning and Machine Intelligence, 1st Edition, Prentice Hall, 1997.
3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Soft Computing: Fundamentals, Techniques and Applications, 1st Edition, McGraw Hill Education, 2018.
4. Laurene V. Fausett, Fundamentals of Neural Networks: Architectures, Algorithms and Applications, 1st Edition, Pearson Education, 2011.
5. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 3rd Edition, Wiley India, 2011.

Reference Books:

1. Simon Haykin, Neural Networks and Learning Machines, 3rd Edition, Pearson Education, 2009.
2. George J. Klir and Bo Yuan, Fuzzy Sets and Fuzzy Logic: Theory and Applications, 1st Edition, Prentice Hall, 1995.
3. David E. Goldberg, Genetic Algorithms in Search, Optimization, and Machine Learning, 1st Edition, Addison-Wesley, 1989.
4. James Kennedy, Russell C. Eberhart, and Yuhui Shi, Swarm Intelligence, 1st Edition, Morgan Kaufmann, 2001.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

5.K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, 1st Edition, Wiley, 2001.

E-Resources:

MOOC / NPTEL Links

- NPTEL: Introduction to Soft Computing – <https://nptel.ac.in/courses/106105173>
- NPTEL: Introduction to Soft Computing (Preview) – https://onlinecourses.nptel.ac.in/noc25_cs48/preview
- NPTEL: Soft Computing Syllabus PDF – https://archive.nptel.ac.in/content/syllabus_pdf/106105173.pdf
- Coursera: Neural Networks and Deep Learning (deeplearning.ai) – <https://www.coursera.org/learn/neural-networks-deep-learning>
- Coursera: Fuzzy Logic and Neural Networks – <https://www.coursera.org/learn/fuzzy-logic-neural-networks>
- edX: Evolutionary Computing and Genetic Algorithms – <https://www.edx.org/learn/genetic-algorithms>
- MIT OpenCourseWare: Computational Intelligence – <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>
- YouTube: NPTEL Soft Computing Lectures – https://www.youtube.com/results?search_query=NPTEL+Soft+Computing
- GitHub: Soft Computing Examples (Neural Networks, Fuzzy, GA, PSO) – <https://github.com/topics/soft-computing>
- scikit-fuzzy Documentation – <https://scikit-fuzzy.github.io/scikit-fuzzy/>
- DEAP (Distributed Evolutionary Algorithms in Python) – <https://deap.readthedocs.io/>
- MATLAB Neural Network and Fuzzy Logic Toolboxes – <https://www.mathworks.com/products/neural-network.html>

E-Books

1. Ronald J. Brachman and Hector J. Levesque - Knowledge Representation and Reasoning (digital lending copy) — Link: archive.org/details/knowledgereprese0000brac

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial and Data Science)							Semester: VI		
Course: DevOps for Cloud							Code: ADPE602C		
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Fundamentals of Cloud Computing									
Course Objectives:									
1. To understand DevOps concepts, culture, and cloud computing fundamentals.									
2. To learn version control and continuous integration tools used in DevOps.									
3. To implement CI/CD pipelines using modern DevOps tools.									
4. To understand containerization, orchestration, and cloud deployment techniques.									
5. To learn configuration management and infrastructure automation.									
6. To apply DevOps practices in real-world cloud environments..									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Understand DevOps principles, cloud computing concepts, and Agile methodologies.								
CO2	Apply version control and build automation tools for software development.								
CO3	Develop CI/CD pipelines using Jenkins and related DevOps tools.								
CO4	Implement containerization and orchestration using Docker and Kubernetes.								
CO5	Perform infrastructure automation and configuration management using Ansible.								
CO6	Deploy and monitor applications on cloud platforms using DevOps practices.								
Course Contents:									
Unit	Description							Duration (Hrs.)	
1.	Unit I – Introduction to DevOps and Cloud Computing Introduction to DevOps, Evolution and Need of DevOps, DevOps Life CycleAgile and DevOps, Cloud Computing Fundamentals, Cloud Service Models (IaaS, PaaS, SaaS), Cloud Deployment Models, Introduction to AWS, Azure, and GCP							04 Hrs.	
2.	Unit II – Version Control and Build Tools Introduction to Version Control Systems, Git and GitHub Basics, Git Commands (Clone, Commit, Push, Pull, Merge), Branching and Merging, Maven Build Tool, Gradle Basics, Dependency Management, Build Lifecycle							04 Hrs.	
3.	Unit III – Continuous Integration and Continuous Deployment Introduction to CI/CD, Jenkins Architecture, Installing and Configuring Jenkins, Creating Jenkins Jobs, Jenkins Pipelines, Automated Testing Continuous Deployment Concepts, Integration with Git and Maven							04 Hrs.	
4.	Unit IV – Deep Learning and Big Data Concepts Introduction to Docker, Docker Architecture Docker Images and Containers, Dockerfile and Docker Compose, Kubernetes							04 Hrs.	



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Basics, Kubernetes Architecture, Pods, Services, and Deployments, Container Orchestration	
5.	Unit V – Configuration Management and Cloud Automation Infrastructure as Code (IaC), Introduction to Ansible, Ansible Installation and Configuration, Ansible Playbooks, YAML Basics, Cloud Automation Load Balancing and Auto Scaling, Monitoring and Logging	04 Hrs.
6.	Unit VI – DevOps on Cloud Platforms DevOps with AWS, DevOps with Microsoft Azure, DevOps with Google Cloud Platform (GCP), Cloud Security Fundamentals, DevSecOps Concepts Monitoring Tools (Prometheus, Grafana), Real-Time DevOps Case Studies Future Trends in DevOps and Cloud	04 Hrs
TOTAL		24 Hrs
Text Books:		
1. Practical DevOps – Packt Publishing. 2. DevOps: A Software Architect's Perspective – Addison-Wesley. 3. The DevOps Handbook – IT Revolution Press. 4. Docker Deep Dive – Leanpub Publication..		
Reference Books:		
1. Continuous Delivery – Pearson Publication. 2. Learning Docker – Packt Publishing. 3. Kubernetes Up and Running – O'Reilly Publication. 4. Ansible for DevOps – Leanpub Publication. 5. Cloud Computing Bible – Wiley Publication		

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)						Semester: VI			
Course: DevOps for Cloud Lab						Code: ADPE602CP			
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
-	02	-	01	-	-	-	-	25	25
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1. Understand the cultural, organizational, and technical foundations of DevOps. 1. Apply version control systems and collaborative workflows for software development. 2. Design and implement CI/CD pipelines for automated build, test, and deployment. 3. Implement infrastructure as code using configuration management and provisioning tools. 4. Containerize applications and orchestrate them using Kubernetes in cloud environments. 5. Evaluate DevOps practices including monitoring, logging, security, and compliance in cloud-native systems.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Analyze the cultural, organizational, and technical foundations of DevOps.								
CO2	Apply version control systems and collaborative workflows for software development.								
CO3	Design and implement CI/CD pipelines for automated build, test, and deployment.								
CO4	Implement infrastructure as code using configuration management and provisioning tools.								
CO5	Containerize applications and orchestrate them using Kubernetes in cloud environments.								
CO6	Evaluate DevOps practices including monitoring, logging, security, and compliance in cloud-native systems.								
LIST OF PRACTICALS									
1. Git and GitHub workflow - Create a repository, practice branching, merging, pull requests, tagging, and resolving merge conflicts.studocu - GitHub example: DevOps Projects or DevOps Labs.github+1									
2. Build automation using Maven or Gradle - Set up a sample Java or Python project and automate build, test, and package steps.studocu - GitHub example: Real-world DevOps projects.github									
3. Continuous Integration with Jenkins - Create a Jenkins pipeline to trigger builds on code push and run automated tests.studocu - GitHub example: DevOps Projects or DevOps Labs.github+1									
4. Containerization with Docker Write a Dockerfile, build an image, run containers, and manage container lifecycle.studocu									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

- GitHub example: [DevOps Learn By Doing.github](#)
- 5. **Container orchestration with Kubernetes**
 - Deploy an application using Pods, Deployments, Services, ConfigMaps, and scaling.[studocu](#)
 - GitHub example: [DevOps Learn By Doing](#) or [DevOps Projects Student Portal.github](#)+1
- 6. **Infrastructure automation with Terraform**
 - Provision cloud infrastructure such as VPC, EC2, security groups, and storage using Terraform.[studocu](#)
 - GitHub example: [DevOps Learn By Doing](#) or [DevOps Labs.github](#)+1
- 7. **Configuration management with Ansible**
 - Write playbooks to install packages, configure servers, and deploy applications automatically.[studocu](#)
 - GitHub example: [DevOps Projects.github](#)
- 8. **Monitoring and logging with Prometheus, Grafana, and ELK**
 - Collect metrics, build dashboards, and centralize logs for a sample application.[studocu](#)
 - GitHub example: [theopskart DevOps Labs](#) via the lab portal.[theopskart](#)
- 9. **CI/CD pipeline for cloud deployment**
 - Build a complete pipeline from Git commit to build, test, image creation, and deployment to cloud or Kubernetes.[studocu](#)
 - GitHub example: [DevOps Projects.github](#)
- 10. **Mini project: end-to-end cloud DevOps workflow**
 - Create a small cloud-native application and automate version control, CI/CD, containerization, deployment, and monitoring.[studocu](#)
 - GitHub example: [DevOps Projects Student Portal](#) or [DevOps Learn By Doing](#).

Text Books:

1. Mikael Krief, Learning DevOps: Accelerate software collaboration with containers, Kubernetes and more, 2nd Edition, Packt Publishing, 2021.
2. Sebastien Goasguen and Hideto Saito, DevOps with Kubernetes: Accelerating software delivery with container orchestrators, 2nd Edition, Packt Publishing, 2019.
3. Chris Fregly and Jennifer Davis, Infrastructure as Code: Dynamic Systems for the Cloud Age, 1st Edition, O'Reilly Media, 2024.
4. Stephen Baron, AWS: The Complete Beginner's Guide to Cloud Computing, 1st Edition, 2020.
5. John Edward Cooper Berg, DevOps: Building CI/CD Pipelines with Jenkins, Docker, AWS ECS, JDK 11, Git and Maven, 3rd Edition, 2022

Reference Books:

1. Sanjeev Sharma, The DevOps Adoption Playbook: A Guide to Adopting DevOps in a Multi-Speed IT Enterprise, 1st Edition, Wiley, 2017.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

2. Rajkumar Buyya, James Broberg, and Andrzej M. Goscinski (Eds.), Cloud Computing: Principles and Paradigms, 1st Edition, Wiley, 2011.
3. Barrie Sosinsky, Cloud Computing Bible, 1st Edition, Wiley India, 2010.
4. Ronald L. Krutz and Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, 1st Edition, Wiley India, 2010.
5. Klaus Homscheid, The DevOps Handbook: How to Create World-Class Agility, Reliability, and Security in Technology Organizations, 2nd Edition, IT Revolution, 2021.

E-Resources:

MOOC / NPTEL Links

- NPTEL: Cloud Computing and Distributed Systems – https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_cs15
- NPTEL: Cloud Computing – <https://nptel.ac.in/courses/106105167>
- NPTEL: Preview Cloud Computing – https://onlinecourses.nptel.ac.in/noc26_cs55/preview
- Coursera: DevOps and Cloud Specialization – <https://www.coursera.org/specializations/devops-cloud>
- edX: DevOps on AWS (Amazon) – <https://www.edx.org/professional-certificate/amazon-devops-on-aws>
- Coursera: Google Cloud DevOps Specialization – <https://www.coursera.org/professional-certificates/google-cloud-devops>
- GitHub: DevOps Books and Resources – https://github.com/rohitg00/DevOps_Books
- GitHub: Cloud DevOps Learning Resources – <https://github.com/ahmedtariq01/Cloud-DevOps-Learning-Resources>
- YouTube: DevOps Tutorials (TechWorld with Nana, FreeCodeCamp) – https://www.youtube.com/results?search_query=DevOps+tutorials
- Docker Documentation – <https://docs.docker.com/>
- Kubernetes Documentation – <https://kubernetes.io/docs/>
- Terraform Documentation – <https://www.terraform.io/docs>
- Jenkins Documentation – <https://www.jenkins.io/doc/>
- AWS DevOps Documentation – <https://docs.aws.amazon.com/devops>
- AWS DevOps Documentation – <https://docs.aws.amazon.com/devops/>
- Azure DevOps Documentation – <https://learn.microsoft.com/en-us/azure/devops/>

[Back to Structure](#)



Program Elective Course - III



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Courses: Data Mining							Code: ADPE603A		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1. Understand the data mining process, knowledge discovery pipeline, and key challenges in mining large datasets.									
2. Apply data preprocessing techniques including cleaning, integration, transformation, and dimensionality reduction.									
3. Design and implement algorithms for frequent pattern mining, association rule discovery, and correlation analysis.									
4. Develop classification models using decision trees, Bayesian methods, k-NN, and support vector machines.									
5. Evaluate clustering algorithms including partitioning, hierarchical, density-based, and model-based methods.									
6. Assess data mining models using appropriate metrics and apply mining techniques to practical case studies.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze the data mining process, knowledge discovery pipeline, and key challenges in mining large datasets.								Analyze
CO2	Apply data preprocessing techniques including cleaning, integration, transformation, and dimensionality reduction.								Apply
CO3	Design and implement algorithms for frequent pattern mining, association rule discovery, and correlation analysis.								Create
CO4	Develop classification models using decision trees, Bayesian methods, k-NN, and support vector machines.								Create
CO5	Evaluate clustering algorithms including partitioning, hierarchical, density-based, and model-based methods.								Evaluate
CO6	Assess data mining models using appropriate metrics and apply mining techniques to practical case studies.								Evaluate
Course Contents:									
Unit	Description								Duration



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

		(Hrs.)
1.	Unit I: Introduction to Data Mining and Data Preprocessing What is data mining? Motivation, applications, and relationship to KDD, machine learning, and statistics; Data mining tasks: descriptive vs. predictive; pattern types (association, classification, clustering, outlier); Data types: structured, semi-structured, unstructured; attribute types and measurement scales; Data quality issues: noise, missing values, inconsistency, duplicates; Data cleaning: binning, smoothing, imputation, outlier handling; Data integration, transformation, normalization, discretization; Dimensionality reduction: feature selection, PCA, feature construction; Similarity and distance measures: Euclidean, Manhattan, cosine, Jaccard, correlation. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	05 Hrs.
2.	Unit II: Frequent Pattern Mining and Association Rules Frequent itemsets, support, confidence, and lift; Apriori algorithm: candidate generation, pruning, multiple scans; FP-Growth: FP-tree construction, conditional pattern bases, mining without candidates; Association rules: generation, evaluation metrics (support, confidence, conviction); Correlation analysis, lift, chi-square, and interestingness measures; Sequential pattern mining: GSP, sequence databases, constraints; Applications: market basket analysis, recommendation systems, web usage mining. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO3 – Create	05 Hrs.
3.	Unit III: Classification and Prediction Classification vs. prediction; training, validation, and test sets; Decision tree induction: attribute selection (information gain, gain ratio, Gini), pruning; Naive Bayes and Bayesian networks for classification; k-Nearest Neighbors: distance metrics, choice of k, pros and cons; Support Vector Machines: linear and kernel SVM, soft margin, multiclass; Ensemble methods: bagging, boosting, random forests; Model evaluation: accuracy, precision, recall, F1, ROC curves, AUC, cross-validation; Overfitting, underfitting, bias-variance tradeoff. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO4 – Create	05 Hrs.
4.	Unit IV: Cluster Analysis What is clustering? Applications in segmentation, anomaly detection, and summarization; Partitioning methods: k-Means, k-Medoids, initialization strategies; Hierarchical clustering: agglomerative vs. divisive, dendrograms, linkage criteria; Density-based clustering: DBSCAN, OPTICS, handling noise and arbitrary shapes; Model-based clustering: Gaussian mixture models, EM algorithm; Clustering validation: internal (silhouette, Davies-Bouldin) and external measures; Clustering high-dimensional data: subspace clustering, bi-clustering; Applications: customer segmentation, image segmentation, document clustering.	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Mapped Outcomes and Bloom's Level: CO4 – Create; CO5 – Evaluate	
5.	Unit V: Outlier Detection and Advanced Topics What are outliers? Types: point, contextual, collective; Statistical methods: z-score, Grubbs' test, robust statistics; Distance-based and density-based outlier detection; Clustering-based outlier detection; isolation forest; Text mining basics: tokenization, TF-IDF, document-term matrices; Web mining: content, structure, and usage mining; Introduction to social network mining: centrality, community detection; Ethical issues in data mining: privacy, bias, fairness, transparency. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Evaluate	05 Hrs.
6.	Unit VI: Data Mining Projects and Case Studies Data mining workflow: problem definition, data acquisition, preprocessing, modeling, evaluation, deployment; Tools and libraries: scikit-learn, pandas, NumPy, matplotlib, seaborn; Case studies: fraud detection, churn prediction, sentiment analysis, medical diagnosis; Mini-project: End-to-end data mining project on a real-world dataset; Data visualization for mining results: scatter plots, heatmaps, parallel coordinates; Interpreting and communicating mining results to stakeholders; Trends in data mining: deep learning integration, AutoML, explainable AI. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Evaluate	05 Hrs.
TOTAL		30 Hrs
Text Books: 1. Jiawei Han, Micheline Kamber, and Jian Pei, Data Mining: Concepts and Techniques, 4th Edition, Morgan Kaufmann, 2022. 2. Pang-Ning Tan, Michael Steinbach, Anuj Karpatne, and Vipin Kumar, Introduction to Data Mining, 2nd Edition, Pearson Education, 2019. 3. Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal, Data Mining: Practical Machine Learning Tools and Techniques, 5th Edition, Morgan Kaufmann, 2025. 4. Charu C. Aggarwal, Data Mining: The Textbook, 1st Edition, Springer, 2015. 5. Mohammed J. Zaki and Wagner Meira, Data Mining: An Introduction, 1st Edition, Cambridge University Press, 2024.		
Reference Books: 1. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009. 2. Sergios Theodoridis and Konstantinos Koutroumbas, Pattern Recognition, 4th Edition, Academic Press, 2008. 3. Lior Rokach and Oded Maimon (Eds.), Machine Learning for Data Science Handbook: Data Mining and Knowledge Discovery Handbook, 3rd Edition, Springer, 2024.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

4. Foster Provost and Tom Fawcett, Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking, 1st Edition, O'Reilly Media, 2013.
5. Jure Leskovec, Anand Rajaraman, and Jeffrey David Ullman, Mining of Massive Datasets, Cambridge University Press, 2020.

E-Resources:

MOOC / NPTEL Links

- NPTEL: Data Mining – https://onlinecourses.nptel.ac.in/noc20_cs12/preview
- NPTEL: Business Analytics & Data Mining Modeling Using R – https://onlinecourses.nptel.ac.in/e-learning/preview/noc22_mg67
- NPTEL: Data Mining for Decision Making (2026) – <https://www.youtube.com/watch?v=mTjG0xkNp9E>
- MIT OpenCourseWare: Data Mining (Sloan) – <https://ocw.mit.edu/courses/15-062-data-mining-spring-2003/>
- Coursera: Data Mining Specialization (University of Illinois) – <https://www.coursera.org/specializations/data-mining>
- edX: Data Mining and Machine Learning (Columbia) – <https://www.edx.org/professional-certificate/columbiacx-data-mining-and-machine-learning>
- Han and Pei Data Mining Companion Site – <https://hanj.cs.illinois.edu/bk4/>
- Scikit-learn Documentation – <https://scikit-learn.org/stable/>
- Kaggle Data Mining Datasets – <https://www.kaggle.com/datasets?tags=13213-Data%20Mining>
- GitHub: Data Mining Examples – <https://github.com/topics/data-mining>
- YouTube: NPTEL Data Mining Lectures – https://www.youtube.com/results?search_query=NPTEL+Data+Mining
- Towards Data Science: Data Mining Articles – <https://towardsdatascience.com/search?q=data%20mining>

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. ((Artificial Intelligence and Data Science))							Semester: VI		
Course : Pattern Recognition							Code: ADPE603B		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1. Understand the principles, components, and workflow of pattern recognition systems. 2. Apply feature extraction, selection, and transformation techniques for representing patterns. 3. Design statistical classifiers including Bayes decision rules, discriminant functions, and parametric/non-parametric methods. 4. Implement clustering algorithms for unsupervised pattern discovery and grouping. 5. Evaluate pattern recognition models using appropriate metrics and validation strategies. 6. Develop end-to-end pattern recognition solutions for real-world applications using modern tools and libraries									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze the principles, components, and workflow of pattern recognition systems.								Analyze
CO2	Apply feature extraction, selection, and transformation techniques for representing patterns.								Apply
CO3	Design statistical classifiers including Bayes decision rules, discriminant functions, and parametric/non-parametric methods.								Create
CO4	Implement clustering algorithms for unsupervised pattern discovery and grouping.								Create
CO5	Evaluate pattern recognition models using appropriate metrics and validation strategies.								Evaluate
CO6	Develop end-to-end pattern recognition solutions for real-world applications using modern tools and libraries.								Create
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Introduction to Pattern Recognition What is pattern recognition? Motivation, applications, and relationship to machine learning, data mining, and AI; Structure of a typical pattern recognition system: sensing, segmentation, feature extraction, classification, post-processing; Supervised, unsupervised, and semi-supervised learning paradigms; Training, validation, and test sets;								05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	cross-validation strategies; Basic mathematical foundations: linear algebra, probability theory, statistics, optimization; Types of patterns: vectors, sequences, trees, graphs, images, and signals; Performance measures: accuracy, precision, recall, F1, ROC, AUC, confusion matrix. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	
2.	Unit II: Feature Extraction and Dimensionality Reduction Feature representation: feature vectors, attribute types, normalization, standardization; Feature selection: filter methods (variance, correlation, mutual information), wrapper methods (sequential forward/backward selection), embedded methods; Feature extraction: principal component analysis (PCA), linear discriminant analysis (LDA/Fisher's LDA); Non-linear dimensionality reduction: kernel PCA, t-SNE, UMAP, autoencoders (introductory); Feature scaling and transformation: log, Box-Cox, whitening; Distance and similarity measures: Euclidean, Manhattan, cosine, Mahalanobis, correlation; Feature engineering for structured data, images, and text. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	05 Hrs
3.	Unit III: Statistical Pattern Classification Bayes decision theory: minimum error rate, minimum risk, loss functions; Discriminant functions and decision surfaces: linear, quadratic, generalized linear discriminants; Parametric methods: maximum likelihood estimation (MLE), maximum a posteriori (MAP), Bayesian estimation; Gaussian classifiers: normal density, covariance structures, decision boundaries; Non-parametric methods: k-nearest neighbors (k-NN), kernel density estimation, Parzen windows; Logistic regression and softmax classifiers for multi-class problems; Naive Bayes classifier for high-dimensional and text data; Ensemble methods: bagging, boosting, random forests for classification. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO3 – Create	05 Hrs.
4.	Unit IV: Clustering and Unsupervised Learning What is clustering? Applications in segmentation, grouping, and anomaly detection; Similarity and dissimilarity measures: distance, correlation, mutual information; Partitioning methods: k-Means, k-Medoids, initialization strategies, convergence; Hierarchical clustering: agglomerative vs. divisive, dendrograms, linkage criteria (single, complete, average, Ward); Density-based clustering: DBSCAN, OPTICS, handling noise and arbitrary shapes; Model-based clustering: Gaussian mixture models (GMM), EM algorithm; Clustering validation: internal measures (silhouette, Davies-Bouldin), external measures (purity, NMI); Clustering high-dimensional data: subspace clustering, biclustering, spectral clustering. Mapped Outcomes and Bloom's Level: CO3 – Create; CO4 – Create	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

5.	Unit V: Advanced Classifiers and Model Evaluation Support Vector Machines (SVM): margin, kernel trick, soft margin, multiclass strategies; Decision trees: attribute selection (information gain, Gini), pruning, C4.5, CART; Hidden Markov Models (HMM): Markov processes, forward-backward, Viterbi, Baum-Welch; Neural network classifiers: perceptron, multi-layer perceptron, backpropagation (introductory); Model evaluation: bias-variance decomposition, overfitting, underfitting, regularization; Hyperparameter tuning: grid search, random search, Bayesian optimization; Comparison of classifiers: statistical tests, McNemar's test, paired t-tests; Calibration of classifiers: Platt scaling, isotonic regression. Mapped Outcomes and Bloom's Level: CO4 – Create; CO5 – Evaluate	05 Hrs.
6.	Unit VI: Applications, Structural PR, and Project Work Structural pattern recognition: graph-based representations, syntactic pattern recognition, grammars; Applications: image classification, object recognition, face recognition, biometrics, speech recognition; Applications: document analysis, handwriting recognition, medical diagnosis, fault detection; Pattern recognition in deep learning: CNNs for images, RNNs/Transformers for sequences; Tools and libraries: scikit-learn, OpenCV, TensorFlow, PyTorch, statsmodels; Mini-project: Design and implement a pattern recognition system for a real-world dataset; Ethical considerations: bias in PR systems, fairness, privacy, transparency, accountability. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Create	05 Hrs.
TOTAL		30 Hrs
Text Books: 1. Richard O. Duda, Peter E. Hart, and David G. Stork, Pattern Classification, 2nd Edition, Wiley, 2001. 2. Christopher M. Bishop, Pattern Recognition and Machine Learning, 1st Edition, Springer, 2006 (reprinted 2025). 3. M. Narasimha Murty and V. Susheela Devi, Pattern Recognition: An Algorithmic Approach, 1st Edition, Springer, 2011. 4. Sergios Theodoridis and Konstantinos Koutroumbas, Pattern Recognition, 4th Edition, Academic Press, 2008. 5. Braga-Neto, Fundamentals of Pattern Recognition and Machine Learning, 1st Edition, Springer, 2020. 6. Mohammed J. Zaki and Wagner Meira, Data Mining: An Introduction, 1st Edition, Cambridge University Press, 2024.		
Reference Books: 1. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction, 2nd Edition, Springer, 2009.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

2. Keinosuke Fukunaga, Introduction to Statistical Pattern Recognition, 2nd Edition, Academic Press, 1990.
3. Jiawei Han, Micheline Kamber, and Jian Pei, Data Mining: Concepts and Techniques, 4th Edition, Morgan Kaufmann, 2022.
4. Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal, Data Mining: Practical Machine Learning Tools and Techniques, 5th Edition, Morgan Kaufmann, 2025.
5. Yann LeCun, Yoshua Bengio, and Geoffrey Hinton, Deep Learning, 1st Edition, MIT Press, 2021.

E-Resources:

MOOC / NPTEL Links

- NPTEL: Pattern Recognition (IIT Madras) – <https://nptel.ac.in/courses/106106046>
- NPTEL: Pattern Recognition and Neural Networks – https://archive.nptel.ac.in/content/syllabus_pdf/117108048.pdf
- NPTEL: Pattern Recognition (Web Course) – https://archive.nptel.ac.in/content/syllabus_pdf/117106100.pdf
- NPTEL: Preview – https://onlinecourses.nptel.ac.in/noc19_ee56/preview
- Coursera: Pattern Recognition Specialization – <https://www.coursera.org/specializations/pattern-recognition>
- edX: Machine Learning and Pattern Recognition (MIT) – <https://www.edx.org/learn/pattern-recognition>
- MIT OpenCourseWare: Pattern Recognition and Machine Learning – <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>
- YouTube: NPTEL Pattern Recognition Lectures – https://www.youtube.com/results?search_query=NPTEL+Pattern+Recognition
- GitHub: Pattern Recognition Examples (scikit-learn, OpenCV) – <https://github.com/topics/pattern-recognition>
- scikit-learn Documentation – <https://scikit-learn.org/stable/>
- OpenCV Documentation – <https://docs.opencv.org/>
- Towards Data Science: Pattern Recognition Articles – <https://towardsdatascience.com/search?q=pattern%20recognition>

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course : Computer Vision							Code: ADPE603C		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	PR	OR	Total
03	-	-	03	40	60	-	-	-	100
Prerequisites: Discrete Mathematics, Data Structures, and Artificial Intelligence fundamentals									
Course Objectives:									
1. Understand the principles of image formation, camera geometry, and digital image representation. 2. Apply image processing techniques such as filtering, enhancement, edge detection, and segmentation. 3. Design feature detection and description pipelines for matching and recognition tasks. 4. Analyze geometric vision concepts including stereo vision, homography, epipolar geometry, and motion estimation. 5. Evaluate classical and deep learning-based approaches for object detection, tracking, and scene understanding. 6. Develop computer vision solutions using modern tools and libraries for practical applications.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								Bloom's Taxonomy Level
CO1	Analyze image formation, camera models, and digital image representation for computer vision tasks.								Analyze
CO2	Apply image filtering, enhancement, edge detection, and segmentation methods to visual data.								Apply
CO3	Design feature extraction, detection, and description pipelines for image matching and recognition.								Create
CO4	Analyze geometric vision concepts including stereo vision, homography, and epipolar geometry.								Analyze
CO5	Evaluate motion estimation, object detection, tracking, and scene understanding techniques.								Evaluate
CO6	Develop computer vision applications using classical and deep learning-based methods and tools.								Create
Course Contents:									
Unit	Description								Duration (Hrs.)
1.	Unit I: Fundamentals of Image Formation and Processing Introduction to computer vision, applications, and challenges; Image formation models: pinhole camera model, perspective projection, and radiometric concepts;								05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Image representation: pixels, intensity images, color images, range images; Camera parameters: intrinsic and extrinsic parameters, calibration basics; Light and color: color spaces, illumination, white balance; Image noise and noise models; Spatial domain filtering: convolution, correlation, kernels, and masks; Image enhancement: smoothing, sharpening, histogram-based methods. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO2 – Apply	
2.	Unit II: Feature Detection, Matching, and Shape Analysis Edge detection: gradient operators, Canny detector, thresholding; Corner detection: Harris, Shi-Tomasi; Blob detection and scale-space ideas; Feature descriptors: HOG, SIFT, SURF, ORB (overview); Feature matching: nearest-neighbor matching, ratio test, matching metrics; Hough transform for line and shape detection; Shape representation: boundaries, contours, region descriptors; Interest points and invariant features for recognition. Mapped Outcomes and Bloom's Level: CO2 – Apply; CO3 – Create	05 Hrs.
3.	Unit III: Geometric Vision and Stereo 2-D geometric transformations: translation, rotation, scaling, affine and projective transforms; Homography and planar scene analysis; Camera geometry and coordinate systems; Stereo vision: epipolar geometry, fundamental matrix, essential matrix; Correspondence problem and disparity estimation; Triangulation and 3D reconstruction basics; RANSAC for robust model fitting; Multiple view geometry: overview and applications. Mapped Outcomes and Bloom's Level: CO1 – Analyze; CO4 – Analyze	05 Hrs.
4.	Unit IV: Motion Analysis and Optical Flow Motion in image sequences: rigid and non-rigid motion; Optical flow concepts and assumptions; Horn-Schunck optical flow algorithm; Lucas-Kanade optical flow algorithm; Motion fields, image warping, and motion estimation; Background subtraction and foreground segmentation; Tracking concepts: Kalman filter basics, object tracking overview; Motion analysis applications in surveillance, robotics, and autonomous navigation. Mapped Outcomes and Bloom's Level: CO4 – Analyze; CO5 – Evaluate	05 Hrs.
5.	Unit V: Segmentation, Classification, and Recognition Image segmentation: thresholding, region growing, split and merge, graph-based segmentation; Classical pattern classification in vision: nearest neighbor, SVM, decision trees, random forests; Dimensionality reduction for visual data: PCA, LDA, feature selection; Model-based vision: shape from shading, shape from texture, aspect graphs; Object recognition pipeline: detection, classification, localization, and evaluation; Pedestrian detection and face recognition overview;	05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Evaluation metrics for vision systems: IoU, mAP, precision-recall curves; Challenges in occlusion, scale variation, and clutter. Mapped Outcomes and Bloom's Level: CO3 – Create; CO5 – Evaluate	
6.	Unit VI: Deep Learning and Modern Computer Vision Introduction to deep learning for vision: perceptrons, MLP, CNNs; CNN architectures: LeNet, AlexNet, VGG, ResNet, EfficientNet (overview); Transfer learning and fine-tuning of pre-trained vision models; Object detection frameworks: R-CNN family, YOLO, SSD (conceptual overview); Image segmentation with deep networks: FCN, U-Net, Mask R-CNN (overview); Vision transformers and multimodal trends (introductory perspective); Tools and libraries: OpenCV, scikit-image, PyTorch, TensorFlow, torchvision; Mini-project: Build and evaluate a computer vision application for a real-world dataset. Mapped Outcomes and Bloom's Level: CO5 – Evaluate; CO6 – Create	05 Hrs.
TOTAL		30 Hrs
Text Books: 1. Richard Szeliski, Computer Vision: Algorithms and Applications, 2nd Edition, Springer, 2022. 2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing, 4th Edition, Pearson, 2018. 3. David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, 2nd Edition, Pearson, 2012. 4. Richard Hartley and Andrew Zisserman, Multiple View Geometry in Computer Vision, 2nd Edition, Cambridge University Press, 2004. 5. Reinhard Klette and Karsten Schlöns, Concise Computer Vision: An Introduction into Theory and Algorithms, 2nd Edition, Springer, 2020.		
Reference Books: 1. E. R. Davies, Computer and Machine Vision: Theory, Algorithms, Practicalities, 4th Edition, Academic Press, 2012. 2. Jan Erik Solem, Programming Computer Vision with Python, 1st Edition, O'Reilly Media, 2012. 3. Bahadir K. Gunturk and William A. Horn, Image and Video Processing: From C to MATLAB, 1st Edition, Academic Press, 2008. 4. Simon J. D. Prince, Computer Vision: Models, Learning, and Inference, 1st Edition, Cambridge University Press, 2012. 5. Ian H. Witten, Eibe Frank, Mark A. Hall, and Christopher J. Pal, Data Mining: Practical Machine Learning Tools and Techniques, 5th Edition, Morgan Kaufmann, 2025. 6. Yann LeCun, Yoshua Bengio, and Geoffrey Hinton, Deep Learning, 1st Edition, MIT Press, 2021.		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

E-Resources:

MOOC / NPTEL Links

- NPTEL: Pattern Recognition (IIT Madras) – <https://nptel.ac.in/courses/106106046>
- NPTEL: Pattern Recognition and Neural Networks –
https://archive.nptel.ac.in/content/syllabus_pdf/117108048.pdf
- NPTEL: Pattern Recognition (Web Course) –
https://archive.nptel.ac.in/content/syllabus_pdf/117106100.pdf
- NPTEL: Preview – https://onlinecourses.nptel.ac.in/noc19_ee56/preview
- Coursera: Pattern Recognition Specialization – <https://www.coursera.org/specializations/pattern-recognition>
- edX: Machine Learning and Pattern Recognition (MIT) – <https://www.edx.org/learn/pattern-recognition>
- MIT OpenCourseWare: Pattern Recognition and Machine Learning –
<https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/>
- YouTube: NPTEL Pattern Recognition Lectures –
https://www.youtube.com/results?search_query=NPTEL+Pattern+Recognition
- GitHub: Pattern Recognition Examples (scikit-learn, OpenCV) – <https://github.com/topics/pattern-recognition>
- scikit-learn Documentation – <https://scikit-learn.org/stable/>
- OpenCV Documentation – <https://docs.opencv.org/>
- Towards Data Science: Pattern Recognition Articles –
<https://towardsdatascience.com/search?q=pattern%20recognition>

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Retrieval-Augmented Generation (RAG)							Code: ADMD604		
Teaching Scheme (5 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
02	-	-	02	40	60	-	-	-	100
Prerequisites: Basics of Python Programming, Fundamental Database Concepts, and Elementary Vector Mathematics.									
Course Objectives:									
1. To introduce the structural pipeline of text chunking and vector embeddings. 2. To study classical similarity matching metrics (Cosine Similarity, Euclidean distance profiling). 3. To understand the operational basis of local vector storage and semantic nearest-neighbor search indexing. 4. To apply document retrieval logic to data-driven decision-making systems, independent of complex ML model training. 5. To evaluate trade-offs between static parametric database lookups and dynamic heuristic context-injection frameworks.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome							Bloom's Taxonomy Level	
CO1	Formulate real-world unstructured documents into token-aware textual chunks.							BL3 – Apply	
CO2	Solve text similarity matching problems using Cosine Similarity and distance metrics.							BL3 – Apply	
CO3	Apply vector database architectures to index and register embedded document payloads.							BL3 – Apply	
CO4	Design and implement automated context-retrieval and prompt-injection components.							BL3 – Create	
CO5	Analyze performance trade-offs, accuracy boundaries, and hallucination metrics of custom pipelines.							BL4 – Analyze	
CO6	Apply localized question-answering systems to enterprise document data tasks.							BL3 – Apply	
Course Contents:									
Unit	Description								Duration
1.	Unit 1: Introduction to RAG Architectures What is Retrieval-Augmented Generation (RAG) Core differences between static model knowledge and non-parametric external knowledge bases. The three core stages of an end-to-end RAG system pipeline: Data Ingestion, Vector Retrieval, and Text Generation.								05 Hrs.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

	Understanding and mitigating hallucinations in generative outputs using factual contextual grounding.	
2.	Unit 2: Text Preprocessing & Chunking Strategies Foundations of text data wrangling: Tokenization pipelines, token footprint boundaries, and context window limits. The necessity of Text Chunking: Why massive production files and manuals must be broken down. Chunking techniques: Fixed-size character chunking, sentence-based splitting, and semantic-based splitting. Managing Chunk Overlap parameters to preserve contextual continuity at document boundaries.	05 Hrs.
3.	Unit 3: Vector Semantics and Text Embeddings Representing words, phrases, and long sentences as high-dimensional numerical arrays (vectors). Introduction to modern embedding frameworks (such as open-source Hugging Face or public model APIs). Mathematical similarity matching operations: Understanding and calculating Cosine Similarity metrics and Euclidean distance profiles.	05 Hrs.
4.	Unit 4: Vector Databases and Indexing Limitations of traditional Relational Databases (RDBMS) with unstructured vectors vs. the necessity of specialized Vector Databases. Architectural overview of popular, lightweight vector storage frameworks: ChromaDB, FAISS, and Pinecone. How indexing works: Creating efficient numeric data indexes for high-speed nearest-neighbor search lookups.	05 Hrs.
5.	Unit 5: The Retrieval and Context Injection Loop The Query Processing lifecycle: How a user's question is vectorized and matched against stored data chunks. Top-K Retrieval parameters: Selecting the most relevant contextual records based on mathematical similarity scores. Context Injection: Structuring the prompt window by stitching user queries and retrieved records into a single text template.	05 Hrs.
6.	Unit 6: Multimodal RAG & Evaluation Metrics Introduction to Multimodal RAG pipelines: Extending retrieval architectures to index both text documents and audio feature segments. Basic Evaluation Frameworks: Measuring pipeline efficiency using the RAGAS metrics (Faithfulness, Answer Relevance, and Context Recall). Ethical safety boundaries: Restricting unauthorized content ingestion and managing enterprise data privacy.	05 Hrs.
TOTAL		30Hrs.
Text Books:		



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

1. *Saloni Garg, Amit Sagtani, Kamal Kant Hiran, "RAG Artificial Intelligence: Retrieval-Augmented Generation in Generative AI", De Gruyter Textbook Series.*
2. *Dr. Balaji Venkateswaran, "Applied RAG: Practical Retrieval-Augmented Generation with Python", BPB Publications.*
3. *Swati Bhatnagar, "Beyond Words: Mastering Retrieval Augmented Generation in AI", Orange Books.*

Reference Books:

1. Denis Rothman, "RAG-Driven Generative AI: Build custom retrieval augmented generation pipelines with LlamaIndex, Deep Lake, and Pinecone", Packt Publishing.
2. O'Reilly Media System Series, "A Simple Guide to Retrieval Augmented Generation", O'Reilly Media.
3. Daniel Jurafsky and James H. Martin, "Speech and Language Processing" (3rd Edition Draft), Stanford University Press.
4. Jia Huang, "RAG from First Principles", Packt Publishing.

E-Resources:

MOOC / NPTEL / YouTube:

1. NPTEL – Natural Language Processing (IIT Kharagpur): <https://nptel.ac.in/courses/106105158>
2. NPTEL – Deep Learning for Computer Vision (IIT Hyderabad): nptel.ac.in
3. DeepLearning.AI – Large Language Models with Semantic Search: deeplearning.ai
4. DeepLearning.AI – Building Applications with Vector Databases: deeplearning.ai
5. Coursera – Introduction to Generative AI Learning Path: coursera.org

E-Books, Digital Manuals & Framework Documentation

1. Stanford University – Speech and Language Processing (3rd Edition Draft): stanford.edu
2. LangChain Framework – Official Production Documentation & Cookbooks: langchain.com
3. LlamaIndex Framework – Data Framework for LLM Applications Manuals: llamaindex.ai
4. ChromaDB Ecosystem – Local Vector Database Storage API Reference: trychroma.com

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Retrieval-Augmented Generation (RAG) Lab							Code: ADMD604P		
Teaching Scheme (4 Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	02	-	01	-	-	50	-	-	50
Prerequisites:									
Foundational programming proficiency in Python (variables, loops, file operations) and familiarity with elementary vector operations (matrix structures, arithmetic arrays).									
Course Objectives:									
1. To build hands-on skills in importing, parsing, and cleaning unstructured textual data sources. 2. To implement token-aware character slicing and chunk overlap architectures programmatically. 3. To write mathematical functions that generate vector representations and calculate spatial text similarity metrics. 4. To deploy, configure, and maintain local vector storage nodes to handle text payload indexing. 5. To assemble an end-to-end local data retrieval and context prompt orchestration framework.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Manipulate unstructured files programmatically using basic string pipelines.								
CO2	Construct custom document chunking rules with configured border overlaps.								
CO3	Compute text embedding arrays and resolve similarity matches using coordinate metrics.								
CO4	Initialize local vector registries and perform nearest-neighbor query extractions.								
CO5	Build automated context injection prompts inside localized software environments.								
CO6	Implement a fully functional, hallucination-free question-answering tool for data tasks.								
List of Experiments:									
Required Tools & Software:									
Environment: Python 3.8+ (IDLE, VS Code, or Jupyter Notebook)									
Libraries: pip install langchain-community chromadb sentence-transformers faiss-cpu									
The student shall complete the following activities as a part of Term Work.									
Complete any Eight Experiments from the following list:									
Experiment 1: Reading Text Files with Python									
Open and read a standard .txt or .pdf file using simple Python file handling, calculate the total word count, and print the text to the terminal.									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Experiment 2: Basic Text Slicing

Write a short Python loop to cut a long document manually into equal pieces of 200 words each to handle text length constraints.

Experiment 3: Creating Text Overlaps

Split a document into paragraphs, ensuring the last 20 words of the first section repeat at the start of the next section to keep the text context unbroken.

Experiment 4: Generating Text Embeddings

Use a free local model (all-MiniLM-L6-v2) to turn 5 sample sentences into basic lists of numbers (embeddings) and print the array.

Experiment 5: Calculating Word Similarity

Write a short script to calculate the mathematical similarity between two sentences to verify if they share a close meaning.

Experiment 6: Local Vector Database Setup

Install and initialize a local, folder-based storage system using ChromaDB or FAISS to prepare a repository for data storage.

Experiment 7: Storing Vectors in the Database

Save your list of sentence embeddings and their matching raw text sentences directly into your local database collection folder.

Experiment 8: Running a Basic Search Query

Type a test question, convert it to numbers, search your local database collection, and pull out the top 2 matching sentences.

Experiment 9: Crafting a Prompt Template

Design a standard Python string formatting layout that automatically stitches your question and the retrieved sentences together into one structured text block.

Experiment 10: Building the Local Question-Answering Bot

Assemble your database search and prompt template code using LangChain to read a new file, accept a question, and print out clean, correct answers.

Text Books:

1. Dr. Balaji Venkateswaran, "Applied RAG - Practical Retrieval-Augmented Generation with Python", BPB Publications.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

2. Saloni Garg, Amit Sagtani, and Kamal Kant Hiran, "**Rag Artificial Intelligence: Retrieval-Augmented Generation in Generative AI**", De Gruyter Textbook Series.
3. Quiet Lion Press, "**Building RAG Applications: A Hands-On Guide to Retrieval-Augmented Generation with Python**", Independently Published.
4. Alok Kumar, "**Foundations of Vector Search and RAG Systems for Beginners**", BlueRose Publishers.

Reference Books:

1. Denis Rothman, "**RAG-Driven Generative AI with LlamaIndex, Deep Lake, and Pinecone**", Packt Publishing.
2. O'Reilly Media System Series, "**A Simple Guide to Retrieval Augmented Generation**", O'Reilly Media.
3. Meenakshi K. & S. Rajkumar, "**Python Data Pipelines for AI Applications**", Shroff Publishers & Distributors.
4. Rhys Calloway, "**RAG in Production: Retrieval-Augmented Generation Beyond the Tutorial**", Production AI Engineering Series.

[**Back to Structure**](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course : Data Visualization & Business Intelligence Lab							Code: ADVS605P		
Teaching Scheme (4 Hrs /week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
01	02	-	02	-	-	50	-	-	50
Prerequisites: Computer Fundamentals, Data Fundamentals, Basic Database and SQL Concepts, Spreadsheet Operations, Basic Descriptive Statistics, and Analytical & Logical Thinking.									
Course Objectives:									
1. Understand the fundamentals of Business Intelligence, data visualization, and dashboard design using Tableau and Microsoft Power BI for data-driven decision-making. 2. Develop practical skills in data acquisition, cleaning, transformation, and modeling from multiple data sources using Power Query, Tableau, and relational databases. 3. Apply visualization techniques, calculated fields, DAX functions, and Level of Detail (LOD) expressions to create interactive dashboards and business reports. 4. Analyze business data from domains such as retail, healthcare, banking, education, and manufacturing to generate meaningful insights for organizational decision-making. 5. Implement industry-standard Business Intelligence solutions by integrating data governance, dashboard optimization, security, and collaborative reporting practices. 6. Design and develop end-to-end Business Intelligence applications using Tableau and Power BI to solve real-world business problems through project-based learning.									
Course Outcomes: After completion of this course, students will be able to -									
CO	Course Outcome								
CO1	Explain the concepts of Business Intelligence, data visualization, dashboard components, and analytics tools used in Tableau and Microsoft Power BI.								
CO2	Develop business intelligence solutions by importing, cleaning, transforming, modeling, and managing data from multiple sources using Tableau and Power BI.								
CO3	Create interactive dashboards, reports, KPIs, calculated fields, DAX measures, and visual analytics to support business decision-making.								
CO4	Analyze business datasets using visualization techniques, filters, drill-throughs, forecasting, and advanced analytical features to identify trends, patterns, and actionable insights.								
CO5	Evaluate dashboard performance, data quality, governance, security, and visualization effectiveness to recommend suitable BI solutions for enterprise applications.								
CO6	Design and implement a comprehensive Business Intelligence solution using Tableau and Microsoft Power BI that addresses a real-world industrial problem through data-driven decision support.								
Required Tools & Software:									
Environment: Windows 10/11 (64-bit), Microsoft Power BI Desktop, Tableau Desktop/Tableau Public, Microsoft Excel, SQL environment (MySQL/PostgreSQL/SQLite), modern web browser, and Internet connectivity.									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Libraries/Technologies: Power Query (M), DAX, Tableau Calculated Fields, LOD Expressions, Parameters, Sets, Groups, Power BI advanced visuals, SQL, and Microsoft Fabric

The student shall complete the following activities as a part of Term Work. Complete any Ten Experiments from the following list:

List of Practical's:

1. Import, clean, transform, and model the sales data using Power Query and Tableau Data Source to prepare it for analytics.
2. Develop an interactive dashboard showing KPIs, monthly trends, regional sales, and category-wise performance.
3. Create HR analytics dashboards showing employee demographics, attrition rate, experience distribution, and salary analysis.
4. Build executive dashboards to visualize patient flow and hospital resource utilization.
5. Develop dashboards using calculated fields, KPIs, and slicers to identify high-risk loan portfolios.
6. Design dashboards to analyze customer segmentation, product performance, and seasonal sales patterns.
7. Develop dashboards showing production targets, machine utilization, quality defects, and maintenance schedules.
8. Create dashboards to analyze inventory levels, supplier performance, delivery delays, and logistics costs.
9. Build academic analytics dashboards using filters, drill-through pages, and calculated metrics.
10. Develop dashboards showing engagement, impressions, click-through rates, conversions, and ROI.
11. Develop a comprehensive executive dashboard using advanced visualizations, bookmarks, drill-downs, and KPI cards.
12. Create dashboards displaying prediction accuracy, precision, recall, F1-score, confusion matrix summaries, and model drift indicators.
13. Develop Tableau dashboards using parameters, sets, groups, Level of Detail (LOD) expressions, forecasting, and stories.
14. Build advanced dashboards using DAX measures, calculated columns, What-If parameters, decomposition trees, and Key Influencers visual.
15. Publish reports to Power BI Service/Tableau Cloud, configure workspaces, dashboards, scheduled refresh, and Row-Level Security (RLS).
16. Design and implement an end-to-end BI solution using Tableau and Power BI, including data preparation, modeling, dashboard development, deployment, and executive presentation.

Text Books:

1. Alex Kolokolov and Maxim Zelensky, The Big Book of Dashboards: Visualizing Your Data Using Real-World Business Scenarios, Wiley Publications, 2017.
2. Brett Powell, Mastering Microsoft Power BI, 3rd Edition, Packt Publishing, 2024.
3. Ryan Sleeper, Practical Tableau: 100 Tips, Tutorials, and Strategies from a Tableau Zen Master, O'Reilly Media, 2018.
4. Cole Nussbaumer Knaflic, Storytelling with Data: A Data Visualization Guide for Business Professionals, 2nd Edition, Wiley Publications, 2023.



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

5. Alberto Ferrari and Marco Russo, The Definitive Guide to DAX: Business Intelligence with Microsoft Power BI, SQL Server Analysis Services, and Excel, 3rd Edition, Microsoft Press, 2022..

Reference Books:

1. Stephen Few, Information Dashboard Design: Displaying Data for At-a-Glance Monitoring, 2nd Edition, Analytics Press, 2013.
2. Wayne Winston, Microsoft Power BI Data Analysis and Visualization, Microsoft Press, 2021.
3. Andy Kriebel, Tableau for Data Visualization: A Practical Guide for Business Intelligence Professionals, Packt Publishing, 2023.
4. Ralph Kimball and Margy Ross, The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd Edition, Wiley Publications, 2013.
5. Wilfried Grossmann and Stefanie Rinderle-Ma, Fundamentals of Business Intelligence, Springer, 2015.

E-Resources:

1. Microsoft Learn – Power BI
<https://learn.microsoft.com/training/powerplatform/power-bi/>
Official Microsoft learning platform covering Power BI Desktop, Power Query, DAX, data modeling, dashboards, reports, and Microsoft Fabric.

Microsoft Power BI Documentation

<https://learn.microsoft.com/power-bi/>
Official documentation for Power BI Desktop, Power BI Service, DAX, administration, deployment, and enterprise BI.

Tableau Learning

<https://learning.tableau.com/>
Official Tableau learning portal offering self-paced courses, hands-on exercises, and certification preparation.

Tableau Documentation

<https://help.tableau.com/>
Official Tableau documentation covering Tableau Desktop, Tableau Prep, Tableau Server, Tableau Cloud, and advanced analytics.

Tableau Public

<https://public.tableau.com/>
Explore thousands of real-world dashboards, visualization projects, and best practices shared by the Tableau community.

Microsoft Fabric Documentation

<https://learn.microsoft.com/fabric/>
Official documentation for Microsoft Fabric, including data engineering, data warehousing, real-time analytics, and Business Intelligence.

SQLBolt



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<https://sqlbolt.com/>

Interactive SQL tutorials for learning database querying, filtering, joins, grouping, and aggregation, essential for BI professionals.

Kaggle Datasets

<https://www.kaggle.com/datasets>

Repository of public datasets for developing Business Intelligence dashboards across healthcare, retail, banking, education, finance, and AI domains.

Data.gov

<https://data.gov/>

Open government datasets suitable for business analytics, visualization, and decision-support applications.

OECD Data

<https://data.oecd.org/>

International datasets for economic, healthcare, education, sustainability, and social analytics.

World Bank Open Data

<https://data.worldbank.org/>

Global datasets for visualization, forecasting, and policy analytics.

GitHub

<https://github.com/>

Open-source repositories containing Power BI templates, Tableau dashboards, sample datasets, and analytics projects.

Power BI Community

<https://community.fabric.microsoft.com/>

Official Microsoft community for Power BI discussions, DAX solutions, report optimization, and enterprise BI support.

Tableau Community

<https://community.tableau.com/>

Official Tableau community providing forums, knowledge articles, dashboard inspiration, and technical support.

[Back to Structure](#)



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

Program: B. Tech. (Artificial Intelligence and Data Science)							Semester: VI		
Course: Internship – V							Code: ADIN605		
Teaching Scheme (Hrs/week)				Evaluation Scheme (Marks)					
Lecture	Practical	Tutorial	Credit	CIE	ETE	TW	OR	PR	Total
-	-	-	02	-	-	25	-	-	25
Preamble:									
Internships serve as vital educational and career development experiences, offering practical exposure in a specific field. Employers seek individuals who possess the necessary skills and an understanding of industry environments, practices, and cultures. This internship is designed as a structured, short-term, supervised training program, often centered on specific tasks or projects with clear timelines. The primary goal is to immerse technical students in an industrial setting, providing experiences that cannot be replicated in the classroom. This exposure aims to develop competent professionals who understand the social, economic, and administrative factors influencing the operations of industrial organizations.									
Course Objectives:									
1. Exposure to students to the industrial environment, which cannot be provided in the classroom and hence creating deployable professionals for the industry. 2. Learn to implement the technical knowledge in real industrial situations.									
Course Outcomes: After completion of this course, students will be able to -									
CO1	Gain exposure to industry practices and understand how academic concepts are applied in professional settings.								
CO2	Develop and demonstrate effective communication and teamwork skills within a work environment.								
CO3	Improve your problem-solving and time management skills by working in real-world industry settings.								
Internship Requirements :									
1. Internship Duration: It is mandatory for all students to undergo an internship after every semester during vacations for the duration of 3 to 5 weeks. Internships completed during this period will be considered for the assessment of Term Work (TW).									
2. Internship Opportunities: Students can explore various opportunities for internships at: f. Industries g. Research labs or organizations h. Collegiate clubs i. In-house research projects j. Online internships									
3. Support and Assistance: Students can seek assistance for securing internships from: e. The Training and Placement cell, along with departmental coordinators f. Department or institute faculty members g. Personal contacts h. Directly connecting with industries or organizations									



DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

4. Request Letter: Once an industry, research organization, or collegiate club is identified, students must obtain a request letter from the concerned department or placement office. This letter, in the standard format must be duly signed by the authority, should be addressed to the HR manager or relevant authority.

1. **Confirmation Letter:** Students must submit the confirmation letter from the industry, research organization, or collegiate club to the Internship Coordinator and the Head of Department (HOD) office.
2. **Joining Report:** Upon commencing the internship, students must submit the joining report, joining letter, or a copy of the confirmation email to the Internship Coordinator and the HOD office.
3. **Faculty Mentor:** A faculty member will be assigned as a mentor to a group of students. The mentor will be responsible for monitoring, evaluating, and assessing student internship activities. The faculty mentor is also required to visit the internship location and submit formal feedback to the Internship Coordinator.
4. **Faculty Visits:** Faculty members are advised to visit the internship site once or twice during the internship period to monitor progress.
5. **Progress Report:** Students must submit progress report fortnightly to their faculty guide and the final internship report to the Internship Coordinator and department office.
6. **Evaluation Report:** After the completion of the internship, the mentor, along with the assessment panel members, should submit the evaluation report of the students to the department office and the Internship Coordinator.
7. **Internship Certificate:** Students must receive the Internship Certificate from the industry and submit it to the Internship Coordinator and department office.
8. **Presentation and Assessment:** Students are required to give a presentation on their internship work as part of the term work. The internship diary and report will also be verified and assessed.

[**Back to Structure**](#)