Scheme with Description

Syllabus

for

B. Tech. in

Computer Science and Engineering

(Artificial Intelligence & Machine Learning)

Department of Computer Science and Engineering

Second Year With effect from the Academic Year 2024-25

Third Year With effect from the Academic Year 2025-26

Fourth Year With effect from the Academic Year 2026-27

Ramrao Adik Institute of Technology

Credit structure -Semester-VI

Course Category	Course Code	Course Name	Teaching Hours		Credits Assigned		
			TH	PR	TH	PR	Total
Programme Core Course	231CAUCC61	Advanced Machine Learning	03	--	03	--	03
	231CAUCC62	Deep Learning	03	--	03	--	03
Program Elective Course - II	231CAUEC21	Data Visualization and Analytics	03	--	03	--	03
	231CAUEC22	Responsible AI					
	231CAUEC23	Big Data Analytics					
	231CAUEC24	Quantum AI					
Program Elective Course - III	231CAUEC31	Natural Language Processing	03	--	03	--	03
	231CAUEC32	Computational Intelligence					
	231CAUEC33	Cognitive Computing					
	231CAUEC34	Cloud for AI					
Multidisciplinary Minor -IV	231CAUMM61	Design of Experiments	02	--	02	--	02
Vocational Skill Enhancement Course	231CAUVS61	Skill Based Lab – III: MLOps	--	04	--	02	02
Programme Core Course Lab	231CAUCL61	Advanced Machine Learning Lab	--	02	--	01	01
	231CAUCL62	Deep Learning Lab	--	02	--	01	01
Program Elective Course - II Lab	231CAUEL21	Data Analytics and Visualization Lab	--	02	--	01	01
	231CAUEL22	Responsible AI Lab					
	231CAUEL23	Big Data Analytics Lab					
	231CAUEL24	Quantum AI Lab					
Program Elective Course - III Lab	231CAUEL31	Natural Language Processing Lab	--	02	--	01	01
	231CAUEL32	Computational Intelligence Lab					
	231CAUEL33	Cognitive Computing Lab					
	231CAUEL34	Cloud for AI Lab					
		Total	**14**	**12**	**14**	**06**	**20**

Evaluation Scheme -Semester-VI

Course Category	Course Code	Course Name	Internal Assessment		Uni. Exam	IA	Uni. Exam	
			IA	MSE	ESE	TW	PR/OR	Total
Programme Core Course	231CAUCC61	Advanced Machine Learning	20	20	60	--	--	100
	231CAUCC62	Deep Learning	20	20	60	--	--	100
Program Elective Course – II	231CAUEC21	Data Visualization and Analytics	20	20	60	--	--	100
	231CAUEC22	Responsible AI						
	231CAUEC23	Big Data Analytics						
	231CAUEC24	Quantum AI						
Program Elective Course - III	231CAUEC31	Natural Language Processing	20	20	60	--	--	100
	231CAUEC32	Computational Intelligence						
	231CAUEC33	Cognitive Computing						
	231CAUEC34	Cloud for AI						
Multidisciplinary Minor -IV	231CAUMM61	Design of Experiments	15	10	50	--	--	75
Vocational Skill Enhancement Course	231CAUVS61	Skill Based Lab – III: MLOps	--	--	--	25	25	50
Programme Core Course Lab	231CAUCL61	Advanced Machine Learning Lab	--	--	--	25	25	50
	231CAUCL62	Deep Learning Lab	--	--	--	25	25	50
Program Elective Course – II Lab	231CAUEL11	Data Analytics and Visualization Lab	--	--	--	25	25	50
	231CAUEL12	Responsible AI Lab						
	231CAUEL13	Big Data Analytics Lab						
	231CAUEL14	Quantum AI Lab						
Program Elective Course – III Lab	231CAUEL31	Natural Language Processing Lab	--	--	--	25	25	50
	231CAUEL32	Computational Intelligence Lab						
	231CAUEL33	Cognitive Computing Lab						
	231CAUEL34	Cloud for AI Lab						
		Total	**95**	**90**	**290**	**125**	**125**	**725**

D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI		**B.TECH IN COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING)**							**THIRD YEAR SEM- VI**
Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUCC61	Advanced Machine Learning	03	--	--	03	--	--	03	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231CAUCC52 Machine Learning
  231CAUCC53 Neural Networks & Fuzzy Systems

- **Course Objectives:**
  - To conceptualize the Linear model.
  - To understand graphical directed and undirected models.
  - To understand Mixture models and EM algorithm.
  - To become familiar with Markov Chain and HMM with inference model.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Identify the generalized linear model and exponential family.
  CO2: Choose an appropriate graphical model for a problem.
  CO3: Identify Mixture model and understand EM algorithm.
  CO4: Apply Markov and Hidden Markov Model in real world problem solution.
  CO5: Analyze and apply the undirected graphical model.
  CO6: Understand and apply Monte Carlo Inference system.

Module No.	Detailed Content	Hrs (45)	CO
1	**Generalized Linear Models and Exponential Family** Introduction, Exponential family, generalized Linear model, Probit regression, Multitask learning, generalized linear mixed models	07	**CO1**
2	**Directed Graphical models** Introduction, examples, inference, learning, conditional independence properties of DGM, decision diagrams	**07**	**CO2**
3	**Mixture Models and EM algorithm** Latent variable models, Mixture models, Goals, parameter estimation of mixture models, EM algorithm, model selection for latent variable models, fitting models with missing data	**09**	**CO3**
4	**Markov and Hidden Markov Models** Introduction, Markov models, Hidden Markov Models, Inference in HMM, learning for HMMs, generalizations of HMMs	**08**	**CO4**
5	**Undirected Graphical Models** Introduction, Conditional independence properties of UGMs, parameterization of MRFs, examples of MRFs, learning, Conditional random fields	**07**	**CO5**
6	**Monte Carlo Inference** Introduction, sampling from standard distributions, rejection sampling, importance sampling, Markov chain Monte carlo inference introduction	**07**	**CO6**

Text books:

1. K. Murphy, *Machine learning - A probabilistic perspective*, Ist Edition, MIT Press, Cambridge, MA, USA, 2012.
2. T. Mitchell, *Machine learning*, Ist Edition, McGraw Hill, NY, USA, 1997.

Reference books:

1. C.M. Bishop, *Neural networks for pattern recognition*, IIIrd Edition, Oxford University Press, 2009.
2. E. Alpaydin, *Introduction to machine learning*, Ist Edition, MIT Press, Cambridge, MA, USA, 2004.
3. L. Devroye, L. Gyoerfi, and G. Lugosi, *A probabilistic theory of pattern recognition*, Ist Edition, Springer- Verlag, NY, USA, 1997.
4. J. Hearty, *Advanced Machine Learning with Python*, Ist Edition, Packt Publishing, Birmingham, UK, 2016.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUCC62	Deep Learning	03	--	--	03	--	--	03

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231CAQCC52 Machine Learning
  231CAUCC53 Neural Networks & Fuzzy Systems

- **Course Objectives:**
  - To introduce the concepts and understanding of deep learning, and the architecture and training methods of deep neural networks.
  - To explore various advanced models like convolutional neural networks and recurrent neural networks, and autoencoders.
  - To implement and apply deep learning techniques to real-world problems including image, text, and audio data.
  - To introduce students to state-of-the-art architectures and practical considerations for training deep learning models.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Distinguish between AI, ML, and DL and identify different types of learning methods and their appropriate use cases.
  CO2: Evaluate train deep neural networks using appropriate architectures, activation functions, and optimization techniques.
  CO3: Analyze and evaluate deep learning models using regularization methods to prevent overfitting and improve generalization.
  CO4: Design and implement Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) for vision and sequence-based tasks.
  CO5: Apply autoencoders and other deep generative models for dimensionality reduction, denoising, and feature learning.
  CO6: Apply CNN and RNN techniques to solve different applications.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Deep Learning** Relationship between AI, ML, and DL, neural networks: deep vs. shallow networks, basic terminologies of deep learning.	05	CO1
2	**Regularization Techniques** Bias variance tradeoff, L1, L2 regularization, early stopping, dataset augmentation, parameter sharing, injecting noise into input, ensemble methods, dropout, greedy layer wise pre-training, advanced activation functions, batch normalization.	09	CO2
3	**Convolution Neural Networks** Introduction, architecture-motivation, layers, kernels, operations (convolution, padding, stride, pooling), non-linear layer, stacking layers, popular CNN architectures: LeNet, AlexNet, VGGNet.	07	CO3
4	**Recurrent Neural Networks** Fundamentals of RNN, bidirectional RNNs, encoder-decoder architectures, Gated Recurrent Unit (GRU), Recursive Neural Networks, Long Short Term Memory Networks (LSTM).	09	CO4
5	**Autoencoders** Autoencoder architecture, regularized autoencoder, denoising autoencoders, representational power: effect on layer size, and depth, stochastic encoders and decoders, contractive encoders.	09	CO5
6	**Applications of Deep Learning** ImageNet Detection and classification, Audio generation using WaveNet, Natural Language Processing with Word2Vec, BioInformatics- Face Recognition, Scene Understanding and sematic segmentation , Automated Image Captioning.	06	CO6

Text books:

1. I. Goodfellow, Y. Bengio, and A. Courville, *Deep learning*, Ist Edition, MIT Press, Cambridge, MA, USA, 2016.
2. J. Zurada, *Introduction to artificial neural systems*, Ist Edition, West Publishing Co., NY, USA, 1992.

Reference books:

1. M. Mohri, A. Rostamizadeh, and A. Talwalkar, *Foundations of Machine Learning*, Ist Edition, MIT Press, MA, USA, 2012.
2. N. K. Manaswi, *Deep Learning with Applications Using Python: Chatbots and Face. Object, and Speech Recognition with TensorFlow and Keras*, Ist Edition, Apress Berkeley, CA, 2018.
3. T. Mitchell, *Machine learning*, Ist Edition, McGraw Hill, NY, USA 1997.
4. S. Haykin, *Neural networks and learning machines*, IIIrd Edition, Pearson Prentice Hall, India, 2009.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEC21	Data Visualization and Analytics	03	--	--	03	--	--	03	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  - 231ADUCC31 Database Management Systems
  - 231ADUMM31 Statistical Methods

- **Course Objectives:**
  - Develop skills to both design and critique visualizations.
  - Understand the components involved in visualization design.
  - Understanding the relationship between data visualization and analytics.
  - To understand the basic techniques for descriptive data analytics.
  - Comprehend data analytics techniques.

- **Course Outcomes:** After completion of this course, learners will be able to:
  - CO1: Understand the fundamentals of data visualization and its importance.
  - CO2: Apply visualization tools / techniques for various data analysis tasks.
  - CO3: Explore D3.js for interactive data visualizations in web browser.
  - CO4: Apply and analyze basic descriptive data analytics techniques.
  - CO5: Explore various Time Series analysis techniques.
  - CO6: Apply visual principles and best practices for designing dashboards.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Data Visualization:** Importance and history of data visualization, Understanding data types (categorical, numerical, time-series, geospatial), Basic visualizations: Bar charts, Line charts, Scatter plots, Pie charts, etc. Principles of Effective Visualization.	06	CO1
2	**Charts, Graphs, and Multivariate Visualization:** Advanced Charts and Graphs: Histograms, Box plots, Heatmaps, Scatter plot matrices, Bubble charts, Radar charts, Visualization of multivariate data using Pair plots and Parallel coordinates. Time-series visualization: Line charts, smoothing techniques, handling missing data.	06	CO2
3	**Introduction to D3.js :** Getting setup with D3, making selections, changing selection's attribute, Data formats you can use with D3, creating a server to upload your data, D3's function for loading data, Dealing with Asynchronous requests, Loading and formatting Large Data Sets.	07	CO3
4	**Pragmatics and Data Analysis Techniques:** Introduction to Regression, Types of Regression: Simple Linear Regression, Multiple Linear Regression, Polynomial Regression, Qualitative predictor variables, Model Evaluation Measures, Model selection procedures, Logistic Regression: Logistic Response function and logit, Predicted values from Logistic Regression, Interpreting the coefficients and odds ratios, Linear Regression Vs Logistic Regression, Assessing the models.	09	CO4
5	**Time Series Analysis:** Introduction to time series, Times series forecasting. Time series components, Decomposition – additive and multiplicative. Exponential smoothing, Time Series Analysis - Box-Jenkins Methodology, ARIMA Model Autocorrelation Function (ACF, PACF) Autoregressive Models, Moving Average Models, ARMA and ARIMA Models, Building and Evaluating an ARIMA Model.	08	CO5
6	**Storytelling, Dashboards, and Big Data Visualization:** Storytelling with Data: Crafting narratives from data and creating data-driven stories, Designing effective dashboards for business intelligence and decision-making, Balancing analytics with storytelling for non-technical audiences. Big Data Visualization: Challenges and tools for visualizing big data. Real-time data visualization with Tableau, Power BI, and Python-based tools.	09	CO6

Textbooks:

1. C. N. Knaflic, *Storytelling with Data: A Data Visualization Guide for Business Professionals*, Ist Edition, Wiley Publication, New Jersey, USA , 2015.
2. S. Sringeswara , P. Tiwari , and U. D. Kumar , *Data Visualization: Storytelling Using Data*, Ist Edition, Wiley Publication, NJ, USA, 2022.
3. K. P. Murphy, *Machine Learning a Probabilistic Perspective*, Ist Edition, MIT Press, Cambridge, Massachusetts, UK, 2020.

Reference Book:

1. E. R. Tufte, *The Visual Display of Quantitative Information*, IInd Edition, Graphics Press, Warwickshire, UK,1995.

2. B. Fry, *Visualizing Data*, II[nd] Edition, O'Reilly Media, California, USA, 2009.
3. S. Acharya and S. Chellappan, *Big Data and Analytics*, 2[nd] Edition, Wiley Publication, NJ, USA.
4. T. Mitchell, *Machine Learning*, 3[rd] Edition, McGraw Hill, NY, USA, 1997.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEC22	Responsible AI	03	--	--	03	--	--	03	
		Evaluation Scheme							
		Theory						Term work	Prac./ Oral	Total
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)		
		Test 1	Test 2	Avg.					
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231CAUCC41 Artificial Intelligence
  231CAUCC52 Machine Learning

- **Course Objectives:**
  - Distinguish the fundamental concepts of responsible AI, including ethics, governance, compliance, and regulatory considerations.
  - Explain the interaction of values with technical and socio-technical systems and trade-offs in AI-based decision making.
  - Deploy and use AI systems in a way that adheres to ethical principles, emerging regulatory frameworks, compliance and accountability.
  - Apply ethical and responsible practices, develop strategies to identify and mitigate irresponsible AI design, development, and deployment.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Analyse the need for responsible AI.
  CO2: Comprehend Data ethics in AI applications.
  CO3: Identify the aspects of responsible AI such as fairness, accountability and bias.
  CO4: Enforce safety and explainability in AI modules.
  CO5: Preserve the privacy of AI application.
  CO6: Develop responsible AI modules for given practical problems.

Module No.	Detailed Content	Hrs (45)	CO
1	**Foundation:** Responsibility: avoiding the blame game, Being Accountable, Eliminating Toxicity, Thinking Fairly, protecting human privacy, Ensuring safety, AI Principles: Fairness, Bias and Human centered values, Transparency and Trust, Social benefits, Privacy, safety and security	**07**	**CO1**
2	**Data Ethics:** Ownership, Data control, Transparency, Accountability, Equality, Privacy, Intention, Outcomes, Data Curation, Best Practices: Annotation and Filtering, Rater Diversity, Synthetic Data, Data Cards and Datasheet, Model cards, Tools, Alternative Datasets	**08**	**CO2**
3	**Fairness**: Defining Fairness: Equalised Odds, Equal Opportunity, Demographic Parity, Fairness through awareness, Fairness through unawareness, Treatment equality, Test fairness, counterfactual fairness, Fairness in Relational domains, Conditional Statistical Parity, Types of Bias: Historical Bias, Representation Bias, Measurement bias, aggregation Bias, Evaluation Bias, Deployment Bias, Measuring Fairness, Fairness tools.	**08**	**CO3**
4	**Safety and Explainability:** AI Safety, Autonomous learning with Benign Intent, Human Controlled with benign Intent, Human controlled with malicious Intent, AI harms, Mitigations and technical considerations, Benchmarking, Human in the Loop, Explainable AI(XAI), Implementing Explainable AI, Dimensions of AI accountability	**08**	**CO4**
5	**Privacy and Robustness:** Privacy Preserving AI, Federated Learning, Differential Privacy, Robust ML models, Sampling, Bias mitigation, Data Balancing, Data Augmentation, Cross Validation, Ensembles, Transfer learning, Adversarial learning, Making ML models Robust	**07**	**CO5**
6	**Ethical Considerations:** AI Ethics, Ethical Considerations for Large Language Models, Ethical Considerations for Generative Models, Ethical Considerations for Computer Vision, Case Study on Responsible AI: Recommendation systems, Medical diagnosis, Hiring/ Education, Computer Vision, Legal domain, Health care domain, Education domain and few other domains.	**07**	**CO6**

Text books:

1. T. Duke, *Building Responsible AI Algorithms: A Framework for Transparency, Fairness, Safety, Privacy, and Robustness*, Ist Edition, Apress publication, NY, USA, 2023.
2. C. Molnar, *Interpretable Machine Learning*, Ist Edition, Lulu, 2019.

Reference books:

1. A. Manure, S. Bengani, and S. Saravanan, *Introduction to Responsible AI: Implement Ethical AI Using Python*, Ist Edition, Apress publication, NY, USA, 2023.
2. V. Dignum, *Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way*, Ist Edition, Springer Nature, 2019.

<table>
<tr><td colspan="2">D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI</td><td colspan="7">B.TECH IN
COMPUTER SCIENCE & ENGINEERING
(ARTIFICIAL INTELLIGENCE &
MACHINE LEARNING)</td><td colspan="3">THIRD YEAR
SEM- VI</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="4">Teaching Scheme
(Contact Hours 45)</td><td colspan="5">Credits Assigned</td></tr>
<tr><td>Lecture</td><td colspan="2">Practical</td><td>Tutorial</td><td>Lecture</td><td>Tutorial</td><td colspan="2">Prac/Oral</td><td>Total</td></tr>
<tr><td rowspan="5">231CAUEC23</td><td rowspan="5">Big Data Analytics</td><td>03</td><td colspan="2">--</td><td>--</td><td>03</td><td>--</td><td colspan="2">--</td><td>03</td></tr>
<tr><td colspan="10">Evaluation Scheme</td></tr>
<tr><td colspan="7">Theory</td><td rowspan="2">Term work</td><td rowspan="2">Prac./ Oral</td><td rowspan="2">Total</td></tr>
<tr><td colspan="3">Internal Assessment</td><td rowspan="2">Mid Sem. Exam</td><td rowspan="2">End Sem. Exam</td><td rowspan="2">Exam duration (Hrs)</td></tr>
<tr><td>Test 1</td><td>Test 2</td><td>Avg.</td><td>20</td><td>20</td><td>20</td><td>20</td><td>60</td><td>2</td><td>--</td><td>--</td><td>100</td></tr>
</table>

- **Prerequisite:**
  231CAUCC31 Database Management Systems

- **Course Objectives:**
  - To introduce the fundamental concepts, characteristics, and challenges of Big Data along with Hadoop ecosystem and its components.
  - To explain data processing models like MapReduce and familiarize learners with Big Data algorithms and NoSQL database systems.
  - To provide knowledge of stream data processing techniques, approximate algorithms, and similarity and clustering methods for Big Data analytics.
  - To expose learners to various Big Data applications such as recommendation systems, collaborative filtering, and social network analysis.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Understand Big Data concepts, business applications, and the Hadoop ecosystem.
  CO2: Examine how MapReduce framework model operates and apply algorithms for Big Data processing.
  CO3: Explore different NoSQL systems and how it handles big data.
  CO4: Analyze various stream processing techniques, filtering methods, and approximation algorithms.
  CO5: Apply frequent itemset mining, similarity measures and clustering methods to handle large datasets.
  CO6: Evaluate algorithms of big data analytics in various applications like recommender systems, social media applications.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Big Data and Hadoop Ecosystem** Big Data characteristics and Types of Big Data , Traditional vs. Big Data business approach , Case Study of Big Data Solutions , Core Hadoop Components; Hadoop Ecosystem	5	CO1
2	**MapReduce Framework and Algorithms for Big Data Processing** MapReduce: The Map Tasks, Grouping by Key, The Reduce Tasks, Combiners, Details of MapReduce Execution, Coping with Node Failures. Algorithms Using MapReduce: Matrix-Vector Multiplication by MapReduce, Relational-Algebra Operations, Computing Selections by MapReduce, Computing Projections by MapReduce, Union, Intersection, and Difference by MapReduce, Hadoop Limitations.	9	CO2
3	**NoSQL** Introduction to NoSQL, NoSQL Business Drivers NoSQL Data Architecture Patterns: Key-value stores, Graph stores, Column family (Bigtable)stores, Document stores, Variations of NoSQL architectural patterns, NoSQL Case Study, NoSQL solution for big data, Understanding the types of big data problems; Analyzing big data with a shared-nothing architecture.	7	CO3
4	**Mining Data Streams** A Data-Stream- Management System, Examples of Stream Sources, Stream Queries, Issues in Stream Processing. Sampling Data techniques in a Stream Filtering Streams: Bloom Filter with Analysis. Counting Distinct Elements in a Stream: Flajolet-Martin Algorithm, Counting Ones in a Window: The Cost of Exact Counts, The Datar-Gionis-Indyk-Motwani Algorithm, Query Answering in the DGIM Algorithm, Decaying Windows.	8	CO4
5	**Handling Larger Datasets** Frequent Itemset Mining : Algorithm of Park, Chen, and Yu (PCY) Finding Similar Items: Applications of Near-Neighbor Search, Jaccard Similarity of Sets, Similarity of Documents Distance Measures: Definition of a Distance Measure, Euclidean Distances, Jaccard Distance, Cosine Distance, Edit Distance, Hamming Distance. Clustering: CURE Algorithm.	8	CO5
6	**Big Data Models to Social Networking** A Model for Recommendation Systems, Content- Based Recommendations, Collaborative Filtering , Case Study: Similar Product Recommendation Social Networks as Graphs, Clustering of Social- Network Graphs, Direct Discovery of Communities in a social graph.	8	CO6

Text books:

1. Rajaraman, A. and Ullman, J.D., 2014. *Mining of Massive Datasets*. IInd ed. Cambridge: Cambridge University Press.
2. Holmes, A., 2014. *Hadoop in Practice*. IInd ed. Shelter Island: Manning Publications; Dreamtech Press.

Reference books:

1. Meh White, T., 2015. *Hadoop: The Definitive Guide*. IVth ed. Sebastopol: O'Reilly Media.
2. Han, J., Kamber, M. and Pei, J., 2012. *Data Mining: Concepts and Techniques*. IIIrd ed. Amsterdam: Elsevier/Morgan Kaufmann.
3. Sharda, R., Delen, D. and Turban, E., 2018. *Business Intelligence, Analytics, and Data Science: A Managerial Perspective*. IVth ed. Harlow: Pearson.
4. McCreary, D. and Kelly, A., 2013. Making Sense of NoSQL: A guide for managers and the rest of us. Shelter Island: Manning Publications.

D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI	**B.TECH IN COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING)**	**THIRD YEAR SEM- VI**

Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEC24	Quantum AI	03	--	--	03	--	--	03

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  - 231CAUCC41 Artificial Intelligence
  - 231CAUCC52 Machine Learning

- **Course Objectives:**
  - Understand the basics of quantum computation
  - Learn quantum information theory and linear algebra concepts used in QML.
  - Explore the foundations and motivation for quantum machine learning.
  - Study quantum models for classification, clustering, and neural networks in AI.

- **Course Outcomes:** After completion of this course, learners will be able to:
  - CO1: Understand basics concepts of quantum computing and circuit models.
  - CO2: Apply quantum information and linear algebra in QML contexts.
  - CO3: Compare QML paradigms and contrast them with classical ML.
  - CO4: Analyze quantum classification models like QSVM and QNN.
  - CO5: Demonstrate quantum clustering and dimensionality reduction methods.
  - CO6: Evaluate QNNs and their real-world applications in AI.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Quantum Computation:** Origin of Quantum Computing, Quantum bits, Bloch sphere representation of a qubit, multiple qubits, quantum superposition and entanglement, Quantum Gates and circuits	07	CO1
2	**Quantum Information Theory and Linear Algebra Refresher:** Dirac Notation (Ket/Bra), Hilbert Space and Quantum States, Tensor Products and Multi-Qubit Systems, Quantum Measurement and Density Matrices, Classical vs. Quantum Information, Basics of Linear Algebra used in QML: Eigenvalues, Eigenvectors, Hermitian operators	06	CO2
3	**Foundations of Quantum Machine Learning:** Classical vs. quantum computation; complexity classes relevant to QML. Limitations of classical ML and motivation for QML. Overview of supervised vs. unsupervised learning. Programming Models for Quantum Computing. Introduction to quantum machine learning paradigms—data encoding, quantum-assisted learning, hybrid models, and quantum-native models. Grover's algorithm and its role in QML.	08	CO3
4	**Quantum Supervised Learning and Classification:** Review of Classical Background. Quantum Classification Models: Quantum Nearest Neighbors (QNN),Quantum Support Vector Machines (QSVM), SVM with Grover's Search,SVM with Exponential Speedup. Kernel Functions and Quantum Feature Maps, Loss Functions in Quantum Learning, Generalization Performance and Computational Complexity (Q vs. Classical).	08	CO4
5	**Quantum Unsupervised Learning and Dimensionality Reduction:** Review of Classical Concept. Quantum Versions: Quantum PCA (qPCA), Quantum Manifold Embedding, Quantum K-Means & K-Medians, Quantum Hierarchical Clustering, Quantum Random Access Memory (QRAM), Computational Complexity in Quantum Clustering.	08	CO5
6	**Quantum Neural Networks and Real-World Use Cases:** Quantum Perceptron, Quantum Neural Networks (QNNs), Quantum Associative Memory. Physical Realizations of Quantum Neural Models Case Studies in QAI: Quantum-enhanced Drug Discovery (classification of molecular structures), Fraud Detection using Quantum Clustering, Portfolio Optimization with QSVM and QNN. Future Directions and Industry Applications	08	CO6

Text books:

1. M. A. Nielsen, *Quantum Computation and Quantum Information*, Cambridge University Press. 2002.
2. P. Kaye, R. Laflamme, and M. Mosca, *An introduction to quantum computing*, OUP

Oxford, 2006.
3. P. Wittek, *Quantum Machine Learning: What Quantum Computing Means To Data Mining*, Elsevier Insights, 2014.

Reference books:

1. N. S. Yanofsky and Mirco A. Mannucci. *Quantum computing for computer scientists*. Cambridge University Press, 2008.
2. D. McMahon, *Quantum Computing Explained John Wiley & Sons*, Inc., Publication, NJ< USA, 2008.
3. N. D. Mermin, *Quantum computer science: an introduction*. Cambridge University Press, 2007.
4. M. Schuld and Francesco Petruccione, *Machine Learning with Quantum Computers*, Second Edition, Springer, 2021.
5. M. Schuld and F. Petruccione, *Supervised Learning with Quantum Computers*, Springer, 2018.

D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI		**B.TECH IN COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING)**							**THIRD YEAR SEM- VI**
Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEC31	Natural Language Processing	03	--	--	03	--	--	03	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231FYUCC22 Data Structure
  2413CAC3T3 Statistical Methods

- **Course Objectives:**
  - Understand the fundamentals of Natural Language Processing and its significance in real-world applications.
  - Apply basic NLP algorithms for tasks such as text preprocessing, tokenization, and part-of-speech tagging.
  - Explain and analyze the key language levels—morphology, syntax, semantics, and pragmatics—used in natural language understanding.
  - Design and implement NLP-based applications using appropriate models and techniques.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Understand the capabilities and limitations of natural language processing.
  CO2: Model linguistic phenomena with formal grammars.
  CO3: Design and implement algorithms for syntax analysis.
  CO4: Use the mathematical and linguistic foundations for semantic analysis.
  CO5: Identify and resolve references between sentences from the discourse.
  CO6: Apply NLP techniques to design real world applications.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Natural Language Processing:** Why NLP? Generic NLP system, Stages of NLP, Challenges in NLP, Applications of NLP.	05	CO1
2	**Morphological Analysis:** Morphology, Types of morphology, Role of Regular expression and finite automata in morphology, Stemming vs Lemmatization, Porter stemmer algorithm, Language model- Ngram.	08	CO2
3	**Syntactic Analysis:** Part-Of-Speech tagging (POS), POS tag ambiguity, Rule based tagging, Stochastic POS tagging, Parsing with CFG, Sequence labelling: Hidden Markov Model (HMM).	09	CO3
4	**Semantic Analysis:** Lexical Semantics, Attachment for fragment of English language, Semantic relations among lexemes & their senses, Wordnet, Word Sense Disambiguation- Dictionary based, Machine Learning based approach.	08	CO4
5	**Pragmatics and Discourse:** Introduction to Pragmatics and Discourse analysis, reference phenomenon, reference resolution problem, Syntactic & semantic constraints on co reference, Lappin and Leass' Algorithm for Pronoun Resolution.	08	CO5
6	**Application:** Machine translation, Information retrieval, Information extraction (Question-Answer System), Summarization, Sentiment Analysis, Named Entity Recognition.	07	CO6

Textbooks:

1. D. Jurafsky and J. H. Martin, *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*, IInd Edition, Pearson Education, India 2023.
2. C. D. Manning and H. Schütze, *Foundations of Statistical Natural Language Processing*, Ist Edition. MIT Press, Cambridge, MA, USA, 1999.

Reference books:

1. T. Siddiqui and U. S. Tiwary, *Natural Language Processing and Information Retrieval*, Ist Edition, Oxford University Press, 2008.
2. D. M. Bikel and I. Zitouni, *Multilingual Natural Language Processing Applications*, Ist Edition, Pearson Education, India, 2013.
3. Y. Goldberg and G. Hirst, *Neural Network Methods in Natural Language Processing*, IInd Edition, Morgan & Claypool Publishers, 2017.
4. N. J. le Roux and S. Lubbe, *A Step-by-Step Tutorial: An Introduction into R Application and Programming*, IInd Edition , CRAN-R Project, 2013.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**					
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total		
231CAUEC32	Computational Intelligence	03	--	--	03	--	--	03		
		Evaluation Scheme								
		Theory								
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.						
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231CAUCC52 Machine learning
  231CAUCC53 Neural Networks & Fuzzy Systems

- **Course Objectives:**
  - To understand the various steps followed in solving Prediction problems and to choose the right prediction method to develop a model.
  - To learn the modern heuristic optimization techniques and apply them for problem solving.
  - To learn MLP BP Neural Network and deep learning methods and to design and develop ANN Classification systems.
  - To learn the underlying theory of building hybrid systems for better decision making.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Understand key concepts of neural networks, evolutionary algorithms, swarm intelligence, and fuzzy systems.
  CO2: Analyze neural network types, training methods, and performance metrics.
  CO3: Explore evolutionary algorithms for solving optimization problems.
  CO4: Understand swarm intelligence techniques for search and optimization.
  CO5: Design fuzzy and hybrid intelligent systems.
  CO6: Apply CI techniques to pattern recognition, optimization, and model tuning.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Computational Intelligence:** Introduction to artificial neural network, evolutionary computation, swarm intelligence, fuzzy systems	04	CO1
2	**Review of Neural Networks:** NN types, supervised learning rules (gradient descent optimization, scaled conjugate gradient, leap frog optimization, particle swarm optimization), ensemble of NN, radial basis function networks, hopfield networks, convolution neural networks, performance measures	09	CO2
3	**Evolutionary Computation:** Introduction (metaheuristics, biological, simulated), elements of evolutionary (solution encoding, fitness, genetic operators), genetic algorithm, evolutionary strategies, differential evolution, cultural evolution, multi-objective strategies	09	CO3
4	**Swarm Intelligence:** Introduction (known and unknown environments), particle swarm optimization (PSO), ant colony optimization, reptile search algorithm, multi-objective and many-objective PSO.	09	CO4
5	**Fuzzy Systems and Hybrid Models:** Review of fuzzy set theory, fuzzy logic controllers, fuzzy inference systems (Mamdani, Sugeno models), neuro-fuzzy systems, evolutionary-fuzzy and swarm-fuzzy hybrid approaches	07	CO5
6	**Applications of Computational Intelligence:** Pattern recognition and classification, optimization in engineering design, feature selection, hyper-parameter tuning	07	CO6

Text books:

1. R. Kruse, C. Borgelt, C. Braune, S. Mostaghim, M. Steinbrecher, F. Klawonn, and C. Moewes, *Computational intelligence*, IIIrd Edition, Springer Verlag, Switzerland, 2011.
2. A. P. Engelbrecht, *Computational intelligence*: *An introduction*, Ist Edition, John Wiley & Sons, Sussex, England, 2007.

Reference books:

1. J. S. R. Jang, *Neuro-fuzzy and soft computing*, IInd Edition, PHI Learning Pvt. Ltd, Delhi, India, 2003.
2. I. Goodfellow, Y. Bengio, and A. Courville, *Deep learning*, Ist Edition, MIT Press, Cambridge, MA, USA, 2016.
3. X. S. Yang, *Nature-inspired algorithms and applied optimization*, Ist Edition, Cham: Springer, Switzerland, 2018.
4. H. Faris, S., Mirjalili, I., Aljarah, M., Mafarja, and A. A. Heidari, *Nature-inspired optimizers: theories, literature reviews and applications* (*Studies in Computational Intelligence Book 811*), Ist Edition, Springer Science Review, 2020.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**					
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total		
231CAUEC33	Cognitive Computing	03	--	--	03	--	--	03		
		Evaluation Scheme								
		Theory						Term work	Prac./ Oral	Total
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
		Test 1	Test 2	Avg.						
		20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231ADUCC41 Artificial Intelligence
  231CAUCC52 Machine learning

- **Course Objectives:**
  - Explore the fundamentals and modes of cognitive computing.
  - Understand human mental states and cognitive processes.
  - Study the cognitive models using cognitive computing concepts.
  - Learn about cognitive tools, software, and their real-world applications

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Understand various cognitive Computing techniques and systems.
  CO2: Explore Cognitive Functioning and different mental states and emotions
  CO3: Develop the cognitive models using cognitive computing concepts.
  CO4: Design Cognitive system using Machine learning technique.
  CO5: Develop optimization technique used to measure cognitive capabilities in humans and machines.
  CO6: Apply Cognitive computing Technique for real-time applications.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction to Cognitive Computing:** Cognitive Computing, Cognitive Psychology, The Architecture of the Mind, The Nature of Cognitive Psychology, Cognitive architecture, Cognitive processes, The Cognitive Modelling Paradigms, Declarative / Logic based Computational cognitive modelling	**06**	**CO1**
2	**Cognitive Functioning and Metal States:** Understand memory (short-term, long-term, episodic, and procedural memory), reasoning, and learning processes in humans. Exploration of mental states: Belief, desire, intention (BDI) models in AI; Emotion-aware systems: Role of emotions in decision-making, emotion recognition; Human-robot interaction (HRI): Integrating emotion, intention, and cognitive states in robots and machines.	**09**	**CO2**
3	**Connectionist Models:** Bayesian models. Introduction to Knowledge-Based AI – Human Cognition on AI – Cognitive Architectures, Application domains of cognitive computing	**08**	**CO3**
4	**Machine Learning Techniques:** Intelligent Decision making, Fuzzy Cognitive Maps, learning algorithms: Nonlinear Hebbian Learning**,** Natural Language Processing, Representing Knowledge, Taxonomies and Ontologies, N-Gram models, Application	**09**	**CO4**
5	**Cognitive Optimization:** Genetic and Meta heuristic optimization: Particle Swarm Optimization (PSO), Ant optimization, Particle filtering, Genetic optimization, Techniques used to measure cognitive capabilities in humans and machines	**07**	**CO5**
6	**Applications of Cognitive Computing:** Cognitive Systems in health care, Cognitive Assistant for visually impaired – AI for cancer detection, Predictive Analytics, Text Analytics, Image Analytics, Speech Analytics – IBM Watson – Introduction to IBM's Power AI Platform - Introduction to Google's TensorFlow Development Environment	**06**	**CO6**

Text books:

1. R. High and T. Bakshi, *Cognitive Computing with IBM Watson: Build smart applications using artificial intelligence as a service*, Ist Edition, Packt Publishing Ltd, Birmingham, UK, 2019.
2. P. Kashyap, *Machine learning for decision makers: Cognitive computing fundamentals for better decision making*, Apress, Bangalore, India, 2017.

Reference books:

1. A. Masood and A. Hashmi, *Cognitive Computing Recipes: Artificial Intelligence Solutions Using Microsoft Cognitive Services and TensorFlow*, Apress, NY, USA, 2019.
2. S. Raschka and V. Mirjalili, *Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2*, IIIrd Edition, Packt publishing Ltd, Birmingham, UK, 2019.
3. J. Hurwitz, M. Kaufman, A. Bowles, A. Nugent, J. G. Kobielus, and M. D. Kowolenko, *Cognitive computing and big data analytics*, vol. 2 G88, Wiley, Indianapolis, 2015.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 45)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEC34	Cloud for AI	03	--	--	03	--	--	03

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
20	20	20	20	60	2	--	--	100

- **Prerequisite:**
  231CAUCC52 Machine Learning

- **Course Objectives:**
  - Understand Cloud Computing and AI Integration:
  - Develop Practical Skills in Cloud-Based AI
  - Apply ML Principles to Cloud AI
  - Analyze and Optimize AI Solutions

- **Course Outcomes:** After completion of this course, learners will be able to:
  - CO1: Explain the principles of cloud computing, including the SPI framework, service models, deployment models.
  - CO2: Deploy and configure cloud compute, storage, and database services ensuring secure configurations for AI workloads.
  - CO3: Implement a machine learning pipeline using Cloud services.
  - CO4: Develop AI solutions for forecasting and computer vision using managed services
  - CO5: Design, implement, and evaluate a conversational AI bot for appointment cloud NLP services.
  - CO6: Evaluate and optimize cloud-based AI models for language processing.

Module No.	Detailed Content	Hrs (45)	CO
1	**Introduction:** Cloud computing, SPI framework, traditional vs cloud computing model, cloud service and deployment model, key drivers to adopting the cloud, impact on users, AI services on cloud platform	06	CO1
2	**Cloud services: Compute, Storage and Database:** Compute services: Virtual machines (AWS EC2, Azure VMs, Google Compute Engine), serverless computing (AWS Lambda, Azure Functions) Storage services: Block, file, and object storage (e.g., AWS S3, Azure Blob Storage) Database services: Relational (e.g., AWS RDS, Azure SQL) and NoSQL (e.g., AWS DynamoDB, MongoDB Atlas) Role of compute, storage, and database service in AI	10	CO2
3	**Implementing a ML Pipeline:** Business problems solved with ML, ML pipeline process, ML Tools: Amazon SageMaker, creating a Jupyter notebook instance. Defining a business problem for ML, extracting, transforming, and loading data, securing your data, feature engineering, training a model using Amazon SageMaker, hosting the model, evaluating the accuracy of the model, hyper parameter and model tuning	08	CO3
4	**Forecasting & Image-video analysis:** Overview, processing time series data, Amazon Forecast, creating a forecast model, simulating models, use cases for computer vision, managed ML services for image and video analysis, use cases for the Amazon recognition service	07	CO4
5	**Natural Language Processing:** Overview, NLP managed services : Amazon Transcribe, Amazon Polly, Amazon Lex, case study : creating a bot to schedule appointments	07	CO5
6	**Working with Languages:** Overview, issues with languages, challenges, language use cases, language detection tool: Amazon comprehend, language translation tool: Amazon translate	07	CO6

Text books:

1. A. Mishra, *Machine Learning in the AWS Cloud*, Sybex, 2019.
2. P. Rangarajan and D. Bounds, *Cloud Native AI and Machine Learning on AWS*, BPB Publications, 2023.

Reference books:

1. N. Gift, *Pragmatic AI -An Introduction to Cloud-Based Machine Learning*, Pearson Education, 2018.
2. P. Elger and E. Shanaghy, *AI as a Service Serverless Machine Learning with AWS*, Manning, 2020.

3. P. Gupta and N. K. Sehgal, *Introduction to Machine Learning in the Cloud with Python Concepts and Practices*, Springer International Publishing, 2021.
4. M. Lanham, *Practical AI on the Google Cloud Platform*, O'Reilly Media, Incorporated, 2020.

D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI	**B.TECH IN COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING)**	**THIRD YEAR SEM- VI**

Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUMM61	Design of Experiments	02	--	--	02	--	--	02

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
15	15	15	10	50	2	--	--	75

- **Prerequisite:**
  2313FYB1T1 Engineering Mathematics-I

- **Course Objectives:**
  - Demonstrate an understanding of the fundamental principles of Design of Experiments (DOE)
  - Apply systematic methodologies and analytical tools to design
  - Design and analyze both full and fractional factorial experiments
  - Evaluate the application of DOE in service industries and Six Sigma initiatives

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Explain the foundational concepts of Design of Experiments (DOE)
  CO2: Analyze interaction effects in experiments and apply a systematic methodology for DOE
  CO3: Construct and evaluate screening designs and full factorial designs
  CO4: Design and interpret two-level fractional factorial experiments
  CO5: Apply DOE principles to service industry contexts and demonstrate the benefits and adaptations of DOE in non-manufacturing environments.
  CO6: Illustrate experimental design support to data-driven decision-making in process improvement.

Module No.	Detailed Content	Hrs (30)	CO
1	**Fundamentals of Design of Experiments** Introduction to Industrial experimentation, Statistical thinking and its role within Design of Experiments(DOE), Basic principles of DOE, Degree of freedom, selection of quality characteristics for industrial experiments	04	CO1
2	**Key Interactions and Systematic Methodology** Introduction, alternative method for calculating the Two Order interaction effect, Synergistic interaction versus antagonistic interaction, Barriers in successful application of DOE, practical methodology for DOE, Analytical tools for DOE, Model building for predicting response function, confidence interval for the mean response, Statistical, Technical and sociological dimensions of DOE	06	CO2
3	**Screening Designs** Geometric and non-geometric Plackett-Burman design, Full factorial design : example of a 2^2 full factorial design, example of a 2^3 full factorial design, example of a 2^4 full factorial design,	04	CO3
4	**Fractional Factorial Designs** Construction of Half Factorial Fractional Designs, Example of a $2^{(7-4)}$ Factorial Design, Application of 2 Level fractional Factorial Design	04	CO4
5	**Design of Experiments and its application in service Industry** Useful and practical tips for making industrial experiments successful, Introduction to service industry, fundamental difference between the manufacturing and service organizations, DOE in the service Industry: fundamental challenges, Benefits of DOE in service/ Non-Manufacturing Industry, Case Studies	06	CO5
6	**Design of Experiments and its role within Six Sigma** Six sigma, quality improvement initiatives of the past, six sigma methodology (DMAIC methodology) DOE and its role within Six Sigma	06	CO6

Text books:

1. J. Antony, *Design of Experiments for Engineers and Scientists*, IIIrd edition, Elsevier, 2003.
2. R. A. Fisher, *Design of experiments*, Hafner Publishing, 1971.

Reference books:

1. K. Krishnaiah and P. Shahabudeen, *Applied Design of Experiments and Taguchi Methods*, PHI, India, 2011.
2. D. C. Montgomery, *Design and Analysis of Experiments*, John Wiley & sons, 2005.
3. P. Goos and B. Jones , *Optimal Design of Experiments: A Case Study Approach*, Wiley, 2011.
4. R. E. Kirk , *Experimental Design: Procedures for the Behavioral Sciences*, Sage, 2013.

<table>
<tr><td colspan="2">D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI</td><td colspan="6">B.TECH IN
COMPUTER SCIENCE & ENGINEERING
(ARTIFICIAL INTELLIGENCE &
MACHINE LEARNING)</td><td>THIRD YEAR
SEM- VI</td></tr>
<tr><td rowspan="2">Course Code</td><td rowspan="2">Course Name</td><td colspan="5">Teaching Scheme (Contact Hours 26)</td><td colspan="2">Credits Assigned</td></tr>
<tr><td colspan="3">Theory</td><td colspan="2">Practical</td><td>Practical</td><td>Total</td></tr>
<tr><td rowspan="5">231CAUVS61</td><td rowspan="5">Skill-Based Lab : MLOps</td><td colspan="3">--</td><td colspan="2">04</td><td>02</td><td>02</td></tr>
<tr><td colspan="7">Practical Evaluation Scheme (Marks)</td></tr>
<tr><td colspan="3">Internal Assessment (30)</td><td colspan="2">End Semester Examination (30)</td><td colspan="2" rowspan="2">Total</td></tr>
<tr><td>Continuous Evaluation</td><td>Lab Quiz</td><td>Attendance</td><td>Practical Performance</td><td>Oral</td></tr>
<tr><td>20</td><td>05</td><td>05</td><td>20</td><td>10</td><td>60</td></tr>
</table>

- **Prerequisite:**
  231CAQCL52 Machine Learning Lab

- **Course Objectives:**
  - Understand MLOps principles to build scalable, reproducible, and maintainable machine learning systems.
  - Apply version control, environment management, and CI/CD practices to streamline ML workflows.
  - Develop, containerize, and deploy ML models using APIs and modern deployment tools.
  - Implement end-to-end pipelines with experiment tracking, model versioning, and cloud-based deployment on platforms like Azure ML and Google Vertex AI.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Set up reproducible and version-controlled ML environments.
  CO2: Implement experiment tracking and manage model/data versions.
  CO3: Develop and serve ML models as APIs using containerization tools.
  CO4: Track and manage ML experiments and models using MLflow and DVC for reproducible workflows
  CO5: Deploy ML models to cloud environments (Azure/GCP) using containers.
  CO6: Design and execute a complete MLOps pipeline using industry tools.

Module No.	Detailed Content	Hrs (26)	CO
1	**Introduction to MLOps:** CI/CD Pipelines, MLOps lifecycle, Versioning & Reproducibility-Reproducibility using Git, Environment management with Conda, Basics of version control,Structure ML projects for maintainability	04	CO1
2	**CI/CD Automation with GitHub Actions & Jenkins for ML Pipelines:** Continuous integration and deployment in MLOps workflows, Automate ML pipelines using GitHub Actions and Jenkins for model training and testing	05	CO2
3	**API Development and Serving Models with FastAPI + Docker:** Build RESTful APIs for ML models using FastAPI and containerize them with Docker, Deploying inference services locally and online	04	CO3
4	**Experiment Tracking and Model Management with MLflow & DVC:** Tools for tracking experiments (MLflow) and managing datasets/models (DVC), Explore logging parameters, metrics, and visualizing model runs across versions.	03	CO4
5	**Cloud Deployment using Azure ML & Google Vertex AI:** Deploying ML models to production on cloud platforms - Model registry, endpoints, container deployment, and comparison of Azure ML and GCP Vertex AI features.	05	CO5
6	**End-to-End Cloud-Integrated MLOps Pipeline:** Workflow from versioning and model development to cloud-based CI/CD deployment	05	CO6

List of Experiments

Sr. No.	Title of the experiment	CO
1	Set up ML project structure with Git & conda : Reproducibility; Azure ML workspace for integration; Coding: Google Colab, Jupyter Notebook Offline Setup : Git init, Conda, requirements Online Setup : Azure ML Environments setup https://learn.microsoft.com/en-us/azure/machine-learning/how-to-use-environments	CO1
2	Automate training/testing using GitHub Actions : Pipeline integration using Azure ML GitHub Action Offline Setup : GitHub Desktop + YAML CI on localhost Online Setup : GitHub Actions to Azure ML pipeline https://github.com/Azure/actions	CO1, CO2
3	Jenkins job to automate model training : Trigger training on GCP Vertex AI, Modeling: Scikit-learn, TensorFlow/Keras, PyTorch (optional) Offline Setup : Jenkins local job + shell/python script Online Setup : Vertex AI via Jenkins job trigger https://cloud.google.com/vertex-ai/docs/pipelines	CO2
4	FastAPI-based ML inference API : Deploy API to Azure App Services/Cloud Run, Compare Flask with FastAPI, Deployment: Flask, FastAPI, Docker (Kubernetes) Offline Setup : FastAPI via Uvicorn on localhost Online Setup : Deploy to Azure App Services, Render, or GCP Cloud Run https://fastapi.tiangolo.com/deployment/	CO3
5	Containerize API with Docker : Push to Azure Container Registry or GCP Artifact Registry, Kubernetes for scalability Offline Setup : Docker Desktop, build/test locally Online Setup : Push to Azure/GCP registries, Deploy the container to Kubernetes clusters using AKS (Azure Kubernetes Service) or GKE (Google Kubernetes Engine) https://learn.microsoft.com/en-us/azure/container-registry/	CO3, CO5
6	Track experiments using MLflow : Integrate MLflow with Azure ML or run standalone, Tracking: MLflow (local/Colab) Offline Setup : MLflow UI on localhost Online Setup : Azure ML integration via MLflow URI • https://learn.microsoft.com/en-us/azure/machine-learning/concept-mlflow?view=azureml-api-2 • https://learn.microsoft.com/en-us/azure/machine-learning/overview-what-is-azure-machine-learning?view=azureml-api-2	CO4
7	Manage data/models using DVC : Use DVC with Git and cloud remote (Azure Blob, GCP) Offline Setup : DVC init, local file tracking Online Setup : Remote setup on Azure/GCP https://dvc.org/doc/start	CO4
8	Evaluate and register models with MLflow Registry : Use Azure ML Model Registry, Data Storage: SQLite, Pandas Offline Setup : Local SQLite-based MLflow Registry	CO4, CO5

	Online Setup : Azure ML Registry/Vertex AI Registry https://mlflow.org/docs/latest/model-registry.html	
9	Deploy model as REST API on Heroku/DockerHub + Render : Cloud deployment with CI Offline Setup : Docker + Heroku CLI for localhost deployment Online Setup : Azure Online Endpoints or GCP AI Endpoints https://learn.microsoft.com/en-us/azure/machine-learning/how-to-deploy-online-endpoints	CO3, CO5
10	End-to-End MLOps Pipeline : CI/CD, versioning, model deployment, Compare pipelines generated via TPOT/AutoSklearn vs. traditional ML, Visualization: Matplotlib, Seaborn Offline Setup : All tools integrated locally Online Setup : Azure ML or GCP full CI/CD cloud setup https://www.presidio.com/a-practical-guide-to-implementing-mlops-part-1/	CO6

Text Books :

1. M. Treveil and A. Subramanian, *Introducing MLOps: How to Scale Machine Learning in the Enterprise*, Ist Edition, O'Reilly, USA, 2020.
2. N. Gift, *Practical MLOps: How to Get Ready for Production Models*, Ist Edition, O'Reilly, USA, 2021.
3. Gupta, P., & Bagchi, A., MLOps: Machine Learning Operations, Ist Edition, Springer, Switzerland, 2024.

Reference Links:

1. Google Cloud- MLOps: Continuous delivery and automation pipelines,2023 https://cloud.google.com/architecture/mlops-continuous-delivery-and-automation-pipelines-in-machine-learning
2. Microsoft Azure- Model management and deployment concepts, 2023 https://learn.microsoft.com/en-us/azure/machine-learning/concept-model-management-and-deployment
3. Databricks-MLflow documentation, 2023 https://mlflow.org/docs/latest/index.html
4. Data Version Control Documentation, 2023 https://dvc.org/doc
5. FastAPI Documentation, 2023 https://fastapi.tiangolo.com/
6. Get Started with Docker, 2023 https://docs.docker.com/get-started/
7. Jenkins.io , 2023 https://www.jenkins.io/doc/
8. Azure ML GitHub Actions https://github.com/Azure/actions

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**					
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total		
231CAUCL61	Advanced Machine Learning Lab	--	02	--	--	--	01	01		
		Evaluation Scheme								
		Theory						Term work	Prac./ Oral	Total
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
		Test 1	Test 2	Avg.						
		--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - To conceptualize the Linear model.
  - To understand graphical directed and undirected models.
  - To understand Mixture models and EM algorithm.
  - To become familiar with Markov Chain and HMM with inference model.

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

  CO1: Identify the generalized linear model and exponential family.
  CO2: Choose an appropriate graphical model for a problem.
  CO3: Identify Mixture model and understand EM algorithm.
  CO4: Apply Markov and Hidden Markov Model in real world problem solution.
  CO5: Analyze and apply the undirected graphical model.
  CO6: Understand and apply Monte Carlo Inference system.

List of Experiments:

Sr. No.	Title of the experiment	CO
1	Build generalized Linear Model.	CO1
2	Develop a regression model for count data using Poisson Regression, a member of the exponential family.	CO1
3	Implement directed Graphical model	CO2
4	Implement Factor Analysis for any real world problem.	CO3
5	Implement EM algorithm for given problem.	CO3
6	Develop a HMM for real world problem (example weather forecasting)	CO4
7	Implement the Viterbi algorithm to find the most likely sequence of hidden states (POS tags) given a sequence of observations (words).	CO4
8	Implement undirected graphical model.	CO5
9	Implement a linear-chain CRF for a sequence labeling task, such as named-entity recognition (NER).	CO5
10	Build Monte Carlo Inference system.	CO6
11	Lab Project	

References:

1. M. P. Deisenroth, A. A. Faisal, C. S. Ong, *Mathematics for Machine Learning*, Ist Edition, Cambridge University Press, MA, USA, 2020.
2. Practical Machine Learning with Tensorflow (nptel.ac.in/courses/106106213).
3. Stanford CS229: Machine Learning Course (www.youtube.com/watch?v=jGwO_UgTS7I).
4. I. Goodfellow, Y. Bengio, and A. Courville, *Deep learning*, Ist Edition, MIT Press, Cambridge, MA, USA, 2016.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUCL62	Deep Learning Lab	--	02	--	--	--	01	01	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		--	--	--	--	--	--	25	25	50

- **Prerequisite:**
  - 231CAQCL52 Machine Learning Lab
  - 231CAUCL53 Neural Networks & Fuzzy Systems Lab

- **Course Objectives:**
  - To introduce the fundamental concepts, architectures, and need for Deep Learning in solving real-world problems.
  - To provide a comprehensive understanding of various deep learning algorithms such as CNN, RNN, LSTM, Autoencoders, and GANs.
  - To impart practical skills in implementing, training, and evaluating deep learning models using Python libraries like TensorFlow and Keras.
  - To enable students to apply deep learning solutions for tasks such as classification, prediction, detection, and generation across various domains.

- **Course Outcomes:** After completion of this course, learners will be able to:
  - CO1: Distinguish between AI, ML, and DL, and identify different types of learning methods and their appropriate use cases.
  - CO2: Evaluate train deep neural networks using appropriate architectures, activation functions, and optimization techniques.
  - CO3: Analyze and evaluate deep learning models using regularization methods to prevent overfitting and improve generalization.
  - CO4: Design and implement Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) for vision and sequence-based tasks.
  - CO5: Apply autoencoders and other deep generative models for dimensionality reduction, denoising, and feature learning.
  - CO6: Apply CNN and RNN techniques to solve different applications.

List of Experiments:

Sr. No.	Title of the experiment	CO
1	Explore Python libraries (NumPy, Pandas, TensorFlow, Keras, PyTorch) for deep learning.	CO1
2	Implement Perceptron algorithm to simulate basic logic gates.	CO2
3	Implement a backpropagation algorithm to train a DNN with at least 2 hidden layers.	CO2
4	Design and implement a CNN model for image classification.	CO3
5	Design and implement an RNN for classification of temporal data.	CO4
6	Write a program for Time-Series Forecasting with the LSTM Model.	CO4
7	Design the architecture and implement the auto encoder model for image compression.	CO5
8	Write a program to detect Dog image using YOLO Algorithm.	CO6
9	Write a program for character recognition using RNN and compare with CNN.	CO4
10	Write a program to develop a GAN for Generating MNIST Handwritten Digits.	CO6
11	Lab Project	

References:

1. N. K. Manaswi, *Deep Learning with Applications Using Python: Chatbots and Face. Object, and Speech Recognition with TensorFlow and Keras*, Ist Edition, Apress Berkeley, CA, 2018.
2. T. Mitchell, *Machine learning*, Ist Edition, McGraw Hill, NY, USA 1997.
3. J. Patterson and A. Gibson, *Deep learning: A practitioner's approach*, Ist Edition , O'Reilly Media, 2017.
4. Scikit-learn Documentation (scikit-learn.org/stable/user_guide.html)
5. TensorFlow Tutorials (www.tensorflow.org/tutorials)
6. Keras Documentation (keras.io)
7. PyTorch Tutorials (pytorch.org/tutorials)

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEL21	Data Visualization and Analytics Lab	--	02	--	--	--	01	01

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - Develop skills to both design and critique visualizations.
  - Understand the components involved in visualization design.
  - Understanding the relationship between data visualization and analytics.
  - To understand the basic techniques for descriptive data analytics.
  - Comprehend data analytics techniques.

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

CO1: Understand the fundamentals of data visualization and its importance.
CO2: Apply visualization tools / techniques for various data analysis tasks.
CO3: Explore D3.js for interactive data visualizations in web browser.
CO4: Apply and analyze basic descriptive data analytics techniques.
CO5: Explore various Time Series analysis techniques.
CO6: Apply visual principles and best practices for designing dashboards.

List of Experiments:

Sr. No.	Title of the Experiment	CO
1	Create bar charts, line graphs, and pie charts using a sample dataset in Tableau/PowerBI applying effective visualization principles.	CO1
2	Build histograms, box plots, heatmaps, and scatter plot matrices using Tableau/Power BI and compare how multivariate data is represented.	CO2
3	Use a time-series dataset to create line charts with smoothing techniques, handle missing data, and visualize trends over time.	CO2
4	Design custom visualizations and interactive dashboards in Power BI using filters, transformations, and visual enhancements.	CO3
5	Set up D3.js, load a dataset, and explore selection binding by creating basic visualizations (bar charts, line charts) using D3's data loading functions.	CO3
6	Implementation of multivariate linear regression using Python.	CO4
7	Implementation of Logistic Regression on a given dataset.	CO4
8	Develop a time series model on a given dataset and evaluate its accuracy.	CO5
9	Design and implement a comprehensive dashboard integrating visualizations such as bar charts, scatter plots, heat maps, sparklines, for business intelligence, considering design best practices and visual perception principles.	CO6
10	Develop a real-time data visualization for a given problem and dataset using Tableau/ Power BI/ Python based tool.	CO6

References:

1. E. R. Tufte, *The Visual Display of Quantitative Information*, IInd Edition, Graphics Press, Warwickshire, UK,1995.
2. B. Fry, *Visualizing Data*, IInd Edition, O'Reilly Media, California, USA, 2009.
3. S. Acharya and S. Chellappan, *Big Data and Analytics*, 2nd Edition, Wiley Publication, NJ, USA.
4. T. Mitchell, *Machine Learning*, 3rd Edition, McGraw Hill, NY, USA, 1997.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEL22	Responsible AI Lab	--	02	--	--	--	01	01	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac/ Oral	Total
		Test 1	Test 2	Avg.					
		--	--	--	--	--	--	25	25	50

- **Prerequisite:**
  231CAUCL41 Artificial Intelligence Lab
  231CAUCL51 Machine Learning Lab

- **Course Objectives:**
  - Distinguish the fundamental concepts of responsible AI, including ethics, governance, compliance, and regulatory considerations.
  - Explain the interaction of values with technical and socio-technical systems and trade-offs in AI-based decision making.
  - Deploy and use AI systems in a way that adheres to ethical principles, emerging regulatory frameworks, compliance and accountability.
  - Apply ethical and responsible practices, develop strategies to identify and mitigate irresponsible AI design, development, and deployment.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Analyze the need for responsible AI.
  CO2: Comprehend Data ethics in AI applications.
  CO3: Identify the aspects of responsible AI such as fairness, accountability and bias.
  CO4: Enforce safety and explainability in AI modules.
  CO5: Preserve the privacy of AI application.
  CO6: Develop responsible AI modules for given practical problems.

List of Experiments:

Sr. No.	Title of the Experiment	CO
1	Recent case study of ethical initiatives in healthcare/ autonomous vehicles / defense.	CO1
2	Train a simple classification model and analyze fairness metrics like Equalized Odds or Demographic Parity.	CO1
3	Generate synthetic datasets using Python libraries like Faker or SDV and evaluate their ethical implications.	CO2
4	Implement bias detection techniques on a dataset and visualize bias impact using fairness tools.	CO2
5	Apply fairness metrics to a trained model and visualize disparities across different demographic groups.	CO3
6	Implement bias mitigation strategies like re-weighting, adversarial debiasing, or data augmentation.	CO3
7	Use SHAP or LIME to interpret model predictions and improve transparency.	CO4
8	Identification on optimization in AI affecting ethics.	CO4
9	Demonstrate federated learning technique to preserve data privacy.	CO5
10	Case Study on AI Ethics in Healthcare – Evaluate AI-driven medical diagnosis models for ethical implications and fairness.	CO6
11	Lab Project (Compulsory)	

References:

1. T. Duke, *Building Responsible AI Algorithms: A Framework for Transparency, Fairness, Safety, Privacy, and Robustness*, Ist Edition, Apress publication, NY, USA, 2023.
2. C. Molnar, *Interpretable Machine Learning*, Ist Edition, Lulu, 2019.
3. A. Manure, S. Bengani, and S. Saravanan, *Introduction to Responsible AI: Implement Ethical AI Using Python*, Ist Edition, Apress publication, NY, USA, 2023.
4. V. Dignum, *Responsible Artificial Intelligence: How to Develop and Use AI in a Responsible Way*, Ist Edition, Springer Nature, 2019.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEL23	Big Data Analytics Lab	--	02	--	--	--	01	01	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		--	--	--	--	--	--	25	25	50

Course Objectives:

- To provide an overview of an exciting growing field of big data analytics.
- To introduce programming skills to build simple solutions using big data technologies such as MapReduce and scripting for NoSQL, and the ability to write parallel algorithms for multiprocessor execution.
- To teach the fundamental techniques and principles in achieving big data analytics with scalability and streaming capability.
- To enable students to have skills that will help them to solve complex real-world problems in for decision support.

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

CO1: Identify the key issues in big data management and explore the Hadoop framework.

CO2: Develop problem solving and critical thinking skills in fundamental enable techniques like Hadoop & MapReduce.

CO3: Construct structured and unstructured data by using NoSQL commands.

CO4: Implement fundamental enabling techniques and scalable algorithms for data stream mining.

CO5: Apply scientific computing algorithms for finding frequent itemset and similar items.

CO6: Analyze the algorithms of big data analytics in various applications like recommender systems, social media applications.

List of Experiments:

Sr. No.	Title of the Experiment	CO
1	Install Hadoop Framework, it's components and study the Hadoop Ecosystem.	CO1
2	Write a program to implement word count program using MapReduce.	CO2
3	Implement Matrix multiplication using MapReduce.	CO2
4	Install and configure MongoDB/ Cassandra/ HBase/ Hypertable to execute NoSQL commands.	CO3
5	Implement CRUD operations using any NOSQL Datastore.	CO3
6	Implement Bloom Filter using any programming language	CO4
7	Perform Streaming Data Analysis using flume for data capture, PYSpark / HIVE for data analysis of twitter data, chat data, weblog analysis etc.	CO4
8	Implement Park, Chen, and Yu (PCY) algorithm to find frequent itemset.	CO5
9	Implement any one Clustering algorithm (K-Means/CURE) using Map-Reduce.	CO5
10	Implementation of Real Time Recommendation Systems	CO6

References:

1. Meh White, T., 2015. *Hadoop: The Definitive Guide*. IVth ed. Sebastopol: O'Reilly Media.
2. Han, J., Kamber, M. and Pei, J., 2012. *Data Mining: Concepts and Techniques*. IIIrd ed. Amsterdam: Elsevier/Morgan Kaufmann.
3. Sharda, R., Delen, D. and Turban, E., 2018. *Business Intelligence, Analytics, and Data Science: A Managerial Perspective*. IVth ed. Harlow: Pearson.
4. McCreary, D. and Kelly, A., 2013. Making Sense of NoSQL: A guide for managers and the rest of us. Shelter Island: Manning Publications.
5. Meh White, T., 2015. *Hadoop: The Definitive Guide*. IVth ed. Sebastopol: O'Reilly Media.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEC24	Quantum AI Lab	--	02	--	--	--	01	01

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - To introduce students to quantum programming tools and platforms used in quantum AI.
  - To develop skills in simulating quantum circuits, gates, and qubit operations.
  - To implement quantum machine learning models such as QSVM, QKNN, and QNN using available simulators.
  - To apply quantum AI tools for solving real-world problems and analyzing their performance.

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

  CO1: Explore and compare quantum computing tools for AI applications.

  CO2: Simulate quantum circuits and analyze gate-level operations using various platforms.

  CO3: Represent and manipulate quantum states using measurement and linear algebra concepts.

  CO4: Encode classical data into quantum systems and apply quantum feature maps.

  CO5: Implement and evaluate quantum ML models like QSVM, QKNN, and quantum classifiers.

  CO6: Design a use case-based project using QML tools and present a working prototype.

List of Experiments:

Sr. No.	Title of the experiments	CO
1	Explore and compare quantum programming tools (Qiskit, PennyLane, Cirq) and set up environments.	CO1
2	Simulate basic quantum circuits and visualize qubit states using any selected tool.	CO2
3	Implement common quantum gates and circuits using different platforms and analyze state transitions.	CO2
4	Represent multi-qubit systems, apply measurements, and simulate quantum state behavior.	CO3
5	Perform classical-to-quantum data encoding using quantum feature maps.	CO4
6	Implement Quantum Support Vector Machine (QSVM) using quantum machine learning libraries.	CO5
7	Build and train a variational quantum classifier (VQC) or hybrid model.	CO5
8	Simulate quantum clustering or dimensionality reduction (qPCA or qKMeans).	CO5
9	Design and implement a Quantum Neural Network (QNN) for a domain-specific application.	CO6
10	Develop and present a mini-project or prototype using a selected quantum tool (e.g., Qiskit, PennyLane).	CO6

References:

1. S. Pattanayak *Quantum Machine Learning with Python*, Ist Edition, Apress (Springer imprint), Berkeley, CA, 2021.
2. Qiskit | IBM Quantum Computing
3. Qiskit Machine Learning 0.8.2
4. https://pennylane.ai/
5. https://sci-hub.se/downloads/2021-08-12/76/ganguly2021.pdf
6. https://github.com/quantum-machine-learning/Hands-On-Quantum-Machine-Learning-With-Python-Vol-1

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
2413CAD6L5	Natural Language Processing Lab	--	02	--	--	--	01	01	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - Understand the fundamentals of Natural Language Processing and its significance in real-world applications.
  - Apply basic NLP algorithms for tasks such as text preprocessing, tokenization, and part-of-speech tagging.
  - Explain and analyze the key language levels—morphology, syntax, semantics, and pragmatics—used in natural language understanding.
  - Design and implement NLP-based applications using appropriate models and techniques.

- **Course Outcomes:** After completion of this course, learners will be able to:
  - CO1: Understand the capabilities and limitations of natural language processing.
  - CO2: Model linguistic phenomena with formal grammars.
  - CO3: Design and implement algorithms for syntax analysis.
  - CO4: Use the mathematical and linguistic foundations for semantic analysis.
  - CO5: Identify and resolve references between sentences from the discourse.
  - CO6: Apply NLP techniques to design real world applications.

List of Experiments:

Sr. No.	Title of the Experiment	CO
1	Study of R tool and basic commands to access text data.	CO1
2	Apply various text preprocessing techniques for any given text: (Tokenization and Filtration & Script Validation).	CO2
3	Apply various other text preprocessing techniques for any given text. (Stop Word Removal, Lemmatization /Stemming).	CO2
4	Implement N-Gram (Bigram) model.	CO2
5	Implement Rule-based Part-of-Speech (POS) Tagging.	CO3
6	Implement chunking to extract Noun Phrases.	CO3
7	Identify semantic relationships between the words from given text (Use WordNet Dictionary).	CO4
8	Write a Python program to find synonyms and antonyms of the word "active" using WordNet.	CO4
9	Case study on discourse analysis.	CO5
10	Perform Name Entity Recognition (NER) on given text.	CO6
11	Lab Project: One real life Natural Language application to be implemented (Use standard Datasets available on the web).	

References:

1. N. J. le Roux and S. Lubbe, *A Step-by-Step Tutorial: An Introduction into R Application and Programming*, IInd Edition, CRAN-R Project, 2013.
2. D. Jurafsky and J. H. Martin, *Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition*, IInd Edition, Pearson Education, India 2023.
3. https://onlinecourses.nptel.ac.in/noc23_cs45/preview.
4. Brian Neil Levine, *An Introduction to R Programming*, Ist Edition, Spring Fall 2013.
5. https://nlp-iiith.vlabs.ac.in/

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEL32	Computational Intelligence Lab	--	02	--	--	--	01	01

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
--	--	--	--	--	--	25	25	50

- **Prerequisite:**
  231CAUCL52 Machine learning Lab
  231CAUCL53 Neural Networks & Fuzzy Systems Lab

- **Course Objectives:**
  - To understand the various steps followed in solving Prediction problems and to choose the right prediction method to develop a model.
  - To learn the modern heuristic optimization techniques and apply them for problem solving.
  - To learn MLP BP Neural Network and deep learning methods and to design and develop ANN Classification systems.
  - To learn the underlying theory of building hybrid systems for better decision making.

- **Course Outcomes:** After completion of this course, learners will be able to:
  CO1: Understand the basics of various CI techniques and to find a suitable classifier based on the given problem.
  CO2: Design and implement feedforward and deep neural networks for classification tasks using solar and medical datasets.
  CO3: Apply genetic algorithms for feature selection in solar radiation prediction.
  CO4: Implement and analyze swarm intelligence methods like PSO and ACO for optimization and prediction tasks.
  CO5: Develop fuzzy and neuro-fuzzy models for weather prediction and energy forecasting.
  CO6: Analyze real-world applications through case studies on computational intelligence techniques.

List of Experiments:

Sr. No.	Title of the experiment	CO
1	To design and implement feedforward backpropagation to classify solar radiation prediction using single-layer perceptron.	CO2
2	To design and implement feedforward backpropagation to classify solar radiation prediction using multi-layer perceptron.	CO2
3	To analyze solar radiation prediction dataset to optimize features using Genetic Algorithm.	CO3
4	To analyze solar radiation prediction dataset to optimize features using Particle Swarm Optimization.	CO4
5	To implement ant colony optimization for pathfinding in a simulated environment.	CO4
6	To design and implement convolution neural network to classify medical images to detect respiratory diseases.	CO2
7	To implement transfer learning to classify medical images to detect respiratory diseases.	CO2
8	To design and implement PSO-MLP model for solar radiation prediction.	CO4
9	To implement Mamdani and Sugeno Fuzzy Inference Systems for weather prediction.	CO5
10	To develop a Neuro-Fuzzy model for load forecasting in energy systems.	CO5
11	Case study on computational intelligence applications.	CO6
12	Lab project	

References:

1. I. Goodfellow, Y. Bengio, and A. Courville, *Deep learning*, Ist Edition, MIT Press, Cambridge, MA, USA, 2016.
2. Mealpy documentation (mealpy.readthedocs.io/en/latest/)
3. X. S. Yang, *Nature-inspired algorithms and applied optimization*, Ist Edition, Cham: Springer, Switzerland, 2018.
4. H. Faris, S., Mirjalili, I., Aljarah, M., Mafarja, and A. A. Heidari, *Nature-inspired optimizers: theories, literature reviews and applications* (*Studies in Computational Intelligence Book 811*), Ist Edition, Springer Science Review, 2020.

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Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**				
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total	
231CAUEL33	Cognitive Computing Lab	--	02	--	--	--	01	01	
		Evaluation Scheme							
		Theory							
		Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)	Term work	Prac./ Oral	Total
		Test 1	Test 2	Avg.					
		--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - Explore the fundamentals and modes of cognitive computing.
  - Understand human mental states and cognitive processes.
  - Study the cognitive models using cognitive computing concepts.
  - Learn about cognitive tools, software, and their real-world applications

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

  CO1: Understand various cognitive computing techniques and systems.

  CO2: Explore cognitive functioning and different mental states and emotions

  CO3: Develop the cognitive models using cognitive computing concepts.

  CO4: Design cognitive system using machine learning technique.

  CO5: Develop optimization technique used to measure cognitive capabilities in humans and machines.

  CO6: Apply cognitive computing technique for real-time applications.

List of Experiments:

Sr. No.	Title of the experiment	CO
1	To simulate and analyze human memory recall performance using a cognitive model implemented in Python.	CO1
2	Design Cognitive computing system to demonstrate v functionality for sentiment analysis	CO2
3	Implement Decision making System to integrate emotion, intention, and cognitive states in robots and machines.	CO2
4	Implement Human Cognition on AI for pattern recognition	CO3
5	Develop Cognitive Computing System using Fuzzy Cognitive Maps for any application	CO4
6	Implement a computer vision model to recognize and classify objects in real time.	CO4
7	Develop a NLP base system for text recognition	CO4
8	Design and Optimize Cognitive System for Real time application.	CO5
9	To develop a cognitive system that uses predictive analytics to forecast outcomes based on learned patterns and human-like reasoning.	CO6
10	Develop a practical application that applies cognitive computing concepts in a real-world domain (e.g., education, healthcare, smart assistants, or smart environments).	CO4, CO5, CO6

References:

1. R. High and T. Bakshi, *Cognitive Computing with IBM Watson: Build smart applications using artificial intelligence as a service*, Ist Edition, Packt Publishing Ltd, Birmingham, UK, 2019.
2. P. Kashyap, *Machine learning for decision makers: Cognitive computing fundamentals for better decision making*, Apress, Bangalore, India, 2017.
3. A. Masood and A. Hashmi, *Cognitive Computing Recipes: Artificial Intelligence Solutions Using Microsoft Cognitive Services and TensorFlow*, Apress, NY, USA, 2019.
4. S. Raschka and V. Mirjalili, *Python machine learning: Machine learning and deep learning with Python, scikit-learn, and TensorFlow 2*, IIIrd Edition, Packt publishing Ltd, Birmingham, UK, 2019.
5. J. Hurwitz, M. Kaufman, A. Bowles, A. Nugent, J. G. Kobielus, and M. D. Kowolenko, *Cognitive computing and big data analytics*, vol. 2 G88, Wiley, Indianapolis, 2015.

D Y PATIL DEEMED TO BE UNIVERSITY — RAMRAO ADIK — INSTITUTE OF TECHNOLOGY NAVI MUMBAI	**B.TECH IN COMPUTER SCIENCE & ENGINEERING (ARTIFICIAL INTELLIGENCE & MACHINE LEARNING)**	**THIRD YEAR SEM- VI**

Course Code	**Course Name**	**Teaching Scheme (Contact Hours 30)**			**Credits Assigned**			
		Lecture	Practical	Tutorial	Lecture	Tutorial	Prac/Oral	Total
231CAUEL34	Cloud for AI Lab	--	02	--	--	--	01	01

Evaluation Scheme								
Theory						Term work	Prac./ Oral	Total
Internal Assessment			Mid Sem. Exam	End Sem. Exam	Exam duration (Hrs)			
Test 1	Test 2	Avg.						
--	--	--	--	--	--	25	25	50

- **Course Objectives:**
  - Understand Cloud Computing and AI Integration:
  - Develop Practical Skills in Cloud-Based AI
  - Apply Cybersecurity Principles to Cloud AI:
  - Analyze and Optimize AI Solutions

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

CO1: Explain the principles of cloud computing, including the SPI framework, service models , deployment models.

CO2: Deploy and configure cloud compute, storage, and database services ensuring secure configurations for AI workloads.

CO3: Implement a machine learning pipeline using Cloud services.

CO4: Develop AI solutions for forecasting and computer vision using managed services.

CO5: Design, implement, and evaluate a conversational AI bot for appointment cloud NLP services.

CO6: Evaluate and optimize cloud-based AI models for language processing.

List of Experiments:

Sr. No.	Title of the Experiment	CO
1	Lab: Compute and Storage Service Task 1: Launch an EC2 instance in AWS cloud with storage block Task 2: Deploy static website in S3 bucket and use of version control	CO2
2	Lab: Build Your DB Server and Interact With Your DB Using an App	CO2
3	Lab: Exploring Amazon SageMaker • Launch an Amazon SageMaker notebook instance. • Launch a Jupyter notebook. • Run code in a notebook. • Download data from an external source. • Upload and download a Jupyter notebook to their local machine	CO3
4	Lab: Visualizing Data using pandas • Explore and display statistics by using pandas • Use charts to explore data characteristics	
5	Lab: Encoding Categorical Variables • Encode ordinal categorical data • Encode non-ordinal categorical data	CO3
6	Lab: Training a Machine Learning Model • Split data into training, validation and test datasets • Train a XGBoost model in Amazon SageMaker	CO3
7	Lab: Machine Learning Pipeline with Amazon SageMaker • Deploy a machine learning model • Use the test dataset to perform a batch transformation with the model	CO3
8	Lab: Generating model performance metrics • Use the test data to generate predictions • Generate a confusion matrix from the results • Generate performance metrics for the model	CO3
9	Lab: Tuning Hyperparameters • Use Amazon SageMaker to create a hyperparameter training job • Tune an XGBoost model by using Amazon SageMaker • Test the tuned model by using performance metrics	CO4
10	Lab: Create a chatbot using Amazon Lex • Create and configure test a bot by using Amazon Lex • Create a Lambda function and configure it to work with Amazon Lex • Create a static webpage in Amazon S3 to host the bot • Interact with the bot in the webpage	CO5
11	Lab: Text Processing • Task 1: Extracting Text from webpages and Images • Task 2: Processing Text • Task 3: Encoding and Vectorizing Text	CO5

12	Lab: Implementing a multi-lingual solution	CO6
13	Lab Project	

References:

1. N. Gift, *Pragmatic AI -An Introduction to Cloud-Based Machine Learning*, Pearson Education, 2018.
2. P. Elger and E. Shanaghy, *AI as a Service Serverless Machine Learning with AWS*, Manning, 2020.
3. P. Gupta and N. K. Sehgal, *Introduction to Machine Learning in the Cloud with Python Concepts and Practices*, Springer International Publishing, 2021.
4. M. Lanham, *Practical AI on the Google Cloud Platform*, O'Reilly Media, Incorporated, 2020.
5. https://aws.amazon.com/?refid=3d19ba5e-9c59-491b-aa3f-18a3a907973a
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