

Course Name: Machine Learning

Course Code: DS-501

(Semester- V)

Course Broad Category: Professional Elective (PE)

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1. Course Prerequisite: Basic concept of Probability and Statistics.

2. Course Learning Objectives:

- To understand the basic concepts, types, and challenges of Machine Learning.
- To learn fundamental concept learning and probabilistic learning techniques.
- To apply supervised learning algorithms for classification and regression tasks.
- To understand the working principles of Artificial Neural Networks and deep learning basics.
- To analyse unsupervised learning techniques for clustering and association rule mining.
- To gain introductory knowledge of genetic algorithms and reinforcement learning.

3. Teaching methodology and evaluation system for the course:

Teaching methodology -

Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. Mid-Term Exam (20 Marks)- Summative Assessment (CIA-1)
- B. Internal Assessment (20 Marks)- Formative Continuous Assessment [Continuous Assessment 1(CIA-2)]
- C. End-Semester Exam (60 Marks)- Summative Assessment.

4. Course Content:

Course Name: Machine Learning

Course Code: DS-501

Hours per Week: 3L: 0T: 0P

Credits: 3

Module	Topics	
1.	Introduction: what is Machine Learning; Human learning and Machine learning; Well-posed learning problem; Types of Machine Learning: Supervised, Unsupervised, and Reinforcement learning; Applications, Issues, and tools of Machine Learning	3L
2.	Concept Learning: Inductive learning hypothesis, general to specific ordering of hypothesis; FIND-S algorithm; Version space, candidate elimination algorithm; Inductive bias.	4L

3.	Supervised learning: Classification- k-Nearest Neighbor, Decision Tree, Random Forest, Support vector machine. Regression- Simple and Multiple linear regression. Bayesian Learning, Naïve Bayes Classifier, Optimal Classifier.	16L
4.	Artificial Neural Networks: Biological neuron and artificial neuron, How ANN works, Parallel distributed model of ANN; Activation functions; Perceptron, McCulloch-Pits model, ADALINE network model; Architecture of ANN- single layer feed forward, multi-layer feed forward, competitive network, recurrent network; Backpropagation algorithm; Basic concept of deep learning.	5L
5.	Unsupervised learning: Different clustering techniques- Partitioning methods (Kmeans, k-medoid, etc. clustering techniques), Hierarchical methods (Agglomerative and Divisive techniques: MIN, MAX, Group average, Ward's etc. methods), and Density-based method (DBSCAN).	6L
6.	Unsupervised learning: Rule mining and Association analysis- different terminology (itemset, support count, support, association rule, confidence, etc.); Association rule mining techniques; Market-Basket analysis; Apriori principle, Apriori algorithm for frequent itemset generation, Rule generation for apriori algorithm.	6L
8	Genetic Algorithm based Learning.	2L
9	Reinforcement Learning: Basic concept, Model based learning, Temporal difference-based Learning	3L
		45L

5. Text Book:

1. Machine Learning by Tom Mitchell [Mc. Graw-Hill].
2. Machine Learning by S. Dutt, S. Chandramouli, and /A. K. Das [Pearson, 2019].
3. Applied machine Learning by M. Gopal [Mc. Graw-Hill, 2018].
4. NPTEL Course materials.

6. Reference Books:

Introduction to Machine Learning by Ethem Alpaydin [MIT Press].

7. COURSE OUTCOMES (COs)

On completion of the course students will be able to

Course Outcomes	Details	Action Verb	Knowledge Level
DS-501.CO1	Understanding of the basic concepts, fundamental issues and challenges of machine learning.	Remember, Understand	Level 2- Understand, Level 4- Analyze
DS-501.CO2	Comprehend the principle and techniques of supervised learning.	Understand, Apply	Level 2- Understand, Level 3-Apply
DS-501.CO3	Explain the basic concepts and techniques of unsupervised learning.	Explain, Apply	Level 2- Understand, Level 3-Apply
DS-501.CO4	Understanding of the basic concepts and challenges of reinforced learning.	Understand, Analyze	Level 2- Understand,

			Level 4- Analyze
DS-501.CO5	Ability to apply the concepts of machine learning in different domains.	Apply, Evaluate	Level 3-Apply, Level 5- Evaluate

7. Mapping of course outcomes to module / course content

Course Outcome (CO)	Mapped Course Content / Module Topics
CO1	Introduction to Machine Learning – definition, human vs machine learning, well-posed learning problem, types of ML, applications, issues, and tools
CO2	Concept Learning – inductive learning hypothesis, FIND-S, version space, candidate elimination, inductive bias, Bayesian Learning – Naïve Bayes, optimal classifier , Supervised Learning – k-NN, Decision Tree, Random Forest, SVM, Linear Regression
CO3	Clustering techniques – K-means, K-medoid, hierarchical methods, DBSCAN ,Association rule mining – terminology, Apriori algorithm, rule generation, market-basket analysis
CO4	Reinforcement Learning – basic concepts, model-based learning, temporal difference learning
CO5	Supervised learning applications, Artificial Neural Networks and deep learning basics, Unsupervised learning applications, Genetic Algorithm based learning

8. Mapping of the Course outcomes to Program Outcomes (PO) (1 = Low, 2 = Moderate, 3 = High)

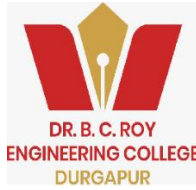
Mapping of COs with POs and PSOs (Course Articulation Matrix):

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	1	0	0	0	0	0	0	0	0	2
CO2	3	3	2	1	0	0	0	0	0	0	0	2
CO3	3	3	2	2	0	0	0	0	0	0	0	2
CO4	2	2	1	2	0	0	0	0	0	0	0	2
CO5	3	3	3	2	2	1	0	0	1	1	1	3

9. Mapping to Program Specific Outcome (PSO)

CO / PSO	PSO1	PSO2	PSO3	PSO4
CO1	3	2	1	1
CO2	3	3	2	1
CO3	3	2	2	1
CO4	2	2	1	1
CO5	3	3	3	2

Reference: NIT Durgapur, IIT ISM Dhanbad,



Course Name: Design and Analysis of Algorithms

Course Code: DS-502

(Semester- V)

Course Broad Category: Program Core (PC)

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1. Course Prerequisite: Discrete Mathematics, Data Structure and algorithm

2. Course Learning Objectives:

- i. To develop a solid understanding of fundamental algorithm design techniques such as divide and conquer, dynamic programming, greedy methods, backtracking, and graph algorithms.
- ii. To acquire the ability to analyze algorithms in terms of time and space complexity, use asymptotic notations, and evaluate algorithmic efficiency and correctness.
- iii. To gain practical skills in formulating and implementing efficient algorithms for real-world problems and selecting appropriate strategies based on performance trade-offs.

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. Mid-Term Exam (40 Marks)- Formative Assessment [Continuous Assessment 1 (CIA-1)]
- B. Internal Assessment (40 Marks)- Formative Assessment [Continuous Assessment 2(CIA-2)]
- C. End-Semester Exam (60 Marks)- Summative Assessment.

4. Course Content:

Course Name: Design and Analysis of Algorithms

Course Code: DS-502

Hours per Week: 3L: 0T: 0P

Credits: 3

Module	Topics	45L
1.	Introduction and basic concepts: Algorithm, Asymptotic notations (big-Oh, big Omega, Theta, small-oh) and their significance, introduction to RAM model of computation, complexity (Time Complexity, Space Complexity)	5L

Module	Topics	45L
	analysis of algorithms, worst case and average case. Solving Recurrences – Substitution method, Recurrence tree method and Master Method, Finding maximum and minimum of n numbers, Finding the second largest of n numbers and exact number of comparisons	
2.	Lower bound: Lower bound for a problem Computing the lower bound for sorting (comparison based sorting) and computing the lower bound for computing convex hull using the lower bound for sorting problem.	2L
3.	Amortized complexity analysis: aggregate analysis, accounting method and potential method. Examples: storage allocation problem, binary counting problem and heap sort.	4L
4.	Using Induction to Design algorithm: The celebrity problem, Majority Finding problem	2L
5.	Divide and conquer Problem: Multiplication of two n -bit integers, Strassen's Matrix Multiplication problem, Closest pair of points, linear time median finding algorithm, Convex hull and its computation..	6L
6.	Greedy Algorithms: Greedy algorithms and their correctness proof: Interval scheduling problem, Interval partitioning problem, Minimizing the Lateness of Intervals problem, Fractional Knapsack Problem	5L
7.	Dynamic Programming: Longest Common Subsequence, Matrix Chain Multiplication, 0-1 Knapsack Problem, longest common subsequence problem, Backtracking Method, Branch and Bound Method.	6L
8.	Graph Algorithms: Depth First Search, Breadth First Search, Dijkstra's Single Source Shortest Path algorithm; All pair shortest path algorithm, Minimum Spanning Tree (Prim's and Kruskal's algorithm)..	4L
9.	Randomized Algorithm: Las Vegas and Monte Carlo; Randomized Quick Sort algorithm and Min Cut problem.	3L
10.	Reducibility between problems and NP-completeness: Different class of Problems (P, NP, NP-Hard, NP-Complete), Discussion of different NP-complete problems like satisfiability, clique, vertex cover, independent set, Hamiltonian cycle, set cover, dominating set problem.	6L
11.	Approximation Algorithm: Approximation ratio for maximization problem and minimization problem, Constant ratio approximation algorithms for metric travelling salesperson problem (TSP) and vertex cover problem, $\log n$ ratio approximation algorithm for Set Cover problem.	2L

5.

Text Book:

1. . T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, *Introduction to Algorithms*, Prentice Hall India.
2. J. Kleinberg, Eva Tardo, *Algorithm Design*, Pearson Education (Indian edition).
3. S. Dasgupta, C. Papadimitriou, U. Vazirani, *Algorithms*, Tata McGraw-Hill.

Reference Books:

1. M.T. Goodrich, R. Tamassia, *Algorithm Design: Foundations, Analysis, and Internet*

Examples, Second Edition, Wiley, 2006.

2. NPTEL's lectures on Design and Analysis of Algorithms (<https://nptel.ac.in/courses/106101060>), IIT Bombay (Prof. Abhiram G Ranade, Prof. Ajit A Diwan, Prof. Sundar Viswanathan).

6. COURSE OUTCOMES (COs)

On completion of the course students will be able to

Course Outcomes	Details	Action Verb	Knowledge Level
DS-502.CO1	Understand and analyse the asymptotic behaviour of algorithms, recurrence relations, lower bounds, amortized complexity, and computational models.	Understand	Level 4 – Analyse
DS-502.CO2	Design efficient algorithms using induction, divide-and-conquer, greedy strategies, dynamic programming, backtracking, and branch-and-bound.	Design	Level 6 – Create
DS-502.CO3	Apply appropriate graph algorithms to real-world network problems and evaluate correctness and complexity.	Apply	Level 3 – Apply
DS-502.CO4	Distinguish between deterministic and randomized algorithms, analyse their performance, and apply randomized techniques.	Analyze/Understand	Level 4 – Analyse
DS-502.CO5	Explain reducibility, NP-hardness, NP-completeness, and classify computational problems accordingly.	Explain/Classify	Level 2 – Understand
DS-502.CO6	Apply approximation strategies to NP-hard problems and evaluate approximation ratios.	Evaluate	Level 5 – Evaluate

7. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	1	1	1	1	1
2	3	1	1	1	1	1
3	3	1	1	1	1	1
4	1	3	1	1	1	1
5	1	3	1	1	1	1
6	1	3	1	1	1	1
7	1	3	1	1	1	1
8	1	1	3	1	1	1
9	1	1	1	3	1	1
10	1	1	1	1	3	1
11	1	1	1	1	1	3

Scale interpretation:

1 = Very Low, 2 = Low, 3 = Moderate, 4 = High, 5 = Very High/Direct

8. Mapping of the Course outcomes to Program Outcomes (PO)

Mapping of COs with POs and PSOs (Course Articulation Matrix):

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	3	2	2	1	1	0	0	2	1	1
CO2	3	3	3	2	3	1	1	0	1	2	1	1
CO3	3	3	3	2	3	1	1	0	1	2	1	1
CO4	3	2	3	2	2	1	1	0	0	2	1	1
CO5	3	2	3	1	1	1	2	1	0	2	1	1
CO6	3	3	3	2	2	1	1	0	1	2	1	1

9. Mapping to Program Specific Outcome (PSO)

	PSO1	PSO2	PSO3	PSO4
CO1	3	2	2	1
CO2	3	3	3	1
CO3	3	3	3	1
CO4	2	3	3	1
CO5	2	2	2	1

Reference: NIT Trichy



Course Name: Machine Learning Algorithms for IoT Systems

Course Code: DS-503

(Semester- V)

Course Broad Category: Program Core (PC)

1. Course Pre-requisite: Basic Programming (Python/C), Probability & Statistics, Fundamentals of IoT

2. Course Learning Objectives:

This course aims to provide a comprehensive understanding of IoT data characteristics and machine learning foundations from an IoT systems perspective, with emphasis on data acquisition, preprocessing, and intelligent learning techniques for analyzing sensor-driven data, enabling scalable, secure, and efficient decision-making in real-world IoT applications.

Upon successful completion of the course, students will be able to:

- Understand the fundamental concepts of the Internet of Things, including architecture, components, and communication models.
- Explore various IoT devices, sensors, and embedded systems used for data acquisition, transmission, and control.
- Gain knowledge of cloud, edge, and fog computing frameworks for efficient IoT data management and processing.
- Apply suitable machine learning algorithms to analyze and interpret IoT-generated data for predictive and intelligent applications
- Integrate IoT with ML techniques to design smart systems for real-world domains such as healthcare, industry, transportation, and agriculture

3. Teaching methodology and evaluation system for the course:

Teaching methodology -

Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. Mid-Term Exam (20 Marks)- Summative Assessment (CIA-1)
- B. Internal Assessment (20 Marks)- Formative Continuous Assessment [Continuous Assessment 1(CIA-2)]
- C. End-Semester Exam (60 Marks)- Summative Assessment.

4. Course Content:

Course Name: Machine learning algorithms for IOT systems (DS-503)

Course Code: DS-503

Hours per Week: 3L: 0T: 0P

Credits: 3

Module	Topics	
1.	Introduction to IoT Data and Machine Learning Foundations: Overview of Internet of Things (IoT): Architecture, Components, and Applications Characteristics of IoT Data: Volume, Velocity, Variety, Veracity Motivation for Machine Learning in IoT Systems Types of Machine Learning: Supervised, Unsupervised, Semi-supervised, Reinforcement Learning (IoT-centric examples)Difference between Traditional Data Analytics and ML-based IoT	6L

	Intelligence Overview of ML workflow for IoT: Data collection → preprocessing → training → deployment	
2.	IoT Data Acquisition, Preprocessing, and Feature Engineering: IoT Sensors and Data Sources (Environmental, Industrial, Wearable, Smart Home) Time-Series Nature of IoT Data. Data Collection Protocols: MQTT, HTTP, CoAP (conceptual overview) Data Cleaning: Noise removal, missing value handling, outlier detection Data Normalization and Scaling Techniques Feature Extraction from Sensor Data (Statistical, Temporal, Frequency-domain features) Dimensionality Reduction: PCA and its relevance in IoT Dataset preparation for ML models (train-test split, cross-validation)	8L
3.	Supervised Learning Techniques for IoT Applications: Regression Models: Linear Regression, Polynomial Regression (Sensor calibration, energy prediction) Classification Models: k-Nearest Neighbors (k-NN) Decision Trees Naïve Bayes Ensemble Methods: Random Forests (Fault detection, activity recognition) Model Evaluation Metrics: Accuracy, Precision, Recall, F1-score, RMSE Overfitting and Underfitting in IoT Context Case Studies: Smart agriculture yield prediction Health monitoring classification	9L
4.	Unsupervised and Semi-Supervised Learning for IoT Systems: Clustering Techniques: k-Means Hierarchical Clustering DBSCAN Anomaly and Outlier Detection in IoT Networks Applications of Clustering in IoT (Device grouping, behavior profiling) Semi-Supervised Learning: Concept and need in IoT environments Autoencoders for anomaly detection (conceptual understanding) Case Study: Intrusion detection in IoT networks	7L
5.	Deep Learning and Edge Intelligence for IoT: Limitations of Traditional ML for Large-Scale IoT Introduction to Deep Learning Artificial Neural Networks (ANN) Convolutional Neural Networks (CNN) for IoT data (images, sensor grids) Recurrent Neural Networks (RNN) and LSTM for time-series IoT data Concept of Edge AI and Edge Computing Model Compression and Lightweight ML Models Deployment challenges on resource-constrained IoT devices	8L
6.	Applications, Security, and Future Trends in ML-enabled IoT: ML-enabled IoT Applications: Smart Cities Healthcare and Wearables Industrial IoT (IIoT) Smart Energy Systems Security and Privacy Issues in ML-based IoT Adversarial Attacks and Data Poisoning (introductory concepts) Ethical Issues in IoT Intelligence Federated Learning for IoT (concept and advantages) Explainable AI (XAI) for IoT Decision Making Emerging Trends and Research Directions	7L
		45L

5. Text Book:

1. Internet of Things: A Hands-On Approach
Authors: Arshdeep Bahga and Vijay Madisetti
Publisher: Universities Press
2. Machine Learning
Authors: Tom M. Mitchell
Publisher: McGraw Hill
3. Internet of Things: Principles and Paradigms

Authors: Rajkumar Buyya et al

Publisher: Elsevier

4. Cloud Computing and IoT

Authors: Oliver Ibe

Publisher: Wiley

5. 'Industrial AI: Applications with Sustainable Performance'

Authors: Jay Lee et al

Publisher: Springer

6. COURSE OUTCOMES (COs)

On completion of the course students will be able to

Course Outcomes	Details	Action Verb	Knowledge Level
DS-503.CO1	Understand the basic concepts, architecture, and communication models of IoT systems.	Understand	Level 2-Understand ,
DS-503.CO2	Identify and utilize IoT hardware components and communication protocols for data collection and management.	Identify	Level 3-Apply, Level 4-Analyze
DS-503.CO3	Explain machine learning concepts, algorithms, and workflows for data-driven decision making.	Explain	Level 2-Understand, Level 2-Apply
DS-503.CO4	Apply and interpret density operators for pure and mixed states.	Understand, Apply	Level 4-Analyze Level 3--Apply
DS-503.CO5	Evaluate real-world IoT and ML integrated systems for efficiency, scalability, and performance.	Evaluate	Level 2-Understand, Level 3-Apply, Level 4-Analyze Level 4-Evaluate

7. Mapping of course outcomes to module / course content

Course Outcome (CO)	Mapped Course Content / Module Topics
CO1	Introduction to IoT Data and Machine Learning Foundations
CO2	IoT Data Acquisition, Preprocessing, and Feature Engineering
CO3	Introduction to IoT Data and Machine Learning Foundations. IoT Data Acquisition, Preprocessing, and Feature Engineering. Supervised Learning Techniques for IoT Applications. Unsupervised and Semi-Supervised Learning for IoT Systems. Deep Learning and Edge Intelligence for IoT
CO4	Supervised Learning Techniques for IoT Applications. Unsupervised and Semi-Supervised Learning for IoT Systems. Deep Learning and Edge Intelligence for IoT
CO5	Deep Learning and Edge Intelligence for IoT. Applications, Security, and Future Trends in ML-enabled IoT. Applications, Security, and Future Trends in ML-enabled IoT

8. Mapping of the Course outcomes to Program Outcomes (PO) (1 = Low, 2 = Moderate, 3 = High)

Mapping of COs with POs and PSOs (Course Articulation Matrix):

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	–	–	–	-	-	-	-	-	-	-
CO2	2	–	–	3	3	-	-	-	-	-	-	-
CO3	3	3	–	2	2	-	-	-	-	-	-	-
CO4	2	3	2	2	3	-	-	-	-	-	-	-
CO5	-	2	3	–	2	-	2	-	-	-	-	3

9. Mapping to Program Specific Outcome (PSO)

CO / PSO	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	-
CO2	3	2	2	-
CO3	3	3	3	-
CO4	3	3	3	-
CO5	2	2	2	3

Reference: North eastern university



Name: Data Visualization and Analytics
Course Code: DS-516
(Semester- V)
Course Broad Category: Program Core (PC)

1. Course Prerequisite: Basic concepts of Probability and Statistics and programming and knowledge in Python/R.

2. Course Learning Objectives:

- i. Understand Core Principles of Data Visualization
- ii. Apply Statistical Thinking in Analytics
- iii. Use Tools and Programming for Visualization

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. Mid-Term Exam (40 Marks)- Formative Assessment [Continuous Assessment 1 (CIA-1)]
- B. Internal Assessment (40 Marks)- Formative Assessment [Continuous Assessment 2(CIA-2)]
- C. End-Semester Exam (60 Marks)- Summative Assessment.

4. Course Content:

Course Name: Data Visualization and Analytics

Course Code: DS-516

Hours per Week: 3L: 0T: 0P

Credits: 3

Module	Topics	45L
1.	Data Perception and Data Visualization : Graphical Excellence – Data Maps – Time-Series – Graphics of Space and Time – Graphical Integrity – Distortion in a Data Graphic – Design and Data Variation – Visual Area and Numerical Measure.	9L
2.	Data-Ink and Graphical Redesign : Data-Ink – Maximizing the Share of Data-Ink – Two Erasing Principles – Application of the Principles in Editing and Redesign - Data-Ink Maximization and Graphical Design – Redesign of Box Plot – Histograms and Scatterplot – Data Density	10L
3.	Visualizing Amounts : Bar Plots – Grouped and Stacked Bars – Dot Plots and Heatmaps - Visualizing Distributions – Histograms and Density Plots – Q-Q Plots – Skewed Distributions - Visualizing Proportions – Pie Charts	10L

Module	Topics	45L
	- Visualizing Time Series – Individual Time Series – Multiple Time Series – Time Series with Multiple Response Variables	
4.	Structural and Relational Data Representations: Mapping – Connections and correlations – Multivariate Analysis – Scatterplot Maps – Trees – Hierarchies and Recursion – Networks and Graphs	8L
5.	Visual Analytics: Visual Analytics vs Data Visualization – Visual Analytics Process – Visual Analytics Applications – Case Studies - Python Data Visualization Libraries	8L

5. Text Book:

1. Edward R. Tufte, The Visual Display of Quantitative Information, 2nd edition, Graphics Press, 2007
2. Claus O. Wilke, Fundamentals of Data Visualization, O’Reilly, 2019
3. Ben Fry, Visualizing Data: Exploring and Explaining Data with the Processing Environment, O’reilly, 1st edition, 2008
4. A. Kerren, J. T. Stasko, J. Fekete, C. North, Information Visualization, Springer, 2008.

6. COURSE OUTCOMES (COs)

On completion of the course students will be able to:

Course Outcomes	Details	Action Verb	Knowledge Level
DS-516.CO1	Define fundamental concepts of data visualization, including data perception, data graphics, data-ink, graphical integrity, and time-series visualization.	Remember	Level 1-Remember
DS-516.CO2	Explain principles of graphical excellence, data-ink maximization, redesign rules, and various visualization techniques such as histograms, scatterplots, bar plots, pie charts, heatmaps, and Q–Q plots.	Understand	Level 2-Understand
DS-516.CO3	Apply appropriate visualization methods to represent distributions, proportions, amounts, correlations, and time-series using Python visualization libraries and tools such as Tableau.	Apply	Level 3-Apply
DS-516.CO4	Analyze multivariate datasets, relationships, patterns, and trends using scatterplot matrices, hierarchical structures, recursion-based visualizations, and network graphs.	Analyze	Level 4-Analyze
DS-516.CO5	Evaluate the effectiveness, integrity, and clarity of visualizations by applying principles	Evaluate	Level 5-Evaluate

	of graphical design, redesign strategies, and data-ink optimization.		
DS-516.CO6	Create effective and insightful data visualizations and dashboards by integrating visual analytics processes and applying them to real-world case studies.	Create	Level 6 Create

7. Mapping of course outcomes to module / course content

Module	CO1	CO2	CO3	CO4	CO5	CO6
1	3	3	1	1	2	1
2	1	3	1	1	3	2
3	1	3	3	3	2	1
4	1	1	3	3	2	1
5	1	2	3	2	2	3

8. Mapping of the Course outcomes to Program Outcomes (PO)

Mapping of COs with POs and PSOs (Course Articulation Matrix):

COs / POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	1	1	1	1	1	1	1	2	1	2
CO2	2	3	1	2	1	1	1	1	1	2	1	2
CO3	2	2	3	3	3	1	1	1	1	2	1	3
CO4	2	3	2	3	2	1	1	1	1	2	1	3
CO5	1	2	1	3	2	1	1	1	1	3	1	2
CO6	2	2	3	3	3	1	1	1	2	3	1	3

9.Mapping to Program Specific Outcome (PSO)

COs \ PSOs	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	1
CO2	2	1	2	1
CO3	3	3	3	1
CO4	3	2	3	1
CO5	3	2	2	2
CO6	3	3	3	2

Reference: NIT Trichy



Course Name: Machine Learning Lab
Course Code: DS-591
(Semester- V)
Course Broad Category: Skill Enhancement Courses

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1. Course Prerequisite: Data Structure, Design and Analysis of Algorithms, Statistics, Artificial Intelligence, Python Programming

2. Course Learning Objectives:

- i. Comprehend and Implement the fundamental concepts of the evolving technologies in machine learning such as Supervised and Unsupervised Learning
- ii. Formulate an engineering problem within the scope of machine learning paradigm.
- iii. Implement the concepts of machine learning to solve problems of making automated decisions dealing with large scale data.
- iv. Develop and Implement ideas for proposing solutions to the challenging problems of machine learning
- v. Analyse the effectiveness of various machine learning Frameworks using appropriate tools.

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. **Internal Assessment (60 Marks)**- Formative Continuous Assessment [Continuous Assessment; Note Book (30 Marks), Viva Voce (20 Marks), Attendance (10 Marks)]
- B. **End-Semester Exam (40 Marks)**- Summative Assessment.

4. Course Content:

Course Name: Machine Learning Lab

Course Code: DS-591

Hours per Week: 0L: 1T: 2P

Credits: 2

Unit/Lab	Content
1	Introduction to Machine Learning Programming Platform & Python Programming Basics
2	Data Exploration: Data Types, Data Attributes, Statistical Description of Data, Data Visualization, Data Feature Vectors, Data Preprocessing: Data Cleaning, Data Transformation
3	Regression: Implementation and Analysis of Linear and Nonlinear Regression Methods
4	Classification: Implementation and Analysis of k-Nearest-Neighbour Classifier, Decision Tree Classifier, Naïve Bayes Classifier
5	Classification: Implementation and Analysis of ANN-Backpropagation and SVM Based Classifier
6	Clustering: Implementation and Analysis of k-Means and k-Medoids
7	Association Analysis: Implementation and Analysis of Apriori Algorithm
8	Mining Time-Series Data: Implementation and Analysis of Time-Series Data Mining Models
9	Discussion on Project Problems and Allocation (Problem Description Report Submission)
10	Designing Solution Model and Proposal Report Submission
11	Project Implementation, Verification and Documentation
12	Project Demonstration and Project Report Review

5. References:

Textbooks:

1. Hands-on Machine Learning with Scikit-Learn, Keras, and TensorFlow, Aurélien Géron, O'Reilly
2. Christopher Bishop, Pattern Recognition and Machine Learning, Springer, 2007
3. Dr. Rajiv Chopra, Machine Learning, Khanna Publishing House, 2018

Reference Books:

1. Machine Learning by Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, Pearson.
2. Machine Learning using Python, Manaranjan Pradhan and U Dinesh Kumar, Wiley

6. Course Outcomes (CO):

After going through this course the Students will be able to:

Course Outcomes	Details	Action Verb	Knowledge Level
DS-591.CO1	Understand and apply the basics concepts of machine learning to Explain or Illustrate and Identify problems where students can Apply the concept appropriately to Solve them.	Understand, Apply, Explain, Identify	Level 2- Understand, Level 3-Apply
DS-591.CO2	Understand and apply the fundamental concepts of regression analysis so that they can propose models for predicting values based on exemplary data and Analyse their performances	Understand, Apply, Analyse	Level 3-Apply, Level 4- Analyze
DS-591.CO3	Understand and apply the fundamental strategies of unsupervised machine learning paradigm to solve clustering problems and Analyse their performances	Understand, Apply, Analyse	Level 4- Analyze, Level 5- Evaluate
DS-591.CO4	Understand and apply the concepts of Mining Frequent Patterns, Associations and Data Streams and Apply them to solve the relevant problems and Analyse their performances.	Understand, Apply, Analyse	Level 3-Apply
DS-591.CO5	Develop ideas to Propose solutions to the problems of supervised learning and Identify problems where students can Apply and Implement the concept appropriately through programming with adequate documentation in collaborative environment for successfully carrying out projects on machine learning problems and investigate their effectiveness by analysing the performances using proper techniques and tools and Assess the limitations of solutions underscoring utilitarian importance for further explorations leading towards lifelong learning.	Develop, Propose, Identify, Apply, Implement	Level 2- Understand, Level 3-Apply,

7. Mapping of course outcomes to Experiments

Unit /Lab	CO1	CO2	CO3	CO4	CO5
1	3	-	-	-	-
2	2	-	-	-	-
3	-	3	-	-	-
4	-	-	-	-	3
5	-	-	-	-	3
6	-	-	3	-	-
7	-	-	-	3	-
8	-	-	-	3	-
9	-	-	-	-	2
10	-	-	-	-	3
11	-	-	-	-	3
12	-	-	-	-	2

8. Mapping of the Course outcomes to Program Outcomes (PO)

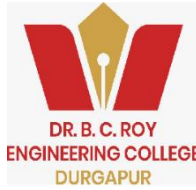
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1	3	2	1	-	2	-	-	-	-	1	-	2
CO2	3	3	2	2	2	-	-	-	-	1	1	2
CO3	3	3	2	2	2	-	-	-	-	1	-	2
CO4	3	3	2	2	3	-	-	-	-	1	-	2
CO5	3	3	3	2	3	1	-	2	3	3	3	3

9. Mapping to Program Specific Outcome (PSO)

	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	1
CO2	3	3	2	1
CO3	3	3	2	1
CO4	3	3	3	1
CO5	3	3	3	3

Reference: NIT Durgapur

*** End of the Syllabus ***



Course Name: Design and Analysis of Algorithms Lab

Course Code: DS-592

(Semester- V)

Course Broad Category: Program Core (PC)

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1. Course Prerequisite: Discrete Mathematics, Data Structure and algorithm

2. Course Learning Objectives:

- i. To enable students to implement various algorithms (e.g., sorting, searching, graph, and dynamic programming) and understand their performance characteristics through experimental analysis
- ii. To develop the ability to measure and compare the time and space complexities of algorithms using empirical and theoretical approaches
- iii. To cultivate problem-solving skills by applying suitable algorithmic paradigms—such as divide and conquer, greedy, and dynamic programming—to design efficient solutions for practical computational problems

3. Teaching methodology and evaluation system for the course:

Teaching methodology – Lectures and Presentations, Interactive Discussions and Case Studies.

Evaluation System –

- A. Mid-Term Exam (40 Marks)- Formative Assessment [Continuous Assessment 1 (CIA-1)]
- B. Internal Assessment (40 Marks)- Formative Assessment [Continuous Assessment 2(CIA-2)]
- C. End-Semester Exam (60 Marks)- Summative Assessment.

4. Course Content:

Course Name: Design and Analysis of Algorithms Lab

Course Code: DS-592

Hours per Week: 0L: 1T: 2P

Credits: 2

Assignment	Algorithmic Paradigm	Title
1.	Divide and Conquer	Write a C program to implement Binary Search using Divide and Conquer approach
2.		Write a C program to implement Merge Sort using Divide and Conquer approach
3.		Write a C program to implement Quick Sort using Divide and Conquer approach
4.		Write a C program to determine Maximum and Minimum element from an array of integer using Divide and Conquer approach
5.	Dynamic Programming	Write a C program to determine the minimum number of scalar multiplication needed for chain of matrix
6.		Write a C program to implement all pair of Shortest path Floyd- Warshall Algorithm for a graph
7.		Write a C program to implement Single Source shortest Path Bellman Ford Algorithm for a graph
8.		Write a C program to implement 0-1 Knapsack Problem
9.	Greedy Method	Write a C program to implement fractional Knapsack Problem
10.		Write a C program to implement single source shortest path Dijkstra Algorithm for a graph
11.		Write a C program to implement Job sequencing with deadlines
12.		Write a C program to determine Minimum Cost Spanning Tree by implementing Prim's Algorithm
13.		Write a C program to determine Minimum Cost Spanning Tree by implementing Kruskal's Algorithm
14.	Graph Traversal Algorithm	Write a C program to implement Breadth First Search (BFS)
15.		Write a C program to implement Depth First Search (DFS)
16.	Branch and Bound	Write a C program to implement 15 Puzzle Problem

Assignment	Algorithmic Paradigm	Title
17.		Write a C program to implement Traveling Salesman Problem
18.	Backtracking	Write a C program to implement 8 Queen problem
19.		Write a C program to implement Graph Coloring Problem
20.		Write a C program to implement Hamiltonian Problem

5.

Text Book:

1. T. H. Cormen, C. E. Leiserson, R. L. Rivest, C. Stein, *Introduction to Algorithms*, Prentice Hall India.
2. J. Kleinberg, Eva Tardo, *Algorithm Design*, Pearson Education (Indian edition).
3. S. Dasgupta, C. Papadimitriou, U. Vazirani, *Algorithms*, Tata McGraw-Hill.

Reference Books:

1. M.T. Goodrich, R. Tamassia, *Algorithm Design: Foundations, Analysis, and Internet Examples*, Second Edition, Wiley, 2006.
2. NPTEL's lectures on Design and Analysis of Algorithms (<https://nptel.ac.in/courses/106101060>), IIT Bombay (Prof. Abhiram G Ranade, Prof. Ajit A Diwan, Prof. Sundar Viswanathan).

6. COURSE OUTCOMES (COs)

On completion of the course students will be able to

Course Outcomes	Details	Action Verb	Knowledge Level
DS-592.CO1	Able to identify the essence of theory into implementation	Identify	L1-Remember, L2-Understand
DS-592.CO2	Able to interpret the theory efficiently through coding	Interpret	L2-Understand
DS-592.CO3	Able to verify the theory experimentally	Verify	L3-Apply, L4-Analyze
DS-592.CO4	Able to explain the behaviour of an algorithm efficiently	Explain	L2-Understand
DS-592.CO5	Able to compare the efficiency of different algorithms	Compare	L4-Analyze, L5-Evaluate

DS-592.CO6	Design and implement solutions using various algorithmic paradigms such as divide-and-conquer, dynamic programming, greedy method, backtracking, and branch-and-bound for real computational problems.	Design/ Implement	L5 – Evaluate, L6-- Create
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7. Mapping of course outcomes to module / course content

Assignment	CO1	CO2	CO3	CO4	CO5
1	3	2	3	2	1
2	2	3	3	2	2
3	2	3	3	2	2
4	2	2	3	3	1
5	1	2	3	3	2
6	1	2	3	2	2
7	1	2	3	2	2
8	1	1	3	3	2
9	1	2	3	2	3
11	1	2	3	2	3
12	1	2	3	2	3
13	1	2	3	2	3
14	1	2	3	2	3
15	1	2	3	2	2
16	1	2	3	2	2
17	1	2	3	3	2
18	1	2	3	3	2
19	1	2	3	3	2
20	1	2	3	3	2

8. Mapping of the Course outcomes to Program Outcomes (PO)

Mapping of COs with POs and PSOs (Course Articulation Matrix):

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	3	3	1	1	1	1	1	2	2
CO2	3	3	3	3	2	1	1	1	1	1	2	2
CO3	2	2	1	1	1	1	1	1	1	1	1	1
CO4	3	2	2	2	2	1	1	1	1	1	2	2
CO5	2	2	2	3	2	1	1	1	1	1	2	2
CO6	3	3	3	3	3	1	1	1	1	2	2	2

9. Mapping to Program Specific Outcome (PSO)

	PSO1	PSO2	PSO3	PSO4
CO1	1	2	3	2
CO2	3	3	2	3
CO3	2	2	2	2
CO4	2	3	3	2
CO5	1	2	3	3
CO5	3	3	3	2

Reference: NIT Durgapur