Shirpur Education Society's

R. C. Patel Institute of Technology, Shirpur

(An Autonomous Institute)

Course Structure and Syllabus

Third Year B. Tech

Computer Science and Engineering (Data Science)

With effect from Year 2025-26

Shahada Road, Near Nimzari Naka, Shirpur, Maharashtra 425405
Ph: 02563 259 802, Web: www.rcpit.ac.in

R. C. PATEL
INSTITUTE OF TECHNOLOGY
An Autonomous Institute

R. C. Patel Institute of Technology, Shirpur

Institute Vision

To become a leading Institute in Technical education fostering innovation, research, ethical values, and sustainable development for the betterment of society.

Institute Mission

To impart high quality Technical Education through:

M1: Innovative and Interactive learning process and high quality, globally recognized instructional programs.

M2: Fostering a collaborative scientific temper among students with ethical responsibility towards the society.

M3: Preparing students from diverse backgrounds to have aptitude for employment, entrepreneurship and research with a spirit of professionalism.

M4: To contribute to nation's sustainable development.

Department of Computer Science & Engineering (Data Science)

Department Vision

To provide cutting-edge Computer Engineering education in Data Science while instilling socio-moral values.

Department Mission

M1: To deliver state-of-the-art, ICT-enabled teaching and learning to achieve excellence in Data Science education.

M2: To develop professionally competent Data Science Engineers, meeting evolving industrial and societal needs.

M3: To prepare employable professionals with ethical values and a commitment to professional and social responsibility.

Program Educational Objectives (PEOs) of the Department

PEO1: Graduates will achieve proficiency in Data Science and pursue lifelong learning to advance as professionals, entrepreneurs, and leaders.

PEO2: Graduates will operate effectively in diverse, dynamic professional and cultural environments, respecting societal perspectives.

PEO3: Graduates will demonstrate ethical values and social responsibility in their professional and personal lives.

Program Specific Outcomes (PSOs) of the Department

PSO1: Apply programming concepts, algorithms, and data structures to develop data-driven software and web solutions.

PSO2: Develop intelligent solutions using machine learning, data analysis, and cloud technologies for practical problem-solving.

Third Year B. Tech Computer Science and Engineering (Data Science) Semester-V (w.e.f. 2025-26)

Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 & TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23DCPC501	Machine Learning-II(Deep Learning)	3			25	15	15	15	60	100	3	4
	PC	RCP23DLPC501	Machine Learning-II Laboratory			2	25				25	50	1	
2	PC	RCP23DCPC502	Design and Analysis of Algorithms	3			25	15	15	15	60	100	3	4
	PC	RCP23DLPC502	Design and Analysis of Algorithms Laboratory			2	25				25	50	1	
3	PC	RCP23DCPC503	Intelligent Systems	2			25	15	15	15	60	100	2	3
	PC	RCP23DLPC503	Intelligent Systems Laboratory			2	25					25	1	
4@	PE	RCP23DCPE511	Recommender Systems	3			25	15	15	15	60	100	3	4
		RCP23DLPE511	Recommender Systems Laboratory			2	25					25	1	
		RCP23DCPE512	Soft Computing	3			25	15	15	15	60	100	3	
		RCP23DLPE512	Soft Computing Laboratory			2	25					25	1	
		RCP23DCPE513	Social Network Analysis	3			25	15	15	15	60	100	3	
		RCP23DLPE513	Social Network Analysis Laboratory			2	25					25	1	
		RCP23DCPE514	Cloud Computing and Security	3			25	15	15	15	60	100	3	
		RCP23DLPE514	Cloud Computing and Security Laboratory			2	25					25	1	
5	MD	RCP23DCMD501	Computer Communication and Networks	3			25	15	15	15	60	100	3	4
	MD	RCP23DLMD501	Computer Communication and Networks Laboratory			2	25				25	50	1	
6#	OE	RCP23OLOE501	DevOps Laboratory			4	50					50	2	2
		RCP23OLOE502	Advanced Java Laboratory			4	50					50	2	
		RCP23OLOE503	Advanced Database Laboratory			4	50					50	2	
7	SC	RCP23IPSC501	Semester Project-III			2	25				25	50	1	1
8	HS	RCP23ICHSX07	Constitution of India	1									Audit Course	
			Total	15		16	325			75	400	800	22	

@Any 1 Programme Elective Course
#Any 1 Open Elective Laboratory

Prepared by:
Dr. P. S. Sanjekar

Checked by:
Prof. S. P. Salunkhe

Prof. Dr. U. M. Patil
BOS Chairman

Prof. S. P. Shukla
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Prof. Dr. J. B. Patil
Director

R. C. Patel Institute of Technology, Shirpur
SES

Third Year B. Tech Computer Science and Engineering (Data Science) Semester-VI (w.e.f. 2025-26)

Sr	Course Category	Course Code	Course Title	Teaching Scheme			Evaluation Scheme					Total	Credit	
							Continuous Assessment (CA)							
							TA	Term Test 1 (TT1)	Term Test 2 (TT2)	Average of (TT1 & TT2)	ESE			
				L	T	P	[A]			[B]	[C]	[A+B+C]		
1	PC	RCP23DCPC601	Machine Learning-III (Reinforcement Learning)	3			25	15	15	15	60	100	3	4
	PC	RCP23DLPC601	Machine Learning-III (Reinforcement Learning) Laboratory			2	25					25	1	
2	PC	RCP23DCPC602	Natural Language Text Processing	3			25	15	15	15	60	100	3	4
	PC	RCP23DLPC602	Natural Language Text Processing Laboratory			2	25				25	50	1	
3	PC	RCP23DLPC603	Advanced Statistics Laboratory			4	50					50	2	2
4	MD	RCP23DLMD601	Applied Data Science Engineering Laboratory			2	25					25	1	1
5@	PE	RCP23DCPE611	Time Series Analysis	3			25	15	15	15	60	100	3	4
		RCP23DLPE611	Time Series Analysis Laboratory			2	25					25	1	
		RCP23DCPE612	Analysis of AI Algorithms	3			25	15	15	15	60	100	3	
		RCP23DLPE612	Analysis of AI Algorithms Laboratory			2	25					25	1	
		RCP23DCPE613	Medical Imaging Informatics and Interoperability	3			25	15	15	15	60	100	3	
		RCP23DLPE613	Medical Imaging Informatics and Interoperability Laboratory			2	25					25	1	
		RCP23DCPE614	Ethical Hacking and Digital Forensics	3			25	15	15	15	60	100	3	
		RCP23DLPE614	Ethical Hacking and Digital Forensics Laboratory			2	25					25	1	
6#	PE	RCP23DCPE621	Computer Vision	4			25	15	15	15	60	100	4	5
		RCP23DLPE621	Computer Vision Laboratory			2	25				25	50	1	
		RCP23DCPE622	Robotics and AI	4			25	15	15	15	60	100	4	
		RCP23DLPE622	Robotics and AI Laboratory			2	25				25	50	1	
		RCP23DCPE623	Applied Game Theory	4			25	15	15	15	60	100	4	
		RCP23DLPE623	Applied Game Theory Laboratory			2	25				25	50	1	
		RCP23DCPE624	Information Security	4			25	15	15	15	60	100	4	
		RCP23DLPE624	Information Security Laboratory			2	25				25	50	1	
7	EL	RCP23IPEL601	Project Stage-I			4	50				50	100	2	2
8	HS	RCP23ITHSX06	Environmental Science Tutorial		1		25					25	1	1
			Total	13	1	18	350			60	340	750	23	

@Any 1 Programme Elective Course from Set-1
#Any 1 Programme Elective Course from Set-2

Prepared by:
Dr. M. S. Patil

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Director

P. C. Patel Institute of Technology Shirpur Autonomous

Semester - V

Program: B.Tech in Computer Science and Engineering (Data Science)	T. Y. B.Tech	Semester: V
Machine Learning-II(Deep Learning) (RCP23DCPC501)		
Machine Learning-II Laboratory (RCP23DLPC501)		

Prerequisite: Linear Algebra, Calculus, Probability, Statistics and Machine Learning Basics.

Course Objective(s):

1. To introduce students with the fundamental concepts of artificial neural network and different learning algorithms: supervised and unsupervised neural networks.
2. To expose Deep Network based methods to solve real world complex problems.
3. Develop in-depth understanding of the Transfer Learning, its key components, challenges and Applications.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze different neural network architectures and their learning algorithms.	L4	Analyze
CO2	Build solution using appropriate neural network and deep network models.	L6	Create
CO3	Analyze optimization strategies and regularization methods to enhance deep learning model training.	L4	Analyze
CO4	Evaluate and implement transfer learning techniques across various applications.	L5	Evaluate

Machine Learning-II(Deep Learning)
(RCP23DCPC501)
Course Contents

Unit-I 07 Hrs.

Introduction to Artificial Neural Learning:

Fundamental concepts of biological Neural Networks, NN Architectures, Important terminologies of ANN: Activation functions: (Sigmoid, Tanh, and ReLU, Leaky ReLU, GELU, Swish, ELU), weights, bias, threshold, learning rate, McCulloch Pitts Neuron: Theory and Architecture; Linear separability; Hebb Network: Theory and Algorithm.

Unit-II 06 Hrs.

Supervised Learning Networks:

Perceptron: Representational power of Perceptron, The Perceptron Training Rule, Delta Rule; Multilayer Networks: Representational Power of Feedforward Networks; Backpropagation Algorithm: Convergence and local minima, Hypothesis space search and Inductive Bias, Generalization, Vanishing & Exploding Gradients.

Unit-III 05 Hrs.

Optimization for Training Deep Models:

Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies. Optimizers: Gradient Descent, Stochastic Gradient Descent, SGD with Momentum, RMSProp, Adam.

Regularization for Deep Learning: Parameter Norm Penalties, Dataset Augmentation, Noise Robustness, Early Stooping, Sparse Representation, Dropout and Batch Normalization.

Unit-IV 07 Hrs.

Convolutional Networks:

The Convolution Operation, sparse interactions, parameter sharing, Dataset Augmentation, Pooling, Variations of Heatmaps. Variants of Basic Convolution Function, Efficient Convolution Algorithms (AlexNet, LeNet-5, VGG, InceptionNet, ResNet, MobileNet (for lightweight models)), Attention Mechanisms in CNNs (Squeeze-and-Excitation (SE) Networks, CBAM).

Unit-V 08 Hrs.

Unsupervised Learning Networks: Kohonen Self-Organizing Feature Maps – architecture, training algorithm, Kohonen Self- Organizing Motor Map.

Autoencoders: Sparse Autoencoder, Undercomplete Autoencoders, Regularized Autoencoders, Denoising Autoencoders, Applications of Autoencoders. Variational Autoencoders (VAEs), Linear Fa

tor Methods such as Probabilistic PCA and Factor Analysis, Independent Component Analysis, Deep Embedded Clustering (DEC).

Self-Supervised Learning: Contrastive learning (SimCLR, CURL), Instance Discrimination Method.

Unit-VI 09 Hrs.

Transfer Learning:

Fundamental of Transfer Learning, Freezing, Fine-tuning. Transfer Learning Strategies: Inductive Transfer.

Types of Deep Transfer Learning: Domain Adaptation, Domain Confusion, One-shot Learning, Zero-shot Learning.

Types of Transferable Components: Instance transfer, Feature-representation transfer, Parameter transfer.

Transfer Learning Challenges: Negative Transfer, Transfer Bounds.

Model: CLIP, SAM (Segment Anything Model).

Applications: Transfer learning for NLP/ Audio/ Speech/ Computer Vision

Machine Learning-II Laboratory (RCP23DLPC501)

List of Laboratory Experiments

Suggested Experiments: (Any 08)

1. Implement Boolean gates using perceptron.
2. Implement backpropagation algorithm from scratch.
3. Monitoring and evaluating deep learning models using Tensorflow and Keras.
4. Evaluate and analyze Prediction performance using appropriate optimizers for deep learning models.
5. Building CNN models for image categorization. (medical image analysis).
6. Implement Graph Convolutional Networks (GCN) for Node Classification and Link Prediction.
7. Implement contrastive learning on unlabeled data.
8. Anomaly detection using Self-Organizing Network.
9. Compare the performance of PCA and Autoencoders on a given dataset.
10. Transfer Learning with Pre-trained CNN model as a Feature Extractor for Image Classification with a Data Availability Constraint.
11. Zero-shot Image Classification using CLIP & Few-shot Learning with DINO.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Practical examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Christopher M. Bishop, Hugh Bishop, "Deep Learning Foundations and concept", Springer Cham, 1st Edition, 2023.
2. S. N. Sivanandam and S. N. Deepa, "Introduction to Soft Computing", 3rd Edition, Wiley India Publications, 2018.
3. Ian Goodfellow and Yoshua Bengio and Aaron Courville, "Deep Learning", An MIT Press, 2016.
4. Simon Haykin, "Neural Networks and Learning Machines", Pearson Prentice Hall, 3rd Edition, 2010.

Reference Books:

1. François Chollet, "Deep Learning with Python", Manning Publication, 1st Edition, 2021.
2. Josh Patterson, Adam Gibson, "Deep Learning: A Practitioner's Approach", O'Reilly Publication, 2017.
3. Andrew W. Trask, Grokking, "Deep Learning", Manning Publication, 2019.
4. John D. Kelleher, "Deep Learning", MIT Press Essential Knowledge series, 2019.

Web Links:

1. Learning Rule: http://vlabs.iitb.ac.in/vlabs-dev/labs/machine_learning/labs/explist.php
2. ANN Virtual Lab: http://cse22-iiith.vlabs.ac.in/List%20of%20experiments.html
3. Deep Learning: https://vlab.spit.ac.in/ai/#/experiments
4. NPTEL Course: Deep Learning Part 1: https://onlinecourses.nptel.ac.in/noc19_cs85/preview

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Design and Analysis of Algorithms (RCP23DCPC502)		
Design and Analysis of Algorithms Laboratory (RCP23DLPC502)		

Prerequisite: Computer Programming, Data structures

Course Objective(s):

1. To provide mathematical approach for Analysis of Algorithms.
2. To introduce important algorithmic design paradigms and approaches for effective problem solving.
3. To introduce the concepts of tractable and intractable problems and the classes P, NP and NP-complete problems.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze the performance of algorithms by solving recurrence relations with various methods.	L4	Analyze
CO2	Solve the problem using appropriate algorithmic design techniques.	L3	Apply
CO3	Demonstrate that certain problems are NP-Complete.	L3	Apply

Design and Analysis of Algorithms (RCP23DCPC502) Course Contents

Unit-I 06 Hrs.

Introduction:

Methods for solving recurrence relations using tree, substitution, master method Problem Solving using divide and conquer algorithm: – Binary search, Quick sort, Merge Sort, Randomized Quick Sort, Analysis of Binary search, quick sort and merge sort.

Unit-II 06 Hrs.

Graph and Tree Algorithms:

B Tree: Properties of B Tree, Insertion, Deletion and Search Operation on B Tree, B+ Tree: Properties of B+ Tree, Insertion, Deletion and Search Operation on B+ Tree, RB Tree: Properties of RB Tree, Insertion, Deletion and Search Operation on RB Tree, Topological sorting, Applications.

Unit-III 06 Hrs.

Greedy Method:

Introduction, control abstraction, Problem solving using - fractional knapsack problem, activity selection problem, job sequencing with deadline, Minimum Spanning trees (Kruskal's algorithm, Prim's algorithm), Single source shortest path (Dijkstra's algorithm), coin change problem.

Unit-IV 11 Hrs.

Dynamic Programming:

Introduction, principle of optimality, Components of dynamic programming, characteristics of dynamic programming, Fibonacci problem, Coin Changing problem, 0/1 knapsack (table and set method), All pairs shortest paths (Floyd Warshall Algorithm), Single source shortest path (Bellman-Ford Algorithm), Matrix Chain Multiplication, Travelling salesperson problem, Longest Common Subsequence (LCS).

Unit-V 08 Hrs.

Backtracking:

Introduction, Basics of backtracking, N–queen problem, Sum of subsets, Graph coloring, Hamiltonian cycles Generating permutation.

Branch-and-Bound:

Introduction, Control abstraction -LC BB, FIFO BB, LIFO BB, 15 Puzzle problem, 0/1 Knapsack problem, Job Sequencing with Deadline.

Unit-VI 05 Hrs.

Basics of Computational Complexity:

Complexity classes: The class P and NP, Polynomial reduction, NP Completeness Problem, NP-Hard Problems, NP Completeness problem using Travelling Salesman problem (TSP), Approximation algorithm using TSP.

Design and Analysis of Algorithms Laboratory (RCP23DLPC502)

List of Laboratory Experiments

Suggested Experiments:(Any 10)

1. Implementation of randomized quick sort.
2. Implementation of minimum spanning tree algorithm – Prim's and Kruskal's using greedy approach.
3. Fractional Knapsack implementation using greedy approach.
4. Implementation of Activity selection using greedy approach.
5. Implementation of job sequencing with deadline using greedy approach.
6. Implementation of Single source shortest path (Dijkstra's algorithm)
7. Implementation of Bellman Ford algorithm using Dynamic programming
8. Implementation of Longest Common Subsequence algorithm using Dynamic programming.
9. Implementation of Travelling Salesperson problem using Dynamic programming.
10. Implementation of multistage graphs/ all pair shortest path using dynamic programming.
11. Implementation of N-queen problem using Backtracking.
12. Given an integer array num of 2n integers, group these integers into n pairs (a1, b1), (a2, b2), ..., (an, bn) such that the sum of min (ai, bi) for all i is maximized. Return the maximized sum. (Using LeetCode Platform)
13. Determine if a 9 x 9 Sudoku board is valid. Only the filled cells need to be validated according to the following rules:
    1. Each row must contain the digits 1-9 without repetition.
    2. Each column must contain the digits 1-9 without repetition.
    3. Each of the nine 3 x 3 sub-boxes of the grid must contain the digits 1-9 without repetition

14. Given an m x n grid of characters' board and a string word, return true if word exists in the grid. The word can be constructed from letters of sequentially adjacent cells, where adjacent cells are horizontally or vertically neighboring. The same letter cell may not be used more than once.

15. Given an array prices where prices[i] is the price of a given stock on the ith day. You want to maximize your profit by choosing a single day to buy one stock and choosing a different day in the future to sell that stock.Return the maximum profit you can achieve from this transaction. If you cannot achieve any profit, return 0.

16. Knuth-Morris-Pratt (KMP) String Matching

17. Implementation of Naive String Matching Algorithm string matching algorithm.

18. Implementation of Selection Sort.

19. Implementation of Bubble Sort.

20. Implement a program to merge two sorted arrays.

21. Implementation of Merge sort algorithm.

22. Implementation of quick sort algorithm.

23. Implementation of Sequential Search method.

24. Implementation of Binary Search method.

25. Multiplying two large integers

26. MIN MAX- Linear Approach

27. MIN MAX- Divide and Conquer Approach

28. Implementation of Strassen's Matrix Multiplication.

29. Implementation of Job Sequencing Problem with Deadlines.

30. Implementation of Job Scheduling.

31. Implement a program for Divide and Conquer Multiplication of two arrays.

32. Implement a program to perform Multiplication of Two Matrices.

33. Road Decoration: Australia and New Zealand have started working on preparation for the World Cup 2015. There are N important venues (like hotels and stadiums) in the city. Out of these important venues, there is one central location where the opening and closing ceremony will be held. There is an existing network of bidirectional roads connecting these venues. The organizin committee has planned to decorate some of these roads that will be used for commuting. The

have decided to choose the roads to decorate such that there is exactly one decorated path to all the venues from the central location. New Zealand is supposed to decorate these roads and Australia has taken up the responsibility of providing transportation. Only decorated roads can be used for transportation. Australia wanted to save fuel costs, and so they wanted to choose the decorated roads to minimize the total sum of distances to all venues from the central location. However, New Zealand had their own plans to minimize decoration cost by choosing the decorated roads such that the sum of the length of the chosen roads will be minimized. To prevent a fight breaking out between these two rivals before they even step on to the field, you have to help them by reporting if there is a solution in which the two rivals could choose the same set of roads while satisfying their respective constraints.

34. Fullmetal Alchemist: After completing the preliminary tests, Full Metal now faces his final exam. Captain Mustang gives him an n*m grid of letters. He defined distance between two rows of the grid as the largest absolute difference between letters in the same column. Full Metal is assigned to mark all the rows. The cost of marking the first row of his choice is zero. Thereafter the cost of marking each row is equal to the distance of the row (being marked) from any one of the previously marked rows. Help Full Metal to determine the least value of the largest cost of marking a row.

35. Implementation of Huffman Algorithm.

36. Implementation of 0/1 Knapsack problem.

37. Implementation of Optimal Binary Search Trees.

38. Implementation of Optimal Binary Search Trees: You are building a Binary Search Tree consisting of values 1,2,..N that would require the minimum number of operations. You are already provided queries given as an array F of length N - Fi stores the number of search queries asked for value i. Output the minimum number of comparisons that would be required to process all the queries.

39. Implementation of Travelling Salesperson Problem (TSP) using Dynamic Programming.

40. Implementation of Knapsack Problem using Branch and Bound.

41. Travelling Salesman Problem using Branch and Bound.

42. Overview of P, NP and NP-Complete Problems.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Practical examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", 1st Edition, Tata McGraw- Hill, 2023.
2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", 4th Edition, The MIT Press, 2022.
3. Ellis Horowitz, Sartaj Sahni, S. Rajsekaran, "Fundamentals of computer algorithms", 1st Edition, University Press, 2018.

Reference Books:

1. S. K. Basu, "Design Methods and Analysis of Algorithm", 2nd Edition, PHI, 2013.
2. John Kleinberg, Eva Tardos, "Algorithm Design", Pearson, 1st Edition, 2013.

Web Links:

1. NPTEL Course: https://onlinecourses.nptel.ac.in/noc19_cs47/preview
2. LeetCode: https://leetcode.com/problem-list

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Intelligent Systems (RCP23DCPC503)		
Intelligent Systems Laboratory (RCP23DLPC503)		

Prerequisite: Basic Mathematics, Data Structures

Course Objective(s):

1. Provide the basic ideas and techniques underlying the design of intelligent systems.
2. Impart the knowledge of various search techniques for problem solving.
3. Learn knowledge representation and provide the knowledge to deal with uncertain and incomplete information.
4. Impart the knowledge of Intelligent planning.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply appropriate search-based method for a given problem.	L3	Apply
CO2	Analyze various IS approaches to knowledge intensive problem solving, reasoning and intelligent planning.	L4	Analyze
CO3	Apply the knowledge of reasoning and intelligent planning to solve a problem.	L3	Apply

Intelligent Systems (RCP23DCPC503)
Course Contents

Unit-I 04 Hrs.

Fundamentals:

Introduction to Intelligence Systems, Evolution, Categorization of Intelligent System, Applications.

Problem solving:

Solving problem by Searching: Problem Solving Agent, Formulating Problems. State Space Search: Uninformed search, Breadth First Search (BFS), Depth First Search (DFS), Depth First Iterative Deepening (DFID).

Unit-II 07 Hrs.

Heuristic Search and Optimization:

Best first Search, Hill Climbing, Variations of Hill Climbing, Solution Space, and Travelling Salesman Problem. Finding Optimal Paths: Branch and Bound, A*, Admissibility and monotonicity properties of A*.

Game Playing:

Game Theory, Board games and game tree, The minimax algorithm, Alpha-Beta Pruning.

Unit-III 05 Hrs.

Knowledge and Reasoning in Logic:

Logic, Soundness and Completeness, Propositional Logic, First Order Logic, forward chaining, Backward chaining and Refutation.

Unit-IV 06 Hrs.

Ontology:

Knowledge Modelling, Definition, and importance of ontologies in AI, Components of ontologies: classes, properties, individuals, Ontology development methodologies (e.g. Protégé), Ontology languages (e.g. OWL, RDF), Ontology reasoning and inference, Applications of ontologies in AI (e.g. semantic web, knowledge management. Ontology-based data access and integration, Rule-based reasoning with ontologies (e.g. SWRL).

Unit-V 06 Hrs.

Planning:

Domain independent planning, Forward and Backward search, Goal Stack Planning, Plan Space Planning, Means Ends Analysis, Graphplan, algorithm AO*.

Intelligent Systems Laboratory (RCP23DLPC503)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Implement domain specific function for different problems.
2. Identify and analyze uninformed search Algorithm to solve the problem. Implement BFS/DFS/DFID search algorithms to reach goal state.
3. Program to implement Local Search algorithm: Hill climbing search.
4. Implement A* search algorithm to reach goal state.
5. To analyze the admissibility property of A* algorithm by comparing the results using admissible and inadmissible heuristics.
6. Implement minimax algorithm for a two-player game.
7. Implement Alpha-Beta Pruning and analyze its effectiveness in optimizing game-tree search by reducing the number of nodes evaluated.
8. Develop a knowledge base using OWL.
9. Develop a Rule based System using SWRL on Protégé software.
10. AI-Based Decision Making Using AO* Algorithm

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Stuart Jonathan Russell, Stuart Russell, Peter Norvig, "Artificial Intelligence: A Modern Approach", Pearson, 2020.
2. Deepak Khemani, " A First Course in Artificial Intelligence", McGraw Hill Education (India), 2013.
3. Dean Allemang, James Hendler, "Semantic Web for the Working Ontologist", 1st Edition, Elsevier 2008.

Reference Books:

1. Saroj Kaushik, "Artificial Intelligence", 1st Edition, Cengage Learning, 2011.
2. Ivan Bratko , "PROLOG Programming for Artificial Intelligence", 4th Edition, Pearson Education, 2011.

3. Crina Grosan, Ajith Abraham, "Intelligent Systems: A Modern Approach", Springer Science & Business Media, 2011.

4. Elaine Rich and Kevin Knight "Artificial Intelligence", 3rd Edition, Tata McGraw-Hill, 2008.

5. Patrick Henry Winston, "Artificial Intelligence", 3rd Edition, Addison-Wesley.

Web Links:

1. NPTEL: Computer Science and Engineering - Artificial Intelligence: Search Methods for Problem Solving

2. NPTEL Course: An Introduction to Artificial Intelligence

Program: B.Tech in Computer Science and Engineering (Data Science)	T. Y. B.Tech	Semester: V
Recommender Systems (RCP23DCPE511)		
Recommender Systems Laboratory (RCP23DLPE511)		

Prerequisite: Statistics for Data Science, and Machine Learning.

Course Objective(s): To provide students with the basic concepts of Recommender Systems, design space, trade- offs and its application in various domain.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the fundamental concepts and biases in recommender systems.	L2	Understand
CO2	Apply neighborhood-based and collaborative filtering techniques for designing recommender systems.	L3	Apply
CO3	Design and evaluate advanced recommender systems using hybrid approaches, constraint-based and context-aware models.	L6	Create

Recommender Systems (RCP23DCPE511)
Course Contents

Unit-I 07 Hrs.

Introduction to Recommender Systems:

Recommender Systems Function, Techniques, Application and Evaluation, Explanations and Persuasiveness, Conversational Systems, Visualization, Biases in Recommender Systems: Statistical, cultural and cognitive, data and algorithm bias and self-selection biases, Issues working with RSs data sets: The cold-start problem.

Recommendation System Properties: User Preference, Prediction Accuracy, Coverage, Confidence, Trust, Novelty, Serendipity, Diversity, Utility, Risk, Robustness, Privacy, Adaptivity.

Evaluation metrics: Rating prediction and accuracy, Ranking Measures: NDPM, Spearman's ρ, R-Score, MAP, NDCG, MRR, implicit/explicit. Other metrics: fairness, coverage, diversity, novelty, serendipity.

Unit-II 05 Hrs.

Content-based Recommender System:

High level Architecture of Content-based Systems, Advantages and Drawbacks of Content-based Filtering, Item profiles, discovering features of documents, obtaining item features from tags, representing item profiles, Methods for Learning User Profiles, Similarity based retrieval, Classification algorithms, Knowledge based recommendation: Knowledge representation and reasoning, Case based recommenders.

Unit-III 08 Hrs.

Neighbourhood-based Recommendation Methods:

Advantages of Neighborhood Approaches, Neighborhood-based Recommendation, User-based Rating Prediction, User-based Classification Regression Vs Classification, Item-based Recommendation, User-based Vs Item based Recommendation, Rating Normalization, Similarity Weight Computation, Neighborhood Selection.

Graph-based Methods: User-Item Graphs, Neighborhoods with Random Walks, Neighborhoods with the Katz Measure, Attacks on collaborative recommender systems

Unit-IV 08 Hrs.

Neighborhood models:

Rule-Based Collaborative Filtering: Leveraging Association Rules for Collaborative Filtering, Item-Wise Models versus User-Wise Models Naive Bayes Collaborative Filtering: Handling Overfitting, Example of the Bayes Method with Binary Ratings.

Collaborative filtering-based Recommender System: Baseline predictors through least squares, Implicit feedback, Matrix factorization models: SVD, SVD++, Time-aware factor model, Comparison, echo chambers, data drift and concept drift.

Unit-V 08 Hrs.

Constraint-based Recommenders Development of Recommender Knowledge Bases: User Guidance in Recommendation Processes, Calculating Recommendations.

Context-Aware Recommender Systems: Context in Recommender Systems, Modeling Contextual Information in Recommender Systems. Paradigms for Incorporating Context in Recommender Systems: Contextual Pre- Filtering, Contextual Post-Filtering, Contextual Modeling, Combining Multiple Approaches, Additional Issues in Context-Aware Recommender Systems.

Unit-VI 06 Hrs.

Hybrid approaches:

Deep Recommender systems, Multimodal Recommenders, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching. Limitations of hybridization strategies.

Recommender Systems Laboratory (RCP23DLPE511)

List of Laboratory Experiments

Suggested Experiments: (Any 10)

1. Processing and analysis of public recommender systems datasets, and performance evaluation and comparison / Master spreadsheet-based tools.
2. Compare and analyze performance of Content-based recommendation engine on different datasets for Book, Movie, Song, product Recommendation.
3. Implement Recommendation System using K-Nearest Neighbors and evaluate its performance on different datasets.
4. Build project-association recommenders using association rule mining.
5. Build a Recommendation Engine with Item-Based Collaborative Filtering.
6. Implement Context-Aware Recommender Systems Trust.
7. Build Constraint-based Recommenders to provide valuable support for users searching for products and services in e-commerce environments.
8. Implement Hacker News algorithm /Subreddit User Recommendation System based on Netflix Algorithm.

9. Implement Bayesian personalized ranking using matrix factorization algorithm
10. Implement Google PageRank algorithm for recommendation.
11. Implement unsupervised learning - Autoencoders and Restricted Boltzmann Machines.
12. Implement recommender systems in 5G wireless networks for optimizing wireless network performance and deploy designed recommender System as Hosted Interactive Web Service on AWS.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Jannach D., Zanker M. and FelFering A., "Recommender Systems: An Introduction", 1st Edition, Cambridge University Press, 2011.
2. Kim Falk, "Practical Recommender Systems", 1st Edition, Manning, 2019.
3. Manouselis N., Drachsler H., Verbert K., Duval E., "Recommender Systems for Learning", 1st Edition, Springer, 2013.
4. C.C. Aggarwal, "Recommender Systems: The Textbook", 1st Edition, Springer, 2016.

Reference Books:

1. M.D. Ekstrand, J.T. Riedl, J.A. Konstan, "Collaborative filtering recommender systems", 1st Edition, Now publishers, 2011.
2. J. Leskovec, A. Rajaraman and J. Ullman, "Mining of massive datasets", Cambridge, 2nd Edition, 2012.
3. Rounak Banik, "Hands-On Recommendation Systems with Python: Start building", Ingram short title, 2018.
4. P. Pavan Kumar, S. Vairachilai, Sirisha Potluri, "Recommender Systems: Algorithms and Applications", CRC Press, 1st Edition, 2021.

Web Links:

1. Udemy course on Recommender Systems and Deep Learning in Python: https://realpython.com/build-recommendation-engine-collaborative-filtering
2. Coursera course on Recommender Systems Specialization: https://www.coursera.org/specializations/recommender-systems

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Soft Computing (RCP23DCPE512)		
Soft Computing Laboratory (RCP23DLPE512)		

Prerequisite: Mathematics, Algorithms.

Course Objective(s): To equip students with the knowledge and skills to apply fuzzy logic, genetic algorithms, evolutionary computation, and hybrid soft computing techniques for solving real-world optimization and decision-making problems.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the fundamentals of soft computing.	L2	Understand
CO2	Apply fuzzy logic and evolutionary algorithms to solve real world decision-making and optimization problems.	L3	Apply
CO3	Analyze multi-objective optimization techniques and hybrid soft computing models to handle complex problem-solving scenarios.	L4	Analyze

Soft Computing (RCP23DCPE512)
Course Contents

Unit-I 03 Hrs.

Introduction:

Concept of computing systems, Tolerance for imprecision and uncertainty, Adaptability and learning capability, Trade-offs between computational efficiency and accuracy. "Soft" computing versus "Hard" computing Characteristics of Soft Computing, major areas of Soft Computing, applications of Soft Computing, Limitations of soft computing approaches.

Unit-II 06 Hrs.

Fuzzy logic:

Introduction to Uncertainty Treatment, Fuzzy logic, Fuzzy sets and membership functions, Operations on Fuzzy sets. Fuzzy relations, rules, propositions, implications and inferences, Defuzzification techniques, Fuzzy logic controller design, Some applications of Fuzzy logic.

Unit-III 07 Hrs.

Genetic Algorithms

Concept of "Genetics" and "Evolution"and its application to probabilistic search techniques, Basic GA framework and different GA architectures. GA operators: Encoding, Crossover, roulette wheel selection, tournament selection, population, binary encoding and decoding for any optimization problem, Selection, Mutation, etc. Solving single-objective optimization problems using Gas, Multi objective Gas, Concepts on Non-domination, tournament selection, crowding distance operator, ranking, Simulated annealing.

Unit-IV 09 Hrs.

Multi-objective Optimization Problem Solving

Concept of multi-objective optimization problems (MOOPs) and issues of solving them. Multi-Objective Evolutionary Algorithm (MOEA), TOPSIS, Non-Pareto approaches to solve MOOPs Pareto-based approaches to solve MOOPs. Some applications with MOEAs.

Unit-V 11 Hrs.

Evolutionary Computation:

Ant Colony Optimization and Artificial Bee Colony Algorithms: Biological ant colony system, Artificial ants and assumptions – Stigmergic communications, Pheromone updating- local - global - Pheromone evaporation - ant colony system ACO models, Touring ant colony system - max min ant system - Concept of elistic ants, Task partitioning in honeybees - Balancing foragers and receiver

– Artificial bee colony (ABC) algorithms - binary ABC algorithms, ACO and ABC algorithms for solving SINX maximization problem, Particle Swarm Optimization.

Unit-VI 06 Hrs.

Rough Sets:

Basic operations, lower and upper, approximations, discernibility matrix, distinction table; Accuracy of Approximations.

Hybridization of Soft Computing tools:

Sequential Hybrid Systems, Auxiliary Hybrid Systems, Embedded Hybrid Systems, Neuro-Fuzzy Hybrid Systems, Neuro-Genetic Hybrid Systems, Fuzzy-Genetic Hybrid Systems., Rough fuzzy, Rough-Fuzzy-GA etc. boundary region. Applications

Soft Computing Laboratory (RCP23DLPE512)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Implement fuzzy set operations (union, intersection, complement) and visualize membership functions.

2. 1. Design and implement a Fuzzy Inference System (FIS) for temperature control.
   2. Implement different defuzzification techniques (e.g., Centroid, Bisector, MOM, SOM, LOM).

3. Genetic Algorithms (GA)
   1. Implement a simple Genetic Algorithm for function optimization.
   2. Apply GA for solving a Traveling Salesman Problem (TSP).
   3. Implement a binary encoding and decoding mechanism for GA-based optimization.
   4. Compare Roulette Wheel Selection and Tournament Selection methods in GA.

4. Multi-objective Optimization Problem Solving
   1. Implement Non-Dominated Sorting Genetic Algorithm (NSGA-II) for solving multi-objective problems.
   2. Solve a multi-objective problem using Pareto-based optimization techniques.

5. Evolutionary Computation (anyone)
   1. Implement Ant Colony Optimization (ACO) for pathfinding in a graph.
   2. Implement Artificial Bee Colony (ABC) optimization for function minimization.
   3. Solve a function maximization problem using ACO and ABC.
   4. Implement Particle Swarm Optimization (PSO) for parameter tuning in an optimization problem.

6. Implement rough set-based data analysis using lower and upper approximations.

7. Compute the discernibility matrix and generate reducts using the Rough Set approach.
8. Implement a Neuro-Fuzzy system for classification tasks.
9. Implement a hybrid Genetic Algorithm-Fuzzy Logic system for an optimization problem.
10. Implement a Rough-Fuzzy system for feature selection and classification.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. S. N. Sivanandam and S. N. Deepa, "Introduction to Soft Computing", 3^{rd} Edition, Wiley India Publications, 2018.
2. Xin-She Yang, "Recent Advances in Swarm Intelligence and Evolutionary Computation, Springer International Publishing, Switzerland, 2015.
3. Kalyanmoy Deb, " Multi-Objective Optimization using Evolutionary Algorithms Paperback – Wiley India Publications, 2010.
4. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms, John Wiley & Sons, 2001.

Reference Books:

1. Timothy J.Rose, "Fuzzy Logic with Engineering Applications", 4^{th} Edition, John Wiley, 2020.
2. D. E. GOLDBERG, "Genetic Algorithms: in search, optimization and machine learning, Dec 2008.
3. B. Yegnanarayana, "Artificial Neural Networks", PHI publication, 1998.
4. James FREEMAN and David Skapura, "Neural Networks: Algorithms, Applications, and Programming Techniques, 1^{st} Edition, Pearson publication, 2002.
5. J.S.R Jang, C.T Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", 2^{nd} Edition, Prentice Hall of India, 2002.

Web Links:

1. Soft Computing — CS60108
2. https://nptel.ac.in/courses/103/103/103103164/
3. https://nptel.ac.in/courses/112/105/112105235/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Social Network Analysis (RCP23DCPE513)		
Social Network Analysis Laboratory (RCP23DLPE513)		

Prerequisite: Probability and Statistics, Machine Learning.

Course Objective(s): To equip students with the knowledge and analytical skills necessary for the study of massive networks, addressing the associated computational, algorithmic, and modeling challenges, and to cultivate a research-oriented perspective on the structure, dynamics, and analysis of large-scale networks.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze social networks using visualization techniques and structural measures.	L4	Analyze
CO2	Illustrate network growth patterns and ranking methodologies in complex networks.	L3	Apply
CO3	Examine methods for detecting communities, predicting links, and modelling information flow.	L4	Analyze
CO4	Apply anomaly detection and representation learning approaches for network analysis.	L3	Apply

Social Network Analysis (RCP23DCPE513)
Course Contents

Unit-I 08 Hrs.

Society & Network:

Introduction, Use of social networks, defining a network, types of network (link-centric, node and link centric, local view, temporal view, generalization, real-world network), levels of social network analysis, graph visualization tools.

Network Measures:

Network basics, node centrality, assortativity, transitivity and reciprocity, similarity, degeneracy.

Network Growth Models:

Overview of real-world networks and their properties, brief introduction to Erdős-Rényi Random Network Model, Watts-Strogatz Model, and Preferential Attachment Model with their key characteristics and limitations.

Unit-II 06 Hrs.

Link Analysis:

Application of link analysis, Signed networks: Balance Theory of Undirected Signed Networks, Status Theory of Signed Networks, Triad Balance vs Status, Strong and Weak Ties: Strength of a Tie, Triadic Closure, Dunbar Number, Local Bridges and Importance of Weak Ties, PageRank, DivRank, SimRank, PathSim.

Unit-III 06 Hrs.

Community Detection:

Application of community detection, types of communities, community detection methods, Disjoint Community Detection: Node-centric community detection, modularity and community detection, Overlapping Community Detection: Clique Dynamics, Local Community Detection.

Link Prediction:

Applications of link prediction, Evaluating Link Prediction methods

Unit-IV 06 Hrs.

Cascade Behaviours & Network Effects:

Preliminaries and Important Terminologies, Cascade Models, Probabilistic Cascades, Epidemic Models, Independent Cascade Models, Cascade Prediction.

Unit-V 07 Hrs.

Anomaly Detection in Networks:

Outliers verses network based anomalies. Anomaly in Static Networks: Plain and attributed networks, relational learning, Anomaly in Dynamic Networks: Preliminaries, feature and decomposition-based approaches, Challenges in anomaly detection.

Unit-VI 09 Hrs.

Graphical Representation Learning:

Intuition behind representation learning, representation learning methods.

Graph Convolutional Network (GCN)

and its variations and applications in social network analysis.

Dynamic Graph Convolutional Networks (DGCN) & Continuous-Time Dynamic Graph Neural Networks (CTDGNN): Advanced models for analyzing evolving social networks.

Social Network Analysis Laboratory (RCP23DLPE513)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Creating and analyzing a graph using Social Network and Gephi Tool.
2. Building a network and network measures using NetworkX:
   a) Degree & Degree Distribution
   b) Clustering Coefficients
   c) Node Centrality Measure
3. Implementation of random scale-free network growth model on network science (Barabási-Albert).
4. Implementation of link analysis using the Random Walk PageRank algorithm.
5. Implementation of link prediction using a classification approach.
6. Implementation of local and global link prediction models.
7. Implement the Clique Percolation Method (CPM) for detecting overlapping communities in a given social network graph.
8. To implement and analyze epidemic models.
9. Implementation of Graph Representation Learning for Social Network Analysis Using GCN.
10. Mini Project

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Tanmoy Chakraborty, "Social Network Analysis", 1st Edition, Wiley, 2021.

2. Stephen P Borgatti, Martin G. Everett, Jeffrey C. Johnson, "Analyzing Social Networks", 2nd Edition, Sage Publications Ltd, 2018.

3. William L. Hamilton, "Graph Representation Learning", Morgan & Claypool Publishers, 2020.

Reference Books:

1. Xiaoming Fu, Jar-Der Luo, Margarete Boos, "Social Network Analysis Interdisciplinary Approaches and Case Studies', 1st Edition, CRC Press, 2020.

2. Dr. Krishna Raj P.M., Mr. Ankith Mohan, Dr. Srinivasa K.G, "Practical Social Network Analysis with Python (Computer Communications and Networks)", 1st Edition, Springer, 2019.

3. John Scott, "Social Network Analysis", 4th Edition, SAGE Publications Ltd,2017.

4. Song Yang, Franziska Barbara Keller, Lu Zheng, "Social Network Analysis : Methods and Examples", 1st Edition, SAGE Publications, 2016.

Web Links:

1. A course on Social Network Analysis:
   https://onlinecourses.nptel.ac.in/noc22_cs117/preview

2. Social Network Analysis 101: Ultimate Guide Comprehensive Introduction for Beginners:
   https://visiblenetworklabs.com/guides/social-network-analysis-101/

3. Real-world use cases of Social Network Analysis:
   https://www.latentview.com/social-media-analytics/a-guide-to-social-network-analysis-and-its-use-cases/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: V
Cloud Computing and Security (RCP23DCPE514)		
Cloud Computing and Security Laboratory (RCP23DLPE514)		

Prerequisite: System Fundamentals and Basic Networking

Course Objective(s):

1. Understand the core principles of cloud computing, including parallel and distributed computing concepts, and virtualization techniques.
2. Analyze the architecture of cloud computing, covering cloud service models, types of clouds and key migration strategies.
3. Explore Virtual Private Cloud (VPC) concepts, Elastic Compute Cloud (EC2) services, and their role in cloud infrastructure design and management.
4. Learn cloud-based storage solutions, Database as a Service (DBaaS) offerings, and cloud security measures for data protection.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Demonstrate the ability to differentiate between parallel and distributed computing and understand the role of virtualization in cloud environments.	L2	Understand
CO2	Apply knowledge of cloud architecture to select appropriate cloud service models and types, and perform effective cloud migrations.	L3	Apply
CO3	Analyze the configuration and management of VPCs and EC2 instances to determine best practices in cloud networking and instance management.	L4	Analyze
CO4	Design and implement cloud storage solutions, leverage DBaaS, and ensure robust cloud security using industry-standard practices and AWS security services.	L6	Create

Cloud Computing and Security (RCP23DCPE514) Course Contents

Unit-I 06 Hrs.

Introduction to Cloud Computing:

Principles of Parallel and Distributed Computing: Parallel vs. distributed computing, Elements of parallel computing and Distributed Computing.

Virtualization:

Characteristics of virtualized environments, Taxonomy of virtualization techniques: hosted, baremetal, Hypervisor and Xen Architecture, Para virtualization with Compiler Support, CPU Virtualization, Other Virtualizations: Storage, Network, Desktop and Application Server Virtualization, Virtualization and cloud computing.

Unit-II 06 Hrs.

Cloud Computing Architecture:

The cloud reference model: SAAS, IAAS, PAAS, Types of clouds: Public, Private Hybrid, Community, Economics of the cloud, Open challenges.

Migrating Applications to the Cloud:

Key aspects, cloud migration techniques, phases during migration, cloud emulators.

Unit-III 08 Hrs.

Virtual Private Cloud (VPC):

Introduction to VPC and its benefits, Networking concepts within a VPC (subnets, route tables, security groups) VPC peering and connectivity options , VPC design best practices and considerations.

Elastic Compute Cloud (EC2) Service:

Overview of EC2 and its role in cloud computing, EC2 instance types and families, Provisioning and launching EC2 instances, configuring security groups and key pairs, Managing EC2 instances (start, stop, terminate), Elastic IP addresses and Elastic Network Interfaces (ENIs).

Unit-IV 07 Hrs.

Cloud-Based Storage:

Provisioning Cloud Storage, Amazon S3, Elastic Block Store (ESB), Cloud Storage Interoperability, Exploring Cloud Backup Solutions.

Database as a Service:

Key advantages of Database as a service offering, Amazon Relational Database Service (Amazon RDS), Amazon DynamoDB, Amazon Redshift, Amazon Aurora.

Unit-V 09 Hrs.

Understanding Cloud Security:

Securing the Cloud: The security boundary, Security service boundary, Security mapping, Securing Data: Brokered cloud storage access, Storage location and tenancy, Encryption, Auditing and compliance, Establishing Identity and Presence, Identity protocol standards: Windows Azure identity standards.

Data Protection:

Protect data at rest and in transit, Identify Amazon Simple Storage Service (Amazon S3) protection features, Encrypt data in Amazon S3, Differentiate between client-side encryption (CSE) and server side encryption (SSE), Identify Amazon Web Services (AWS) services that help protect your data.

Unit-VI 06 Hrs.

Administration for Clouds:

The AAA model, single sign-on for clouds, industry implementation for AAA, authentication management standards for controlling access, SAML,authorization management, accounting for resource utilization.

Cloud Computing and Security Laboratory (RCP23DLPE514)

List of Laboratory Experiments

Suggested List of Experiments: (Any 08)

1. Virtualisation: a)Hosted Virtualisation. b)Bare Metal Virtualisation.
2. Host a Static Website on cloud.
3. Create and migrate relational database on cloud.
4. Create a Virtual Private Clouds and establish connections between each other.
5. Implement user level authentication on your cloud applications.
6. Implement Load balancing on your created cloud application.
7. Automate Infrastructure Development.
8. Implement serverless architecture and configure notification services.
9. Implement Hybrid storage and Data Migration.
10. Mini Project (Capstone Project).

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Pravin Mishra, "Cloud Computing with AWS", Apress, 2023.
2. Rajkumar Buyya, " Mastering Cloud Computing", McGraw Hill Education (India), 2017.
3. Sk Singh, "Cloud Computing and AWS Introduction: Mastering AWS Fundamentals and Core Services",Amazon Digital Services, 2024.
4. Ray Rafaels,"Cloud Computing: From Beginning to End," CreateSpace Independent Publishing, 2015.

Reference Books:

1. Dr. Sunilkumar, S. Manvi, "Cloud Computing: Concepts and Technologies", CRC Press, 2021.
2. Temitayo Fagbola, Kamal Kant Hiran, "Cloud Computing: Master The Concepts, Architecture and Applications with Real-World Examples And Case Studies", BPB Publications, 2019.
3. Ricardo Puttini, Thomas Erl, and Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture," Pearson Publication, 2013
4. Michael J Kavis, "Architecting the Cloud," Wiley, 2014.
5. Thomas Erl, Zaigham Mahmood, "Cloud Computing: Concepts, Technology & Architecture", Pearson Education, 2014.

Web Links:

1. A course on Cloud Computing: https://onlinecourses.nptel.ac.in/noc22_cs20/preview
2. A comprehensive guide to Social Network Analysis: https://www.analyticsvidhya.com/blog/2021/04/what-is-cloud-computing/
3. AWS Cloud Services: https://docs.aws.amazon.com//?nc2=h_ql_doc_do

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: V
Computer Communication and Networks (RCP23DCMD501)		
Computer Communication and Networks Laboratory (RCP23DLMD501)		

Prerequisite: Computer System Fundamentals.

Course Objective(s):

1. To provide a foundational understanding of computer networks, their topologies, protocols, and network communication models.
2. To explore the working principles of network layers, including network, transport, and data link layers, along with addressing schemes and routing algorithms.
3. To introduce IoT architecture, communication protocols, and interconnectivity models, emphasizing smart applications and IPv6-based smart networks.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the fundamentals of computer networks, including topologies, protocols, and network models such as OSI and TCP/IP.	L2	Understand
CO2	Apply knowledge of network addressing, subnetting, supernetting, and routing algorithms to design efficient network solutions.	L3	Apply
CO3	Analyze transport and data link layer protocols, error control, and flow control mechanisms to enhance network communication reliability.	L4	Analyze
CO4	Evaluate IoT architectures, communication protocols, and smart networking applications to propose innovative IoT-based solutions.	L5	Evaluate

Computer Communication and Networks (RCP23DCMD501) Course Contents

Unit-I 05 Hrs.

Introduction to Computer Networks:

Basics of Computer Networks, Network Topologies and Protocols, OSI and TCP/IP Models, Network Devices and Components.

Unit-II 08 Hrs.

Data link Layer:

Introduction, transmission medium, physical addressing, Error control (Hamming code, CRC), Flow control, Data-Link Layer Protocols: HDLC, Media Access Control: ALOHA, CSMA, Wired LANs: Ethernet, Wireless LANs.

Unit-III 08 Hrs.

Network Layer:

Services, Packet switching, ARP, RARP, Unicast Routing Algorithms-(DVR, LSR), IPv4 Addressing (Classfull and Classless), Subnetting, Supernetting design problems, IPv4 Protocol, IPV6 protocol.

Unit-IV 09 Hrs.

Transport & Application Layer:

Services, sockets, Transport Layer Protocols - User Datagram Protocol (UDP), Transmission Control Protocol (TCP), ARQ, Sliding Window Protocol. Application layer protocols: HTTP, SMTP, DNS.

Unit-V 06 Hrs.

IoT Architecture and Technologies:

Introduction to the Internet of Things (IoT), IoT Architecture and Components, Communication Protocols for IoT (MQTT, CoAP, etc.).

Unit-VI 06 Hrs.

Interconnecting Smart Objects with IP:

Architecture, IP Protocol Architecture, IPv6 for Smart Object Networks and the Internet of Things, Connectivity Models for Smart Object Networks The applications: Smart Cities and Urban Networks, Home Automation, Structural Health Monitoring

Computer Communication and Networks Laboratory (RCP23DLMD501)

List of Laboratory Experiments

Suggested Experiments:(Any 08)

1. Learn to use commands like tcpdump, netstat, ifconfig, nslookup and traceroute. Capture ping and trace route PDUs using a network protocol analyser.
2. Implementation of an error detection code using CRC.
3. Setting up and configuring routers & switches using CLI.
4. Assigning IP addresses and subnetting a network.
5. Establishing communication between different networks using static and Dynamic routes.
6. To design and configure Virtual Local Area Network and check the communication privacy among different sub networks.
7. Implement applications using TCP sockets like:
   (a) Echo client and echo server
   (b) Chat
   (c) File Transfer
8. Implement IoE based on IPv6 using packet tracer.
9. Simulate the home automation using Packet Tracer.
10. Design and Simulation of a Scalable College Network Using Cisco Packet Tracer.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Practical examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. James Kurose, "Computer Networking:A Top-Down Approach", Pearson Education, 8^{th} Edition, 2022.
2. Behrouz A. Forouzan, " TCP/IP Protocol Suite", McGraw Hill Education ,4^{th} Edition, 2017.

Reference Books:

1. Maciej Kranz, "Building the Internet of Things", by Maciej Kranz, Wiley,1^{st} Edition, 2016.

2. Rajkumar Buyya, Amir Vahid Dastjerdi, and Sriram Venugopal, “Internet of Things: Principles and Paradigms”, Morgan Kaufmann Publishers, 2016.

3. Jean-Philippe Vasseur, “Interconnecting Smart Objects with IP The Next Internet”, Morgan Kaufmann Publishers, 2010.

Web Links:

1. Routing Protocol Information: https://www.cisco.com/c/en/us/support/docs/ip/routing-information-protocol-rip/13788-3.html

2. Transmission of IPv6 Packets over IEEE 802.15.4 Networks: https://datatracker.ietf.org/doc/html/rfc4944

3. IPv6 in IoT: https://pianalytix.com/advantages-of-ipv6-in-iot/

Program: Computer Science and Engineering (Data Science)	T. Y. B.Tech	Semester: V
DevOps Laboratory (RCP23OLOE501)		

Prerequisite: Computer System Fundamentals, Web Engineering and Project Management.

Course Objective(s):

To equip students with fundamental DevOps skills in automation, CI/CD implementation, containerization, orchestration, monitoring, and MLOps integration.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply Virtualization, Containerization, and Infrastructure Automation.	L3	Apply
CO2	Design CI/CD Pipelines and Automated Testing.	L6	Create
CO3	Develop monitoring, logging, and performance enhancement strategies.	L6	Create

DevOps Laboratory (RCP23OLOE501)
Course Contents

Unit-I — 04 Hrs.

Virtualization and Containerization with Docker

1. Install Docker on Linux or Windows.
2. Run a simple container.
3. Build a custom Docker image for a Python web application.
4. Use Docker Compose to run multi-container applications.

Unit-II — 04 Hrs.

Infrastructure as Code with Terraform

1. Install Terraform and configure it locally.
2. Write a Terraform script to provision a virtual machine.
3. Use Terraform modules to reuse infrastructure code.
4. Manage Terraform workspaces for different environments.
5. Destroy and clean up infrastructure after deployment.

Unit-III — 06 Hrs.

Configuration Management with Puppet and Ansible

1. Install Puppet and Ansible on a Linux server.
2. Write a basic Puppet manifest to install a web server.
3. Deploy a LAMP stack using Puppet modules.
4. Write an Ansible playbook to set up users and install software.
5. Use Ansible roles to manage complex configurations.

Unit-IV — 06 Hrs.

Continuous Integration with Jenkins

1. Install Jenkins and set up a basic job.
2. Implement CI/CD pipelines with Jenkins & GitHub Actions.
3. Automate build, test, and deployment processes.
4. Secure CI/CD pipelines using secrets management.
5. Set up SonarQube in a Jenkins pipeline.
6. Vulnerability detection using SonarQube.

Unit-V — 06 Hrs.

Automated Testing using Selenium

1. Install Selenium and set up WebDriver
2. Write Selenium scripts for web UI testing.
3. Automate form submission and validations.
4. Capture screenshots on test failures.
5. Run Selenium scripts on different browsers.
6. Create a Jenkins job to execute Selenium scripts automatically.

Unit-VI 06 Hrs.

DevOps Automation and Scripting

1. Write a Bash script to automate package installation.
2. Develop a Python script to monitor system logs.
3. Schedule automated tasks using cron jobs.
4. Write a script to restart services automatically.
5. Implement a simple chatbot for DevOps automation.

Unit-VII 07 Hrs.

Container Orchestration with Kubernetes

1. Install and set up a local Kubernetes cluster.
2. Deploy a simple Nginx application using Kubernetes.
3. Expose services externally using Kubernetes services.
4. Scale applications dynamically using Kubernetes auto-scaling.

Unit-VIII 05 Hrs.

Traffic Management with Kubernetes Ingress

1. Understand Kubernetes Ingress and its role in routing external traffic.
2. Configure an Ingress resource for multiple services.
3. Implement SSL/TLS termination using Kubernetes secrets.
4. Set up path-based and host-based routing.
5. Test and troubleshoot Ingress rules.

Unit-IX 05 Hrs.

Monitoring and Logging with ELK Stack

1. Install the ELK stack (Elasticsearch, Logstash, and Kibana).
2. Use Logstash to collect logs from a web server.
3. Set up Kibana dashboards to visualize logs.
4. Analyze logs for troubleshooting.

Unit-X 07 Hrs.

MLOps with PyCaret

1. Train a machine learning model using PyCaret.
2. Deploy the model as a REST API using Flask.
3. Automate model retraining using Jenkins pipelines.
4. Monitor ML model performance using the ELK stack.

Text Books:

1. Karl Matthias and Sean P. Kane, "Docker: Up and Running", 3rd Edition, O'Reilly Publication, 2022
2. John Ferguson Smart, "Jenkins, The Definitive Guide", 1st Edition, O'Reilly Publication,2011.
3. Ryan Russell-Yates, "Mastering Puppet 5: Optimize enterprise-grade environment performance with Puppet", 1st Edition, Packt Publishing, 2018
4. Jonathan McAllister, "Master Jenkins", Packt Publishing, 2015.
5. Deepak Gaikwad, Viral Thakkar, "DevOps Tools from Practitioner's Viewpoint", Wiley,2019.
6. Stephane Jourdan, Pierre Pomès ," Infrastructure as Code (IAC) Cookbook",2nd Edition, Packt Publishing, 2017.
7. Martin Alfke , Felix Frank, "Puppet 5 Essentials", 3rd Edition, O'Reilly Publication,2017
8. Yevgeniy Brikman, Terraform: Up & Running, 2nd Edition, O'Reilly, 2019

Reference Books:

1. Sanjeev Sharma and Bernie Coyne, " DevOps for Dummies", 3rd Edition, Wiley Publication,2017
2. Httermann, Michael, "DevOps for Developers", 1st Edition, APress Publication, 2012
3. Joakim Verona, "Practical DevOps", 2nd Edition Packt publication,2018
4. Martin Alfke, " Puppet Essentials - Third Edition: A fast-paced guide to automating your infrastructure", 3rd Revised Edition, Packt Publishing, 2017.

Web Links:

1. Introduction to DevOps:
   https://www.coursera.org/learn/intro-to-devops
2. Learn DevOps:
   Docker, Kubernetes, Terraform and Azure DevOps:
   https://www.udemy.com/course/devops-with-docker-kubernetes-and-azure-devops

3. MLOps for Beginners:

   https://www.udemy.com/course/mlops-for-beginners

   /?srsltid=AfmBOorNfhfo-VtBlnULsdPHYEg6NFisnhct77hRVw4LH7yv9LJUZqcz

4. Free DevOps Course Certification:

   https://intellipaat.com/academy/course/devops-free-course/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Advanced Java Laboratory (RCP23OLOE502)		

Prerequisite: Core Java and OOP concepts.

Course Objective(s):

1. To familiarize students with advanced object-oriented concepts and design patterns in Java for creating scalable applications.
2. To enable students to optimize data handling through the Java Collections Framework, generics, and the Streams API.
3. To equip students with skills to design, build, and secure web applications using Spring and Spring Boot frameworks, with a focus on database connectivity.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply advanced object-oriented concepts and design patterns in Java to develop scalable and maintainable solutions for real-world problems.	L3	Apply
CO2	Analyze data processing and performance using the Java Collections Framework, Streams API,and generics.	L4	Analyze
CO3	Build secure, database-driven web applications using Spring and Spring Boot, with RESTful web services	L6	Create

Advanced Java Laboratory (RCP23OLOE502)
Course Contents

Unit-I 04 Hrs.

Design Patterns:

Introduction to design patterns and Implementation: Singleton, Factory, Observer, Strategy

Unit-II 04 Hrs.

SOLID Principles:

Understanding and applying SOLID principles for better design, Implementation of SOLID Principles.

Interfaces and Abstract Classes:

Demonstration of Advanced uses of interfaces and abstract classes, Default methods in interfaces.

Unit-III 04 Hrs.

Collections:

List: ArrayList, LinkedList, Set: HashSet, Tree Set, Map: HashMap, LinkedHashMap.

Unit-IV 04 Hrs.

Java Streams:

Introduction to Streams API, Creating streams from collections, arrays, I/O Stream operations: map, filter, reduce, collect.

Unit-V 04Hrs.

Java Reflection API:

Understanding the Java Reflection API Accessing and manipulating class properties at runtime, Creating instances of classes dynamically Inspecting methods, fields, Annotations: Predefined, Customized.

Unit-VI 04 Hrs.

Java Database Connectivity (JDBC):

Connecting to databases using JDBC, Executing SQL queries and managing results.

Unit-VII 04 Hrs.

Introduction to Object-Relational Mapping (ORM):

Overview of Hibernate and JPA, Creating a simple application using Hibernate.

Unit-VIII 04 Hrs.

Microservices:

Fundamentals of Microservices, Microservices Architecture & Design Principles.

Tools for Microservices:

Spring Boot, Eureka API Gateway & load balancing between multiple instances of a microservices.

Unit-IX 04 Hrs.

Introduction to Spring:

Overview of Spring Framework features, Inversion of Control (IoC) and Dependency Injection (DI).

Unit-X 05 Hrs.

Spring Core:

Understanding Beans, Application Context, and Bean Lifecycle Configuring Spring with XML and Java annotations.

Unit-XI 05 Hrs.

Introduction to Spring Boot:

Understanding its purpose and advantages over traditional Spring.

Setting Up Spring Boot Applications:

Project structure and configuration.

Unit-XII 05 Hrs.

Building RESTful Web Services:

Creating REST APIs using Spring Boot.

Spring Data JPA:

Introduction to database interactions and repository pattern.

Unit-XIII 05 Hrs.

Securing Spring Boot Applications:

Basics of security in Spring Boot using Spring Security.

Text Books:

1. Mark Heckler, "Spring Boot: Up and Running", O'Reilly Media, 1^{st} Edition, 2021.
2. Craig Walls, Spring in Action, Manning Publications, 6^{th} Edition, 2022.

Reference Books:

1. Herbert Schildt, "Java: The Complete Reference", 13^{th} Edition, McGraw Hill.

2. Dinesh Rajput, “Mastering Spring Boot 2.0”, Packt Publishing, 2nd Edition, 2020.

Web Links:

1. Nptel Course: https://onlinecourses.nptel.ac.in/noc20_cs58/preview
2. Oracle links: https://docs.oracle.com/javase/tutorial/collections/; https://docs.oracle.com/javase/tutorial/jdbc/
3. Spring documentation: https://docs.spring.io/spring-boot/index.html

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Advanced Database Laboratory (RCP23OLOE503)		

Course Objective(s): To provide practical exposure to advanced database technologies, enabling learners to apply distributed, graph, and spatial databases in real-world scenarios.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Design and implement database solutions using advanced, object-oriented, and distributed database systems.	L3	Apply
CO2	Apply query optimization, security, and visualization techniques for efficient and secure data handling.	L3	Apply
CO3	Analyze emerging database technologies like vector and graph databases through practical usecases and case study.	L4	Analyze

Advanced Database Laboratory (RCP23OLOE503) Course Contents

Unit-I 04 Hrs.

Introduction to Modern Databases:

Overview of emerging database paradigms (Document, Columnar, Graph, Objectoriented, Vector DBs). Use-case-based classification of databases.

Unit-II 08 Hrs.

Document-Oriented Databases – MongoDB:

Overview of MongoDB as a Document-Oriented Database, Installing MongoDB, Introduction to MongoDB Compass (GUI) and Mongo Shell, Document-Oriented Data Handling, Work with JSON, XML, Query JSON/XML using inbuilt functions.

Unit-III 04 Hrs.

Distributed DB Design:

Perform fragmentation (Range, List, Hash, Key), Simulate replication and allocation..

Unit-IV 04 Hrs.

Document-Oriented Data Handling:

Work with JSON, XML, Query JSON/XML using inbuilt functions.

Unit-V 04 Hrs.

Query Optimization & Processing:

View Query Execution Plan, Optimize queries using heuristics.

Unit-VI 04 Hrs.

Object-Oriented Database with DB4O:

Store Java objects, Retrieve objects and update DB.

Unit-VII 05 Hrs.

Graph Databases :

Install Neo4j, Create nodes and relationships, Query using Cypher.

Unit-VIII 09 Hrs.

Vector DB :

Vector indexing, Similarity search example app, MongoDB Vector, PG Vector.

Unit-IX 05 Hrs.

Ethical & Legal Issues in Modern Databases:

Explore Real-World Data Breaches, Policy Analysis Activity, Design a Privacy-Compliant Database Schema.

Unit-X 09 Hrs.

Mini Project:

Explore an emerging databse technology such as a Graph or Vector database, Design a small use-case to demonstrate its core concept or application, Analyze its features, benefits, and limitations in comparison to traditional models.

Text Books:

1. Avi Silberschatz, Henry F. Korth, Sudarshan, "Database System Concepts", 7^{th} Edition, Mc Graw Hill, 2021.
2. Sveta Smirnova and Alkin Tezuysal, "My SQL Cookbook" 4^{th} Edition, O'Reilly Publication, 2022.
3. Shannon Bradshaw, Eoin Brazil, "MongoDB: The Definitive Guide - Powerful and Scalable Data Storage", 3^{rd} Edition, O'Reilly Publication, 2020.
4. Christos Tjortjis, "Graph Databases Applications on Social Media Analytics and Smart Cities", 1^{st} Edition, CRC Press, 2023.

Reference Books:

1. Vinicius M. Grippa and Sergey Kuzmichev, "Learning MySQL" 2^{nd} Edition, O'Reilly Publication, 2021.
2. Tamer OEzsu, Patrick V, "Principles of Distributed Database System", Springer Publication, 2020.
3. Jeff Carpenter, Eben Hewitt, "Cassandra: The Definitive Guide - Distributed Data at Web Scale" 3^{rd} Edition, O'Reilly Media, 2020.
4. Alex Petrov, "Database Internals: A Deep Dive into How Distributed Data Systems Work", 1^{st} Edition, O'Reilly Media, 2019.

Web Links:

1. MongoDB Developer Center:
   Advanced Tutorials https://www.mongodb.com/developer/expertise-levels/advanced/tutorials

2. Cassandra: DataStax Academy https://www.datastax.com/dev/academy

3. Neo4j GraphAcademy:

   Advanced Courses https://graphacademy.neo4j.com/categories/advanced/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Semester Project-III (RCP23IPSC501)		

Course Objective(s):

Students are expected to design, simulate/implement a project based on the knowledge acquired from current semester subjects.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze a survey of several available literatures in the preferred field of study.	L4	Analyze
CO2	Describe various/alternate approaches to complete a project.	L2	Understand
CO3	Apply a collaborative project environment by interacting and dividing project work among team members.	L3	Apply
CO4	Use technical communication skills to present project work in the form of a technical report/paper.	L3	Apply
CO5	Apply teamwork and project management skills to plan, execute, and manage the research study.	L3	Apply

Semester Project:

The purpose of semester project is to provide exposure to students with a variety of projects based on the knowledge acquired from the semester subjects. This activity is supposed to enrich their academic experience and bring enough maturity in student while selecting the project. Students should take this as an opportunity to develop skills in implementation, presentation and discussion of technical ideas/topics. Therefore, proper attention shall be paid to the content of semester project report which is being submitted in partial fulfillment of the requirements of the Second Year and it is imperative that a standard format be prescribed for the report.

Each student shall work on project approved by departmental committee approved by the Head of Department, a group of 03 to 05 students (max allowed: 5 students in extraordinary cases, subject to the approval of the department committee and the Head of the department) shall be allotted for each Semester Project. Each group shall submit at least 3 topics for the Semester Project. The departmental committee shall finalize one topic for every group. Semester Project Title or Theme should be based on knowledge acquired during semester. The project work shall involve sufficient work so that students get acquainted with different aspects of knowledge acquired from semester subjects.

Student is expected to:

- Select appropriate project title based on acquired knowledge from current semester subjects.
- Maintain Log Book of weekly work done(Log Book Format will be as per Table 1).
- Report weekly to the project guide along with log book.

Assessment Criteria:

- At the end of the semester, after confirmation by the project guide, each project group will submit project completion report in prescribed format for assessment to the departmental committee (including project guide).
- Assessment of the project (at the end of the semester) will be done by the departmental committee (including project guide).

Prescribed project report guidelines:

Size of report shall be of minimum 25 pages. Project Report should include appropriate content for:

- Introduction
- Literature Survey
- Related Theory
- Implementation details

- Project Outcomes
- Conclusion
- References

Assessment criteria for the departmental committee (including project guide) for Continuous Assessment:

Guide will monitor weekly progress and marks allocation will be as per Table 2.

Assessment criteria for the departmental committee (including project guide) for End Semester Exam:

Departmental committee (including project guide) will evaluate project as per Table 3.

Table 1: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				
2				

Table 2: Continuous Assessment Table

Sr	Exam Seat No	Name of Student	Student Attendance	Log Book Maintenance	Literature Review	Depth of Understanding	Report	Total
			5	5	5	5	5	25

Table 3: Evaluation Table

Sr	Exam Seat No	Name of Student	Project Selection	Design/ Methodology	Implementation	Result Verification	Presentation	Total
			5	5	5	5	5	25

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech	Semester: V
Constitution of India (RCP23ICHSX07)		

Prerequisite: Nil

Course Objective(s):

1. To provide basic information about Indian constitution.
2. To identify individual role and ethical responsibility towards society.
3. To understand human rights and its implications.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the historical background, philosophy, and salient features of the Indian Constitution.	L2	Understand
CO2	Interpret the fundamental rights, duties, and directive principles enshrined in the Constitution for responsible citizenship.	L2	Understand
CO3	Describe the structure, roles, and functions of the legislative, executive, and judiciary branches of government.	L2	Understand
CO4	Analyze the federal structure, center-state relations, and constitutional provisions for governance and emergency powers.	L4	Analyze
CO5	Apply constitutional principles to contemporary socio-political and legal issues, fostering ethical and democratic values.	L3	Apply

Constitution of India (RCP23ICHSX07)
Course Contents

Unit-I 02 Hrs.

Introduction to the Constitution of India :

The Making of the Constitution and Salient features of the Constitution. Preamble to the Indian Constitution. Fundamental Rights & its limitations.

Unit-II 02 Hrs.

Directive Principles of State Policy:

Relevance of Directive Principles, State Policy, Fundamental Duties. Union Executives – President, Prime Minister, Parliament, Supreme Court of India.

Unit-III 03 Hrs.

State Executives:

Governor, Chief Minister, State Legislature, High Court of State. Electoral Process in India, Amendment Procedures, 42^{nd}, 44^{th}, 74^{th}, 76^{th}, 86^{th} & 91^{st} Amendments.

Unit-IV 02 Hrs.

Special Provisions:

For SC & ST, Special Provision for Women, Children & Backward Classes, Emergency Provisions.

Unit-V 03 Hrs.

Human Rights:

Meaning and Definitions, Legislation Specific Themes in Human Rights, Working of National Human Rights Commission in India, Powers and functions of Municipalities, Panchayats and Co-Operative Societies.

Unit-VI 02 Hrs.

Scope & Aims of Engineering Ethics:

Responsibility of Engineers and Impediments to Responsibility. Risks, Safety and liability of Engineers. Honesty, Integrity & Reliability in Engineering.

Text Books:

1. Durga Das Basu, "Introduction to the Constitution on India", Student Edition, Prentice –Hall EEE, 19^{th}/ 20^{th} Edition, 2001.
2. Charles E. Haries, Michael S Pritchard and Michael J. Robins, "Engineering Ethics", Thompso

Asia, 2003.

Reference Books:

1. M.V.Pylee, "An Introduction to Constitution of India", 3rd Edition, Vikas Publishing, 2002.
2. M.Govindarajan, S.Natarajan, V.S.Senthilkumar, "Engineering Ethics", Prentice – Hall of India Pvt. Ltd. New Delhi, 2013.
3. Brij Kishore Sharma, " Introduction to the Constitution of India", 7th Edition, PHI Learning Pvt. Ltd., New Delhi, 2011.
4. Latest Publications of Indian Institute of Human Rights, New Delhi.

Web Resources

1. www.nptel.ac.in
2. www.hnlu.ac.in
3. www.nspe.org
4. www.preservearticles.com

Evaluation Scheme:

1. Student should submit a report on the case study declared by teacher.
2. Audit point shall be awarded subject to submission of report of the case study declared by teacher.

Semester - VI

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Machine Learning – III (Reinforcement Learning) (RCP23DCPC601)		
Machine Learning – III (Reinforcement Learning) Laboratory (RCP23DLPC601)		

Prerequisite: Machine Learning-I, Machine Learning-II and Artificial Intelligence.

Course Objective(s):

1. To make students learn to build programs that act in a stochastic environment, based on past experience using various Reinforcement Learning methods.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze basic and advanced Reinforcement Learning techniques.	L4	Analyze
CO2	Describe suitable learning tasks to which Reinforcement learning and Deep Reinforcement Learning techniques can be applied.	L2	Understand
CO3	Apply appropriate Reinforcement Learning method to solve a given problem.	L3	Apply

Machine Learning – III (Reinforcement Learning) (RCP23DCPC601) Course Contents

Unit-I 04 Hrs.

Introduction:

Reinforcement Learning (RL), Elements of Reinforcement Learning, Reinforcement Learning Vs Supervised Learning, Approaches of solving Reinforcement Learning: Value based, policy based, model based, Exploration - Exploitation dilemma, Evolutionary methods, Immediate Reinforcement Learning.

Unit-II 06 Hrs.

Immediate Reinforcement Learning:

Bandit Problems: Bandit problems, Value-action based methods (sample average), Greedy method, ϵ-greedy method, Incremental Implementation, Non-stationary problem, Optimistic Initial values, UCB algorithm, Thompson Sampling.

Policy Gradient Approaches: Linear reward Penalty Algorithm, Parameterized policy representation(θ), Evaluation of policy((θ)), REINFORCE algorithm.

Unit-III 08 Hrs.

Full Reinforcement Learning:

Difference between Immediate and Full Reinforcement Learning, Agents and Environment, Goals, Rewards, Returns, Policy in Full Reinforcement Learning, Episodic and Continuing Tasks.

Markov Decision Process (MDP)

Markov Property, Finite Markov Decision Process, Value functions, Bellman'sequations, optimal value functions, Definition of MDP in Reinforcement Learning, Solution of the Recycling Robot problem

Unit-IV 08 Hrs.

Dynamic Programing:

Policy evaluation, policy improvement, policy iteration, value iteration, Asynchronous Dynamic Programing, bootstrap, full back up.

Monte Carlo Method:

Advantages of Monte Carlo over Dynamic Programing, Monte Carlo Control, on-policy, off- policy, Incremental Monte Carlo, Issues/Assumptions in Monte Carlo Methods, Solution of BlackJack using Monte Carlo Method.

Unit-V 08 Hrs

Temporal Difference Learning:

What is Temporal Difference learning, Advantages of Temporal Difference methods over Monte Carlo and Dynamic Programming methods, TD (0), On-policy vs off-policy, SARSA, Q learning.

Eligibility traces:

N-step Temporal Difference methods, On-line vs Off-line updation, TD(λ): forward view, backward view, Traces: Accumulating trace, Dutch trace, Replacing trace, Equivalence of forward and backward view, SARSA(λ).

Unit-VI 08 Hrs.

Deep Reinforcement Learning:

Function Approximation:

Drawbacks of tabular implementation, Function Approximation, Gradient Descent Methods, Linear parameterization, Policy gradient with function approximation.

Deep Reinforcement Learning:

Intro of Deep Learning in Reinforcement Learning, Deep learning training workflow, Categories of Deep learning, Deep Q-Network, Ways of improving Deep Q-Network, REINFORCE in Full Reinforcement Learning, Actor-Critic Algorithm, A2C, A3C, DDPG. Proximal Policy Optimization (PPO).

Machine Learning – III (Reinforcement Learning) (RCP23DLPC601)

List of Laboratory Experiments

Suggested Experiments(At Least 08)

1. Bandit Problem:
    - Implement Greedy and Epsilon greedy methods.
    - Comparison between Greedy and Epsilon Greedy Policy.
    - UCB: Upper Confidence Bound.
2. Policy Gradient (Convergence)
    - Implement REINFORCE algorithm on a CartPole/ Lunar Lander.
3. Dynamic Programming and Monte Carlo Methods.
    - Implementation of GridWorld using Dynamic Programming.
    - Jack's Car Rental using Dynamic Programming.
    - Gamblers Problem using Dynamic Programming.

- BlackJack using Monte Carlo.
- Race Track Problem.

4. Temporal Difference.
   - Implement Frozen Lake using SARSA.
   - Implement Grid world using Q learning.
5. Deep Reinforcement Learning.
   - Compare the performance of Reinforcement Learning and Deep Reinforcement Learning on a Cart pole. problem.
   - Implementation of Deep Q-Network algorithm.
   - Actor Critic: Find the optimal policy using the Actor Critic method.
   - Analyze the effects of PPO's clipping parameter and learning rate on policy stability and convergence

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction", MIT Press, 2nd Edition, 2022.
2. Laura Graesser Wah Loon Keng, "Foundations of Deep Reinforcement Learning", Pearson Education, 1st Edition, 2020.

Reference Books:

1. Phil Winder, "Reinforcement Learning Industrial Applications of Intelligent Agents", O'Reilly, 1st Edition, 2020.
2. Csaba Szepesvari, "Algorithms for Reinforcement Learning," Morgan Claypool Publishers, 1st Edition, 2019.
3. Enes Bilgin, "Mastering Reinforcement Learning with Python", Packt publication, 1st Edition, 2020.
4. Brandon Brown, Alexander Zai, "Deep Reinforcement Learning in Action", Manning Publications, 1st Edition, 2020.
5. Micheal Lanham, "Hands-On Reinforcement Learning for Games," Packt Publishing, 1st Edition, 2020

6. Abhishek Nandy, Manisha Biswas, "Reinforcement Learning: With Open AI, TensorFlow and Keras using Python," Apress, 1st Edition, 2018.

Web Links:

1. NPTEL Course in Reinforcement Learning: https://onlinecourses.nptel.ac.in/noc22 cs75/preview
2. Reinforcement Learning Course (Stanford University): https://www.youtube.com/watch?v=FgzM3zpZ55o
3. AI Games with Deep Reinforcement Learning: https://towardsdatascience.com/how-to-teachan-ai- to-play-games-deep reinforcement-learning-28f9b920440a
4. Deep Reinforcement Learning: https://www.v7labs.com/blog/deep-reinforcement-learning-guide

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Natural Language Text Processing (RCP23DCPC602)		
Natural Language Text Processing Laboratory (RCP23DLPC602)		

Prerequisite: Machine Learning-II, Foundations of Data Analysis, Statistics for Data Science.

Course Objective(s):

1. To introduce basics of language computation fundamental through morphological computation, syntax,semantic and discourse analysis. Apply these concepts to develop Computational Models for Real World Applications.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply appropriate pre-processing techniques on linguistic data.	L3	Apply
CO2	Analyze different Machine Learning and deep learning algorithms to develop applications based on natural language processing.	L4	Analyze
CO3	Evaluate Natural Language Processing Applications.	L5	Evaluate

Natural Language Text Processing (RCP23DCPC602) Course Contents

Unit-I 05 Hrs.

Introduction:

Generic Natural Language Processing (NLP) system, levels of NLP, Knowledge in language processing, Ambiguity in Natural language, stages in NLP, challenges of NLP, Applications of NLP Machine Translation, Sentiment Analysis etc.

Text Processing:

Word Tokenization and Segmentation, Lemmatization, Bag of words, N-gram language model, N-gram for spelling correction. Edit distance – Dynamic Programming Approach, Weighted Edit Distance, Finding Dictionary Entries with Small Edit Distances, Noisy Channel Model, Non-word errors Real-word errors. Evaluation of Language Models, Basic Smoothing, Advanced Smoothing Models. Advanced: Perplexity's Relation to Entropy.

Unit-II 09 Hrs.

Computational Semantics and Semantic Parsing:

Vector Semantics: Words and Vectors, Term Frequency-Inverse Document Frequency (TFIDF), Word2vec, Continuous Bag of Words, ELMO, GloVe Vector Visualizing Embedding's, Semantic properties of embedding's, Bias and Embedding's Evaluating Vector Models, Cosine for measuring similarity, Pointwise Mutual Information (PMI), PPMI vector models.

Lexical Semantics: Word Senses -Relations Between Senses, WordNet: A Database of Lexical Relations, Word Sense Disambiguation Alternate WSD algorithms and Tasks.

Unit-III 05 Hrs.

Text Classification:

Text classification definition and datasets, Generative text classifiers (Naïve Bayes) Discriminative text classifiers (Support Vector Machine), Bag-of-words Generative Classifier, BOW Discriminative Model, Multi-class Classification: Softmax, Gradient Descent, Statistical significance testing, Dataset understanding and creation.

Unit-IV 07 Hrs.

Recurrent Neural Networks:

Recurrent Neural Network, RNNs as Language, RNNs for Sequence Classification, Stacked Recurrent Neural network, Bidirectional RNNs, Managing Context in RNNs: Long Short-Term Memory (LSTMs) and gated Recurrent Unit (GRUs).

Unit-V 12 Hrs.

Computational Morphology and Syntax Analysis:

Computational Morphology:

Morphological Processes, Morphological Analysis- Inflectional morphology Derivational morphology, Regular expression, Finite State Automata, Finite State Transducer, Morphological parsing with FST, Lexicon free FST Porter stemmer, and two-level morphology.

Syntax Analysis:

Introduction to POS Tagging, Probabilistic Tagging, Markov Models, Hidden Markov Models (HMM) for POS Tagging, Conditional Random Fields (CRF), Named Entities and Named Entity Tagging, Context-Free Grammars-Derivation, Constituency Parsing, Dependency Parsing.

Unit-VI 4 Hrs.

Discourse Coherence:

Coherence Relation, Discourse Structure Parsing, Centring and Entity-Based Coherence, Global Coherence.

Natural Language Text Processing Laboratory (RCP23DLPC602)

List of Laboratory Experiments

Suggested Experiments(At Least 08)

1. Perform Pre-processing steps in Natural language Processing (Tokenization, Stop Word detection, Stemming and Lemmatization.
2. Implement Parts of Speech tagging using HMM
3. Implement word-embedding and TF-IDF vectors in Natural language Processing
4. Implement language model using Ngram language model
5. Generate recursive set of sentences using Context Free Grammar. Identify the word senses using "synset" in NLTK
6. Implement Spelling Check, Spelling Correction and Auto complete using Language models or CFG.
7. Implement a Spam classifier in Natural Language Processing
8. Implement Fake News Classifier Using LSTM-Deep Learning in NLP
9. Implement a Sentiment Analysis in Natural Language Processing

10. Implement NLP application on Regional Language
11. Implement Question Answering in NLP
12. Implement Chatbot in NLP
13. Implement Information Retrieval for extracting Text from Webpages and Images
14. Mini Project

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Jurafsky and Martin, "Speech and Language Processing", Prentice Hall, 3rd Edition, 2020.
2. Uday Kamath, "Deep Learning for NLP and Speech Recognition", 1st Edition, 2019.

Reference Books:

1. Jelinek, F., "Statistical Methods for Speech Recognition", The MIT Press, 2022.
2. Yuli Vasiliev, "Natural Language Processing with Python and spaCy - A Practical Introduction", No Starch Press, 2022.
3. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana, "Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems", O'Reilly, 1st Edition, 2020.

Weblinks:

1. Virtual Lab: -https://nlp-iiith.vlabs.ac.in/
2. Virtual Lab:-http://vlabs.iitb.ac.in/vlabs dev/vlab_bootcamp/bootcamp/The_Big_Bang_Nerds/index.html
3. Nptel Course: - https://nptel.ac.in/courses/106105158

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Advanced Statistics Laboratory (RCP23DLPC603)		

Prerequisite: Statistics for Data Science, Python and Machine Learning.

Course Objective(s):

1. This course introduces the theoretical and computational foundations of statistical inference, covering parameter estimation, hypothesis testing, and model diagnostics. It integrates classical, Bayesian, and nonparametric approaches with resampling and model assessment techniques to enable robust, data-driven decision-making.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Interpret and evaluate estimators under classical and Bayesian paradigms.	L2	Understand
CO2	Apply and interpret hypothesis tests for linear and logistic regression models.	L3	Apply
CO3	Apply nonparametric testing methods when parametric assumptions fail.	L3	Apply
CO4	Examine model performance and generalization.	L3	Apply
CO5	Use statistical reasoning with computational implementation.	L3	Apply

Advanced Statistics Laboratory (RCP23DLPC603) Course Contents

Unit-I 06 Hrs.

Estimation Theory Fundamentals:

- Estimation of Parameters using Maximum Likelihood Estimation (MLE) and Method of Moments.
- Estimate μ for a Normal (μ, σ^2) using MLE and compute Cramér–Rao Lower Bound (CRLB).
- Derive MLE for Bernoulli(p), Normal Distributions and analyze estimator properties.

Unit-II 04 Hrs.

Linear Regression Inference & Hypothesis Testing:

- Fit and Evaluate a Simple Linear Regression Model using t-test, F-test, and Confidence Intervals for Coefficients.
- Compare Nested and Non-Nested Regression Models using Likelihood Ratio, AIC, and BIC Criteria.

Unit-III 04 Hrs.

Regression Diagnostics and Model Assumptions:

- Perform Regression Diagnostics: Multicollinearity (VIF) and Normality Tests on Residuals.
- Detect and Correct Heteroscedasticity using Breusch–Pagan Test, White Test, and Log/Weighted Least Squares Transformations.

Unit-IV 06 Hrs.

Logistic Regression and GLMs:

- Estimate and Interpret Logistic Regression Coefficients, Odds Ratios, and Model Fit using Hosmer–Lemeshow Test and Pseudo-R^2.
- Extend Logistic Regression to Generalized Linear Models (GLMs) using Different Link Functions and Evaluate Model Deviance.

Unit-V 6 Hrs.

Multinomial Logistic and Generalized Models:

- Model Count Data using Poisson Regression under the Generalized Linear Models (GLMs) Framework.

- Fit and Interpret Multinomial and Ordinal Logistic Regression Models.
- Compare Logit and Probit Link Functions within the Exponential Family of GLMs.

Unit-VI 06 Hrs.

Nonparametric Hypothesis Testing:

- Compare Two Independent Samples using Mann–Whitney U and Wilcoxon Rank-Sum Tests.
- Perform Goodness-of-Fit Testing using Kolmogorov–Smirnov and Chi-Square Tests.
- Construct Bootstrap-Based Confidence Intervals and Conduct Nonparametric Inference.

Unit-VII 04 Hrs.

Bayesian Inference:

- Perform Bayesian Estimation for Normal and Binomial Models using Conjugate Priors and Credible Intervals.

Unit-VIII 04 Hrs.

Markov Chain Monte Carlo (MCMC) Techniques :

- Implement MCMC Methods (Metropolis–Hastings and Gibbs Sampling) for Posterior Inference using PyMC/Stan.
- Analyze Convergence Diagnostics and Visualize Posterior Distributions using Trace and Density Plots.

Unit-IX 02 Hrs.

Advanced Bayesian Methods:

- Perform Bayesian Regression.
- Model Comparison using Posterior Predictive Checks and Information Criteria.
- Model Comparison (e.g., WAIC, LOO).

Unit-X 02 Hrs.

Bayesian Hypothesis Testing:

- Bayes Factors (BF and BF)
- Posterior Odds vs. Prior Odds
- Evidence Interpretation Scale (Jeffreys scale)
- Bayesian One-Sample Two-Sample Tests (Mean difference)
- Bayesian A/B Testing (Beta-Binomial model)

- Hypothesis Testing using Credible Intervals

Unit-XI 06 Hrs.

Uncertainty Quantification and Resampling:

- Integrate Frequentist, Bayesian, and Resampling Approaches using Cross-Validation, Bootstrapping, and Permutation Methods.
- Quantify Uncertainty through Confidence vs. Credible Intervals and Posterior Predictive Checks.
- Integrate Frequentist, Bayesian, and Resampling Approaches using Cross-Validation, Bootstrapping, and Permutation Methods.

Unit-XII 02 Hrs.

High-Dimensional Inference:

- Perform High-Dimensional Inference with Multiple Testing Corrections.
- Benjamini–Hochberg FDR.

Unit-XIII 04 Hrs.

Causal Inference, and Regularization Techniques:

- Apply Causal Inference and Regularization Methods:
- Propensity Scores.
- Instrumental Variables
- Ridge, Lasso, and Elastic Net.

Text Books:

1. G. Casella R. L. Berger, "Statistical Inference", 2^{nd} Edition, Cengage Learning (2021).
2. Gelman, J. B. Carlin, H. S. Stern, D. B. Dunson, A. Vehtari, and D. B. Rubin, "Bayesian Data Analysis", CRC Press, 4^{th} Edition, 2025.
3. B. Efron and R. J. Tibshirani, "An Introduction to the Bootstrap, Chapman" & Hall/CRC, Reprint Edition, 2003.
4. Agresti, "Categorical Data Analysis", Wiley, 3^{rd} Edition, 2013.

Reference Books:

1. G. James, D. Witten, T. Hastie, and R. Tibshirani, "An Introduction to Statistical Learning with Applications in R", Springer, 2^{nd} Edition, 2021.
2. C. M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.

3. R. McElreath, "Statistical Rethinking: A Bayesian Course with Examples in R and Stan", CRC Press, 2nd Edition, 2020.

4. C. Davison and D. V. Hinkley, "Bootstrap Methods and Their Application", Cambridge University Press, Reprint Edition, 2006.

Web Links:

1. L. Wasserman, All of Statistics: A Concise Course in Statistical Inference, Springer, 2004. All of Statistics: A Concise Course in Statistical Inference — SpringerLink

2. Bayesian Data Analysis in Python Course with Datacamp. Data Analytics A-Z with Python — Udemy

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Applied Data Science Engineering Laboratory (RCP23DLMD601)		

Prerequisite: Foundations of Data Analysis, Database Systems, Python Laboratory.

Course Objective(s):

1. To introduce students to the fundamentals of big data processing, analytics, and performance monitoring tools.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze large-scale datasets on real-time messaging workflows using Hadoop, HDFS, MapReduce, and AMPS.	L4	Analyze
CO2	Develop data processing pipelines using ML models, and evaluate model drift using Apache Spark.	L6	Create
CO3	Evaluate system metrics, KPIs, and workflows using Prometheus, Grafana, and Apache Airflow.	L5	Evaluate

Applied Data Science Engineering Laboratory (RCP23DLMD601) Course Contents

Unit-I 02 Hrs.

Introduction to Big Data and Hadoop:

- Big Data Concepts and Hadoop Architecture.
- Core Hadoop Components.
- Hadoop Ecosystem.
- Data profiling and documentation (EDA).

Unit-II 02 Hrs.

Hadoop Distributed File System:

- Understand Hadoop Distributed File System (HDFS) architecture and commands.
- Introduction to MapReduce.
- Write and run a basic MapReduce program (WordCount).
- View MapReduce job output and logs.

Unit-III 04 Hrs.

Messaging Services using AMPS:

- Real-time messaging using AMPS.
- Pub / Sub models.
- Using SOW Topics and Historical Replay in AMPS.
- Filtering, Message Queuing and Expiration/Acknowledgement in AMPS.
- Complete Real-Time Messaging Workflow with AMPS: From Publish to SOW.

Unit-IV 04 Hrs.

Introduction to Apache Spark:

- Apache Spark ecosystem.
- Setup and shell.
- Setup and shell.
- Real-time and Batch processing of high volume of data.

- Processing high volume records in-memory (SQL).

Unit-V 4 Hrs.

Data analytics and Visualization:

- Spark Dataframe
- Build a classification pipeline using MLlib.
- Apply feature transformers/regression model.
- Data visualization using GraphX / Graph Frames.

Unit-VI 02 Hrs.

Model Drift:

- Introduction to Model Drift.
- Types of Model Drift.
- Drift Detection Techniques: Statistical tests, PSI, and distribution analysis.
- Implementing Drift Detection using Apache Spark.

Unit-VII 02 Hrs.

Prometheus – Metric Instrumentation and Monitoring:

- Learn to install and configure Prometheus
- Instrument an application or system for metrics collection
- Scrape metrics using Prometheus.
- Configure alerts using Alertmanager.

Unit-VIII 02 Hrs.

Grafana – Dashboard Visualization:

- Connect Grafana to Prometheus data source.
- Create dashboards with time-series graphs, heatmaps, and charts.
- Configure alerts in Grafana dashboards
- Visualize trends and analyze system/application performance

Unit-IX 02 Hrs.

Performance Indicator:

- Gather structured data from Grafana dashboards.

- Identify all Key performance indicators (KPIs).
- Build a KPI matrix linking technical, operational, and business KPIs.
- Present KPIs as insights to business stakeholders.

Unit-X 04 Hrs.

Apache Airflow:

- Install and configure Apache Airflow
- Create a Cron-based scheduled workflow (Airflow Cron Job).
- Configure and schedule a recurring job using Cron expressions.
- Monitor DAG execution performance through Airflow's UI.

Text Books:

1. Thompson Carter," Big Data with Hadoop and Spark: Analyze Massive Datasets with Apache Hadoop, Spark, and NoSQL" , 2024.
2. Steven L. Brunton , J. Nathan Kutz, "Data Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control" , Cambridge University Press (2^{nd} Edition 2022).

Reference Books:

1. Tanvir Habib Sardar , Bishwajeet Kumar Pandey, "Big Data Computing: Advances in Technologies, Methodologies, and Applications", 2023.
2. William Hegedus, "Mastering Prometheus", 2024.
3. Julian de Ruiter, Ismael Cabral, "Data Pipelines with Apache Airflow", 2^{nd} Edition, 2024.

Web Links:

1. https://www.udemy.com/course/grafana-tutorial
2. https://www.pluralsight.com/courses/prometheus-grafana-building-dashboards-data
3. https://airflow.apache.org/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Time Series Analysis (RCP23DCPE611)		
Time Series Analysis Laboratory (RCP23DLPE611)		

Prerequisite: Probability, Statistics and Linear Models.

Course Objective(s):

1. Learn basic analysis of time series data; concepts in time series regression, auto-regressive and model averaging models, learn basic concepts of spectral analysis and space-time models.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Interpret a correlogram and a sample spectrum	L2	Understand
CO2	Apply appropriate model for a time series dataset.	L3	Apply
CO3	Calculate forecasts for a variety of linear and non-linear methods and models.	L3	Apply

Time Series Analysis (RCP23DCPE611)
Course Contents

Unit-I 06 Hrs.

Introduction:

Types of forecasting methods, Types of Time Series, simple descriptive techniques, trends in time series (Parametric trends, differencing, nonparametric methods, noise), seasonality.

Stationary Time Series:

Formal definition of a time series, the sample mean and its standard error, Stationary processes: types of stationarity, statistical inference of time series.

Unit-II 06 Hrs.

Linear Time Series:

Motivation, Linear time series and moving average models, The AR model, simulating from an autoregressive process, The ARMA model, The ARIMA model, Unit roots, integrated and non-invertible processes, Box – Jenkins Model Selection, Seasonality, The SARIMA model.

Unit-III 08 Hrs.

Prediction:

Using prediction in estimating, forecasting for autoregressive processes, forecasting for AR, forecasting for general time series using infinite past, One-step ahead predictors based on the finite past: Levinson -Durbin algorithm; Forecasting for ARMA processes, State space model, The Kalman filter.

Automated Forecasting Systems:

Auto-ARIMA, Auto Prophet, Auto ML for time series, Integration of Auto ML and Hashing for Time Series Forecasting.

Unit-IV 10 Hrs.

Models with Trend:

Removing trend, Unit Root and Regression Residuals, The Monte Carlo Method, Dickey-Fuller tests.

Multi equation Time Series Models:

Intervention Analysis, ADLs and Transfer Functions, Introduction to VAR, Vector Error Correction Model (VECM), Structural VAR (SVAR), Time-Varying Parameter VAR, Bayesian VAR (BVAR).

Unit-V 6 Hrs.

Multivariate Time Series:

Background: Sequences and Functions, Convolution, Spectral Representations and mean squared errors; Multivariate time series regression: Conditional independence, Partial correlation and coherenc

between time series.

Unit-VI 06 Hrs.

Non Linear Time series:

The ARCH model: Feature of an ARCH, Existence of a strictly stationary solution, The GARCH model: Existence of stationary solution of a GARCH(1,1) and Bilinear models: Bilinear auto regression model(BAR), Advanced Nonlinear Models: Stochastic Volatility (SV) models, Nonlinear Autoregressive Models (NAR, NARX).

Time Series Analysis Laboratory (RCP23DLPE611)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Time Series Characteristics: Time Series Data, Cross-Section Data, Panel data/ Longitudinal data.
2. Trends: (1) Detecting trends using Hodrick -Prescott Filter. (2) Detrending a Time Series
3. Seasonality: (1) Multiple Box Plots (2) Autocorrelation Plot (3) Deseasoning of Time-Series Data (4) Seasonal Decomposition (5) Detecting Cyclic Variations
4. Data Wrangling and Preparation for Time Series Data.
5. Smoothing Methods: Simple exponential, Double exponential and Triple exponential.
6. Making Data Stationary: Plots, Summary Statistics, Statistics Unit Root Tests, Augmented Dickey – Fuller Test.
7. Automated Forecasting Systems using Auto-ARIMA.
8. Prophet, AutoML.
9. Multivariate Time Series Analysis using VAR,VECM,SVAR modeling
10. Evaluation and Model Selection for Time Series Forecasting (Compare ARIMA vs XGBoost vs other candidate models using metrics like RMSE, MAE, and MAPE).

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Walter Enders," Applied Econometric Time Series" , Fourth Edition, Wiley, 2014.

2. B. V. Vishwas and Ashish Patel, "Hands-on Time Series Analysis with Python", First Edition, Apress, 2020.

Reference Books:

1. Chris Chatfield, "Time- Series Forecasting", First Edition, Chapman & Hall/CRC, 2001.

2. Douglas C. Montgomery, Cheryl L. Jennings and Nurat Kulahci, "Introduction to Time Series Analysis and Forecasting", Second Edition, Wiley, 2015.

3. Aileen Nielsen, "Practical Time Series Analysis", O'Reilly, 2019.

4. James D Hamilton, "Time Series Analysis", Princeton University Press, 1994.

5. Robert H. Shumway and David S. Stoffer, "Time Series Analysis and Its Applications", Springer, 2000.

Web Links:

1. A course on Time Series Analysis. https://caciitg.com/resources/tsa/

2. A comprehensive guide to Time Series Analysis. https://www.analyticsvidhya.com/blog/2021/10/a-comprehensive-guide-to-time-series-analysis/

3. The Complete Guide to Time Series Analysis and Forecasting. https://towardsdatascience.com/the-complete- guide-to-time-series-analysis-and-forecasting-70d476bfe775

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Analysis of AI Algorithms (RCP23DCPE612)		
Analysis of AI Algorithms Laboratory (RCP23DLPE612)		

Prerequisite: Data Structures, Design and Analysis of algorithms, Machine Learning.

Course Objective(s):

1. The course aims to develop analytical skills to understand algorithmic foundations, complexity, and performance trade-offs in designing efficient intelligent systems. It also equips students to apply, analyze, and evaluate data structures, optimization, probabilistic, randomized, and approximation algorithms for solving computationally complex AI problems effectively.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze algorithmic and computational complexity foundations, including time–space trade-offs and machine-learning model complexities during training and testing phases.	L4	Analyze
CO2	Apply various searching, indexing, and data-structuring techniques such as hash-based search, trees, graphs, and spatial indices to develop efficient retrieval and reasoning systems in AI.	L3	Apply
CO3	Evaluate advanced optimization, probabilistic, randomized, and approximation algorithms to address complex AI problems considering efficiency, convergence, and scalability aspects.	L5	Evaluate

Analysis of AI Algorithms (RCP23DCPE612) Course Contents

Unit-I 04 Hrs.

Algorithmic and Complexity Foundations:

Review of algorithm analysis: Time and space complexity Complexity classes: P, NP, NP-hard, NP-complete Trade-offs in AI algorithm design (accuracy, scalability, efficiency)

Complexity Analysis of Machine Learning Algorithms:

Training Time Complexity and Testing Time Complexity, Train/Test Complexity of Linear Regression, Train/Test Complexity of Random Forest, Train/Test Complexity of Naïve Bayes Classifier, Train/Test Complexity of SVM

Unit-II 06 Hrs.

Searching and Indexing for AI:

Linear, Binary, Hash-based Searching, Heuristic Search, Search problems: Sliding tile puzzles, the Rubik's Cube, Sokoban, Inverted index and TF-IDF Vector space models and similarity search. High-dimensional indexing: KD-Trees, Ball Trees, Approximate Nearest Neighbor (ANN) search and LSH, Modern AI retrieval systems - IVF, FNSW/HNSW (FAISS, Annoy, ScaNN).

Unit-III 08 Hrs.

Graphs and Trees in AI:

Flow networks and Ford–Fulkerson algorithm, Bipartite matching and Hungarian algorithm, Minimum spanning trees and disjoint sets. Tries, Tango tree, R Tree, Splay Tree, 2-3 Tree, Max spanning Tree, Binomial tree, and Binomial Heap, Operations on binomial heap.

Unit-IV 12 Hrs.

Optimization Algorithms:

Kernel Trick, Advanced First-Order Optimization Methods: Momentum and Gradient Methods (MGD, NAG, AdaGrad, RMSProp) Quasi Newton's Method, Hessian Approximation. (BFGS / L-BFGS) Swarm-based algorithms: PSO, ACO, GA, Differential Evolution Exploration vs. exploitation, convergence, and complexity trade-offs

Unit-V 6 Hrs.

Probabilistic Randomized Algorithms:

Probabilistic data structures: Bloom Filters, Count-Min Sketch, LogLog and HyperLogLog, random projections, and the Johnson–Lindenstrauss Lemma Randomized Algorithms: Monte Carlo and Las Vegas algorithm, Randomized gradient methods, Randomized matrix algorithms and sketchin

Markov Chain Monte Carlo (MCMC), Gibbs sampling.

Unit-VI 06 Hrs.

Approximation Algorithms:

Approximation ratios and performance bounds, Low-rank matrix decomposition (SVD, PCA, NMF), Semi-definite programming and convex relaxations Applications in recommendation systems and clustering

Analysis of AI Algorithms Laboratory (RCP23DLPE612)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Analyze and demonstrate how kernel functions map data to higher dimensions for better separability.
2. Analyze the implementation of Gradient Descent, Momentum, and Nesterov Accelerated Gradient (NAG) and compare their convergence speeds.
3. Analyze the Ford–Fulkerson algorithm by implementing it for a given flow network and evaluating how it determines the maximum flow.
4. Analyze Quasi-Newton optimization by implementing it and comparing its convergence behavior against first-order methods.
5. Analyze swarm-based optimization algorithms through implementation and evaluation of their search dynamics.
6. Analyze the structure of a 2–3 tree by implementing insertion, split, and deletion operations and validating balancing invariants under random inputs.
7. Analyze an R-Tree by designing and implementing it for multidimensional spatial indexing and evaluating its performance on range and nearest-neighbor queries.
8. Analyze Binomial Trees of various orders by constructing them and verifying their structural properties.
9. Analyze a randomized rounding algorithm by implementing it and evaluating its approximation quality.
10. Analyze differences between Monte Carlo and Las Vegas algorithms by implementing them o a sample problem and comparing probabilistic accuracy and runtime behavior.

11. Analyze the MAX-CUT problem by applying SDP relaxation and randomized rounding to evaluate approximation performance.

12. Analyze low-rank approximation techniques such as SVD, Tucker, or Tensor Train decomposition by implementing them and examining reconstruction error.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, "Algorithms", Tata McGraw- Hill, 1^{st} Edition, 2023.

2. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, "Introduction to Algorithms", 4^{th} Edition, The MIT Press, 2022.

3. Daphne Koller, Nir Friedman, "Probabilistic Graphical Models: Principles and Techniques", 2018.

Reference Books:

1. Vijay V. Vazirani, "Approximation Algorithms", 2021 (New edition).

2. Bruce Croft, Donald Metzler, Trevor Strohman "Search Engines: Information Retrieval in Practice " , 3^{rd} Edition, 2019.

3. Rajeev Motwani, Prabhakar Raghavan "Randomized Algorithms", 2020

Web Links:

1. https://www.coursera.org/learn/advanced-algorithms-and-complexity

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

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Medical Imaging Informatics and Interoperability (RCP23DCPE613)		
Medical Imaging Informatics and Interoperability Laboratory (RCP23DLPE613)		

Prerequisite: Machine Learning, Cloud Computing and Security.

Course Objective(s):

1. To equip students with the skills to understand medical imaging and digital pathology workflows, apply interoperability standards like HL7 v2.x, FHIR, and DICOM, and evaluate enterprise imaging systems including PACS, VNA, RIS, LIS, and Mirth Connect. Students will also learn to manage imaging data using DICOMweb and cloud platforms, and apply data science and AI methods for imaging analytics, digital pathology, and workflow integration.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Describe the structure, components, and workflows of medical imaging and digital pathology systems.	L2	Understand
CO2	Apply healthcare interoperability standards such as HL7 v2.x, FHIR, and DICOM for accurate and secure data exchange.	L3	Apply
CO3	Design imaging data pipelines using Mirth Connect, PACS, VNA, and cloud-based DICOMweb services.	L6	Create
CO4	Analyze medical imaging and digital pathology datasets using data science and AI techniques, including federated learning workflows.	L4	Analyze

Medical Imaging Informatics and Interoperability (RCP23DCPE613) Course Contents

Unit-I 06 Hrs.

Modalities in Medical Imaging:

Overview of medical imaging modalities (Radiology, Cardiology, Pathology): X-ray, XA, mammography, CT, MRI, PET, Ultrasound, Echocardiogram, Whole slide imaging (WSI).

Unit-II 10 Hrs.

Healthcare Interoperability and Data Exchange Standards:

HL7 v2.x messaging: ADT, ORM, ORU, SIU, MDM, DFT, BAR, RDS, RDE, ACK.

Medical Coding & Terminology Standards:

LOINC, SNOMED CT, ICD, CPT, Healthcare API Standards, API Workflow in Healthcare, Challenges in Healthcare API Adoption.

Unit-III 08 Hrs.

DICOM and Imaging Data Standards:

DICOM architecture, DICOM file format, SOP classes, DIMSE operations (C-ECHO, C-STORE, C-FIND, C-MOVE). DICOM association, metadata, IODs. PACS workflow using DICOM DICOM for Digital Pathology (VL Whole Slide Microscopy Image IOD).

Unit-IV 08 Hrs.

DICOMweb & Cloud Imaging:

JSON and REST-based imaging workflows, DICOM web services (WADO-RS, STOW-RS, QIDO-RS). AWS Health Imaging, S3, Sage Maker, IAM – DICOM storage and AI integration. GCP Healthcare API, Vertex AI, Big Query – DICOM web and FHIR interoperability. Azure Health Data Services, Blob Storage, Power BI – secure imaging workflows.

Unit-V 06 Hrs.

Enterprise Imaging Systems:

Imaging workflow and personas: Radiology, cardiology and pathology workflows, PACS, RIS, LIS, VNA, HIS, viewer, WSI scanner PACS and VNA architectures. IHE profiles – SWF, PIR, XDS-I.

Unit-VI 04 Hrs.

AI in Medical Imaging::

Imaging datasets (DICOM, NIFTI, Pathology data), federated learning, MonAI models and integrat

in imaging workflow, Data anonymization.

Medical Imaging Informatics and Interoperability Laboratory (RCP23DLPE613)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Deploy a cloud-hosted PACS using Orthanc on AWS and verify DICOM C-STORE and C FIND operations.
2. Configure DICOM Web endpoints on Azure and perform QIDO-RS, WADO-RS, and STOW RS operations using REST tools.
3. Launch OHIF viewer on GCP and integrate with Orthanc to visualize CT/MRI studies and annotations.
4. Use Google Cloud Healthcare API to create a DICOM datastore, upload studies, run QIDO queries, and export metadata to Big Query.
5. Simulate a Radiology workflow using Mirth Connect by sending HL7 ADT and ORM messages to Orthanc and generating a DICOM worklist.
6. Convert Whole Slide Image (WSI) files to DICOM-VL format, upload to Orthanc, and view multi-resolution tiles in OHIF pathology mode.
7. Implement Federated Learning for medical imaging using Flower/NVFlare and train a shared CNN model without sharing raw data.
8. Train a MONAI-based UNet on MRI tumor segmentation data, export the trained model, and deploy an inference API using FastAPI.
9. Deploy MONAI Label and perform AI-assisted interactive annotation on CT/MRI studies using 3D Slicer or OHIF.
10. Mini Project.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. Tim Benson , Grahame Grieve, "Principles of Health Interoperability: HL7, FHIR, and SNOMI Springer, 2021.

2. Darren Treanor ,Keith J. Dreyer, "Digital Pathology: Current Practices and Future Directions", Springer, 2021.

3. Barton F. Branstetter, "Practical Imaging Informatics: Foundations and Applications for PACS Professionals", Springer, 2021.

4. H.K. Huang, "PACS and Imaging Informatics: Basic Principles and Applications", Wiley Blackwell, 2010.

5. Oleg S. Pianykh, "Digital Imaging and Communications in Medicine (DICOM): A Practical Introduction and Survival Guide" , Springer, 2012.

Reference Books:

1. HL7 International, HL7 v2.x and FHIR Specifications, Available at: www.hl7.org, 2024.

2. IHE International, IHE Technical Frameworks (Radiology, IT Infrastructure, Pathology), 2024

3. NEMA, DICOM Standard (PS3.1–PS3.20) and Supplement 145: Whole Slide Imaging, National Electrical Manufacturers Association, 2023.

4. Daniel Rueckert et al., Deep Learning in Medical Image Analysis, Academic Press, 2020.

5. Maier, A., Steidl S., Christlein V., Hornegger, J.,"Medical Imaging Systems: An Introductory Guide.", Springer,2018.

6. George C. Kagadis , Steve G. Langer, "Informatics in Medical Imaging", CRC Press, 2011.

Web Links:

1. Health Informatics Specialization: Coursera, offered by Johns Hopkins University

2. Health Informatics on FHIR (edX/Georgia Tech)

3. HL7 FHIR Official Site: https://hl7.org/fhir

4. DICOM Standard: https://dicomstandard.org/

5. IHE Technical Frameworks: https://profiles.ihe.net/

6. NextGen Mirth Connect Documentation: https://docs.nextgen.com/display/mirthconnect

7. NIH Digital Pathology Resources: https://www.pathologyatlas.nih.gov/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Ethical Hacking & Digital Forensics (RCP23DCPE614)		
Ethical Hacking & Digital Forensics Laboratory (RCP23DLPE614)		

Prerequisite: Information Security.

Course Objective(s):

1. To understand ethical hacking concepts, hacker classifications, and hacking methodologies.
2. To understand and use basic tools and methods to find information about computer systems through footprinting, scanning, and enumeration.
3. To introduce the phases and tools used in penetration testing and system hacking.
4. To explain the fundamentals and significance of digital forensics in various domains.
5. To develop the ability to collect, preserve, and analyze digital evidence using proper techniques and tools while considering legal and anti-forensic challenges.
6. To familiarize students with modern forensic tools and techniques used in email and mobile device investigations.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain ethical hacking concepts, hacker types, legal aspects, and real-world applications.	L2	Understand
CO2	Use footprinting, scanning, and enumeration tools to gather system and network information.	L3	Apply
CO3	Demonstrate basic system hacking techniques and Perform penetration testing.	L3	Apply
CO4	Apply file system and disk forensics tools and describe digital evidence.	L3	Apply
CO5	Apply evidence collection, hashing, and anti-forensics detection methods.	L3	Apply
CO6	Analyze network traffic, email artifacts, and mobile device data using forensic tools.	L4	Analyze

Ethical Hacking & Digital Forensics (RCP23DCPE614) Course Contents

Unit-I 06 Hrs.

Introduction to Ethical Hacking:

Introduction to Ethical Hacking, Classification of Hackers (White Hat, Black Hat, Grey Hat), Phases of Ethical Hacking, Cybersecurity vs Ethical Hacking, Cyber Laws and Ethical Responsibilities, Introduction to Artificial Intelligence in Cybersecurity and Hacking, Real-World Case Studies of Ethical Hacking .

Unit-II 06 Hrs.

Footprinting, Scanning, and Enumeration:

Footprinting Techniques, DNS Interrogation, Email Harvesting, Social Engineering, Footprinting Tools (Maltego, Recon-ng), Scanning Methodology, Port Scanning Types and Tools (Nmap, Netcat), Enumeration Techniques, Enumeration Tools (SNMP, SMB, LDAP), Banner Grabbing, Use of AI for Automated Reconnaissance and Threat Detection .

Unit-III 08 Hrs.

Penetration Testing and System Hacking:

Penetration Testing: Fundamentals of Penetration Testing, Types of Penetration Testing (Black Box, White Box, Grey Box), Phases of Penetration Testing, Penetration Testing Tools (Metasploit, Burp Suite, Nikto,etc)

System Hacking: Password Attacks (Brute-force, Dictionary, Rainbow Tables), Privilege Escalation Techniques, Malware and Rootkits, Executing Applications and Hiding Files, System Hacking Tools, Introduction to Dark Web and TOR Network, Dark Web-based Threat Intelligence and Anonymity Tools.

Unit-IV 07 Hrs.

Introduction to Digital Forensics:

Definition and Scope of Digital Forensics, Types and Characteristics of Digital Evidence, Phases of a Digital Investigation, File System Forensics (FAT, NTFS), Disk Imaging and Cloning (Bit-by-Bit Copy), Data Recovery Concepts, Deleted File and Slack Space Analysis, Metadata Extraction and Timestamp Interpretation, Disk Forensics Tools (FTK Imager, Autopsy, EnCase), Role of AI and Machine Learning in Digital Forensics.

Unit-V 08 Hrs.

Evidence Collection and Data Analysis:

Evidence Collection Techniques (Live vs Dead), Chain of Custody and Legal Considerations, Volatile and Non-Volatile Evidence Acquisition, Remote Evidence Acquisition, Hashing Algorithms (MD5, SHA1, SHA256) for Verification, Write Blockers and Imaging Devices, Anti-Forensics Techniques (Data Hiding, Steganography, File Obfuscation), Detection and Countering Anti-Forensics, Use of AI Tools for Pattern Detection and Data Anomaly Analysis, Data Carving and Signature-Based Recovery.

Unit-VI 07 Hrs.

Network, Email, and Mobile Forensics:

Network Forensics (Packet Capture, Flow Analysis), Live Traffic Monitoring Tools (Wireshark, TCP-Dump), Log File and Firewall Analysis, Intrusion Detection Logs, Honeynet and Sandbox Environments, Email Forensics (Header and Server Log Analysis, MIME Format), Mobile Device Forensics (Android and iOS), Acquisition Techniques (Logical, Physical, Cloud), SIM and App Data Extraction, Tools (Cellebrite, XRY, MOBILedit), Open Source Intelligence (OSINT) and Threat Attribution Techniques.

Ethical Hacking & Digital Forensics Laboratory (RCP23DLPE614)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. **Footprinting and Reconnaissance:**
   Objective: Gather information about a target using passive and active footprinting techniques.
   Tools: Recon-ng, theHarvester, SpiderFoot (for AI-powered OSINT), ThreatFox, VirusTotal

2. **DNS Interrogation and Email Harvesting**
   Objective: Perform WHOIS lookups, DNS zone transfers, and identify email addresses.
   Tools: nslookup, dig, whois, theHarvester

3. **Scanning and Enumeration**
   Objective: Identify open ports, services, and perform OS detection.
   Tools: Nmap, Netcat

4. **Enumeration**
   Objective: Extract user and system info via SMB and SNMP protocols.
   Tools: enum4linux, snmpwalk

5. **Web Application Scanning**
   Objective: Scan a web server for vulnerabilities.
   Tools: Nikto, OWASP ZAP, Burp Suite Community Edition

6. **Exploitation Using Metasploit Framework**

   Objective: Exploit vulnerabilities in a virtual test machine.

   Tools: Metasploit Framework, DVWA, Metasploitable VM

7. **Password Cracking**

   Objective: Perform brute-force and dictionary attacks on password hashes and login services.

   Tools: John the Ripper, Hydra, Hashcat

8. **Disk Imaging and Basic Forensic Analysis**

   Objective: Create and analyze a disk image.

   Tools: FTK Imager, Autopsy, dd

9. **File System and Deleted File Analysis**

   Objective: Recover deleted files and analyze file system metadata.

   Tools: Autopsy, Sleuth Kit (fls, icat), Scalpel

10. **Hashing and Data Integrity Verification**

    Objective: Generate and verify file hashes to maintain evidence integrity.

    Tools: md5sum, sha256sum, HashCalc

11. **Network Traffic Capture and Protocol Analysis**

    Objective: Capture and analyze live network traffic for suspicious activity.

    Tools: Wireshark, TCPDump

12. **Email Header Analysis and Evidence Extraction**

    Objective: Trace the source of an email and extract digital evidence.

    Tools: Autopsy (email plugin), ExifTool

13. **Live Memory Acquisition and Analysis (Windows/Linux)**

    Objective: Acquire and examine volatile memory for evidence.

    Tools: WinPmem (Windows), LiME (Linux), Volatility

14. **Steganography and Anti-Forensics Detection**

    Objective: Detect hidden data in images and analyze steganographic files.

    Tools: OpenStego, Steghide, binwalk

15. **Dark Web Exploration & TOR-based Threat Discovery**

    Objective:To explore TOR and Dark Web Securely

    Tools: TOR browser, OnionScan, Ahmia

16. **Mobile Device Forensics and App Data Extraction**

    Objective: TOR browser, OnionScan, Ahmia

    Tools: MOBILedit, ADB, Cellebrite (demo)

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Text Books:

1. EC-Council, "Ethical Hacking and Countermeasures Attack Phases", Cengage Learning,2^{nd} Edition, 2017.
2. Rafay Boloch, "Ethical Hacking and Penetration Testing Guide", CRC Press, 2014.
3. John R. Vacca, "Computer Forensics", Computer Crime Investigation Firewall Media, New Delhi. 2012
4. Nelson, Phillips, Steuart, "Guide to Computer Forensics and Investigations", CENGAGE Learning, 6^{th} Edition, 2020.
5. E. Casey, "Digital Evidence and Computer Crime: Forensic Science, Computers and the Internet", 3rd edition. Burlington, MA, USA: Academic Press, 2011.
6. S. Davidoff, J. Ham, "Network Forensics: Tracking Hackers through Cyberspace", Upper Saddle River, NJ, USA: Prentice Hall, 2012.

Reference Books:

1. Kevin Smith, "Hacking How to Hack - The ultimate Hacking Guide", Hacking Intelligence,2018.
2. Kevin Beaver, "Ethical Hacking for Dummies", Sixth Edition, Wiley, 2018.
3. Keith J. Jones, Richard Bejtiich, Curtis W. Rose, "Real Digital Forensics", Addison- Wesley Pearson Education 2006
4. Tony Sammes , Brian Jenkinson, "Forensic Compiling", A Tractitioneris Guide, Springer International edition.
5. Christopher L.T. Brown, "Computer Evidence Collection & Presentation", Firewall Media.
6. Jesus Mena, "Homel and Security, Techniques & Technologies", Firewall Media.
7. J. T. Luttgens, M. Pepe, K. Mandia, "Incident Response and Computer Forensics", 3^{rd} edition.

Web Links:

1. Ethical Hacking – IIT Kharagpur (NPTEL) nptel.ac.in/courses/106/105/106105217/
2. Digital Forensics – UTAustin / Prof. Matt L. (Free Online Course) https://digital-forensics.utexas.edu/
3. Introduction to Cybersecurity Tools & Cyber Attacks – IBM (Coursera Free Audit) https://www.coursera.org cybersecurity-tools-cyber-attacks

4. Cybersecurity Fundamentals – University of Washington (edX Free Audit) https://www.edx.org/learn/cyber
of-washington-cybersecurity-fundamentals

5. Digital Forensic Techniques – OpenLearn (The Open University) https://www.open.edu/openlearn/science-
maths-technology/digital-forensics/content-section-0

6. Network Forensics – University of California, Davis (Coursera Free Audit) https://www.coursera.org/learn/n
security

7. Open-Source Intelligence (OSINT) Training – EUROPOL / ENLETS https://osintframework.com/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Computer Vision (RCP23DCPE621)		
Computer Vision Laboratory (RCP23DLPE621)		

Prerequisite: Machine Learning -I , Machine Learning- II(Deep Learning).

Course Objective(s):

1. To equip students with advanced skills in image, video, and computer vision processing, emphasizing feature extraction, shape and motion analysis, object detection, and action recognition through both classical and deep learning approaches for effective visual understanding and prediction.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Apply fundamental image and video processing techniques for visual data analysis	L3	Apply
CO2	Analyze object detection and recognition algorithms for visual understanding.	L4	Analyze
CO3	Apply advanced vision models for data analysis and prediction.	L3	Apply

Computer Vision (RCP23DCPE621)
Course Contents

Unit-I 09 Hrs.

Foundations of Computer Vision and Image Preprocessing:

Basics of image processing. Image acquisition. Preprocessing.Enhancement.Segmentation. Representation. Image transforms: Fourier Transform, Discrete Cosine Transform,Wavelet Transform.

Morphological Image Processing:

Dilation, Erosion, Opening and Closing, Hit-or-Miss Transformation. Morphological Algorithms: Boundary Extraction, Region Filling, Extraction of Connected Components, Thinning, Thickening, Skeletons, Pruning,Morphological Reconstruction. Image Preprocessing Challenges: Clutter, deformation, intra-class variation, Gaussian blur, noise removal, illumination variance, normalization techniques.

Unit-II 10 Hrs.

Shape Analysis and Segmentation Techniques in Vision:

Contour-Based Methods: Chain Codes, Geometric Border Representation, Fourier Transform of Boundaries, Boundary Description using Segment Sequences, BSpline Representation, Shape Invariants. Region-Based Methods: Scalar Region Descriptors, Moments, Convex Hull, Graph Representation Using Region Skeletons, Region Decomposition, Region Neighborhood Graphs.

Thresholding: Foundation, Role of illumination, Basic Global thresholding, Otsu's method Region Based segmentation: Region Growing, Region Splitting and merging, Relationships between pixels, Hough transform.

Unit-III 10 Hrs.

Object Detection:

Two Stage/Proposal: Convolutional Neural Networks for Detection: R-CNN, Fast R-CNN, Faster R-CNN, RFCN and Mask RCN;Architecture and Issues in each algorithm. Backprop-to-image/Deconvolution Methods.

One Stage/Proposal Free: YOLO, SSD, evaluation metrics (IoU, AP), Non-max suppression YOLO Loss function, Variants of YOLO.

Face Recognition and Verification: Zero-shot, One-shot, Few-shot Learning;Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss; Attention Models in Vision.

Unit-IV 09 Hrs.

Generative Models:

Types of generative models: Implicit and Explicit density; Generative Adversarial Network; Vanilla GAN, Mode Collapse in GAN (Strategies to address Mode Collapse and Convergence Issues); Cond

tional GAN, DC GAN, Wasserstein GAN (WGAN), CycleGAN, StyleGAN; GAN objective functions, JSD Divergence, EM Distance, Least Squares, Evaluation Metrics: Inception Score (IS), Fréchet Inception Distance (FID)

Unit-V 10 Hrs.

Object Segmentation:

Semantic segmentation, Scene Parsing, semantic flow,Bilinear Interpolation, Symmetry in Segmentation, Featured image pyramid,pixel-wise softmax, PSPNet, FPN, UNet, clustering method for segmentation,Distance metrics(Euclidean, Cosine, Hamming, Manhattan, Minkowski,Chebyshev,Jaccard, Haversine), Linkage Types (Single, Average, Complete,Centroid).

Unit-VI 08 Hrs.

Motion Analysis and Optical Flow:

Basics of motion estimation and optical flow using classical and deep learning methods. 3D Vision Components: Stereo Matching, disparity estimation, depth computation.

Action Recognition and Object Tracking: Introduction to recognizing actions and tracking moving objects in videos. Video Processing and Spatio-Temporal Features Overview of video signals, motion models, and basic spatio-temporal analysis.

Computer Vision Laboratory (RCP23DLPE621)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. To perform morphological operations on Image.
2. To perform image enhancement in frequency domain.
3. To perform segmentation using region growing , merging and splitting.
4. To detect cancer cells using medical image processing techniques through CNN-based object detection.
5. To identify vehicles from road traffic CCTV video footage using the YOLO object detection algorithm.
6. To convert black-and-white images into colored images using GAN.
7. To detect deepfakes in digital media using GAN.
8. To perform image segmentation using advanced deep learning models such as PSPNet, FPN and UNet.

9. To analyze body postures through motion analysis using spatio-temporal feature extraction techniques.

10. Mini Project.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning" , MIT Press, Reprint Edition with updates, 2022.

2. Shafqat Alauddin, Mrutyunjaya S. Yalawar, S. Bharathidasan, T. Thiyagarajan, "Image Processing Techniques and its Applications in Computer Vision and Artificial Intelligence",2024.

Reference Books:

1. Richard Szeliski, "Computer Vision: Algorithms and Applications ", 2^{nd} Edition, Springer, 2022.

2. Kevin P. Murphy, "Probabilistic Machine Learning: An Introduction" , MIT Press, 2022.

3. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing ", 4^{th} Edition, Pearson Education, 2021.

Web Links:

1. Virtual Lab on Vision and deep learning Lab https://www.ee.iitb.ac.in/ viplab/

2. Virtual Lab on Computer Vision Laboratory https://www.iitk.ac.in/ee/computer-vision-lab

3. Course on Modern Computer Vision
   https://www.youtube.com/playlist?list=PLzWRmD0Vi2KVsrCqA4VnztE4t71KnTnP5

4. Coursera course on Advanced Computer Vision with TensorFlow
   https://www.coursera.org/learn/advanced-computer-vision-with-tensorflow

5. Udemy course on Deep Learning and Computer Vision A-Z™: OpenCV, SSD & GANs — Udemy

6. Vision Lab: Computer Vision
   http://cse.iitm.ac.in/lab_details.php?arg=NQ

7. Funded Projects on Computer Vision at NAVER LABS Europe
   https://europe.naverlabs.com/research/computer-vision/

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Robotics and AI (RCP23DCPE622)		
Robotics and AI Laboratory (RCP23DLPE622)		

Prerequisite: Linear algebra and Probability theory.

Course Objective(s):

1. To introduce fundamental concepts, kinematics, perception, planning, and control in robotics with an emphasis on data acquisition, machine learning, and autonomous navigation.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Illustrate the fundamental principles, components, and kinematics of robotic systems.	L3	Apply
CO2	Apply sensor data acquisition, preprocessing, and fusion techniques using Python and ROS.	L3	Apply
CO3	Analyze computer vision, path planning, and SLAM algorithms for perception and navigation.	L4	Analyze
CO4	Develop control and decision-making strategies for autonomous robot operation.	L6	Create

Robotics and AI (RCP23DCPE622)
Course Contents

Unit-I 08 Hrs.

Introduction to Robotics:

Evolution of Robotics, Types of robots – industrial, mobile, humanoid, and autonomous, Components of robotic system (sensing, actuation, control, AI), Types of Sensors – IMU, LiDAR, Camera, GPS, Ultrasonic, Proximity Sensors (Infrared), Vision Sensors, Accelerometers, Gyroscopes, and Encoders (Linear or Rotary), Types of Actuators – Electric (DC, Stepper, Servo Motors), Hydraulic, Pneumatic, and Emerging Smart Actuators (Piezoelectric, Shape Memory Alloy, Electroactive Polymer).

Unit-II 12 Hrs.

Robot Kinematics and Motion planning:

Coordinate frames and transformations – homogeneous transformation matrices,Forward and inverse kinematics; Denavit–Hartenberg (D–H) parameters,Differential kinematics and Jacobians – conceptual and numerical examples,Configuration space and robot motion representation, Motion planning – introduction, path and trajectory concepts,Types of trajectory planning – Point-to-Point (PTP) and Continuous Path (CP).

Unit-III 08 Hrs.

Data Acquisition and Preprocessing:

Data collection and preprocessing from multiple sensors through frameworks and middleware (e.g., ROS) for acquisition, synchronization, and refinement of sensor data., Understanding sensor data formats and structures (CSV, JSON, image/video files and ROS bag files). Noise handling using Gaussian, Median, and Kalman filtering methods. Aligning multi-sensor data streams (camera, LiDAR, IMU) using temporal synchronization, spatial calibration, and sensor fusion methods. Handling missing or corrupted data using interpolation, statistical imputation, and smoothing methods, Sensor calibration using intrinsic and extrinsic methods for camera– LiDAR and IMU sensors.

Unit-IV 08 Hrs.

Robot Perception:

Introduction to robot perception and environment understanding, Computer vision in robotics – image acquisition, feature extraction, and object recognition,Application of machine learning and deep learning for perception: Classification using CNN and SVM, Object detection using YOLO and SSD, Image segmentation using U-Net and SegNet, building 3D representations from LiDAR using Voxel Grid Mapping or from stereo vision using SGBM (Semi-Global Block Matching).

Unit-V 12 Hrs.

Path Planning:

Path planning algorithms –Rapidly-exploring Random Tree(RRT), and PRM, Simultaneous Localization and Mapping (SLAM),Components – Localization, mapping, sensor data processing, Types of SLAM – Visual SLAM, LiDAR-based SLAM, RGB-D SLAM, Data association and map building, Learning-based SLAM and navigation using neural implicit mapping and policy learning, Integration of SLAM with path planning and control for autonomous navigation, Evaluation metrics – accuracy, drift, real-time performance, and scalability, Reinforcement Learning for Navigation using Q-Learning, Sim-to-Real Transfer – Domain Randomization, Imitation Learning, Challenges, and Evaluation.

Unit-VI 08 Hrs.

Control and Decision Making:

Control architectures – Open Loop, Closed Loop, and Hierarchical, PID and Feedback Control, Model Predictive Control (MPC) for trajectory tracking,Behavior-Based Robotics – Subsumption Architecture and Reactive Control, Reinforcement Learning for Robot Control – DDPG, PPO, A3C, TRPO, TD3, Human-Robot Interaction – Shared Autonomy, Intent Recognition, and Safety Considerations.

Robotics and AI Laboratory (RCP23DLPE622)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Install and explore ROS or Webots; visualize a simple robot model.
2. Simulate a robotic arm and perform forward and inverse kinematics using Python or MATLAB.
3. Acquire and preprocess sensor data (camera or LiDAR dataset) using Python
4. Implement visual feature detection using SIFT or SURF, or deep object recognition using YOLO or MobileNet.
5. Simulate SLAM using ROS or Gazebo datasets
6. Implement EKF-based localization or 2D SLAM using Python
7. Implement a RRT-based path planner in Webots or Gazebo
8. Implement PID control for a mobile robot simulation using Python or Webots.
9. Implement a simple reinforcement learning control policy for navigation or balancing tasks using Python or Webots.
10. Integrate perception, localization, and planning on a simulated robot using TurtleBot or dror simulation.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. Roland Siegwart, Illah R. Nourbakhsh, and Davide Scaramuzza, "Introduction to Autonomous Mobile Robots", 3rd Edition, MIT Press, 2022.
2. Peter Corke, "Robotics, Vision and Control: Fundamental Algorithms in Python", 3rd Edition,Springer, 2023.
3. Jonathan Cacace, "Ultimate Robotics Programming with ROS 2 and Python", 1st Edition, 2024.

Reference Books:

1. Mohamed M. Atia, "Sensor Fusion Approaches for Positioning, Navigation, and Mapping: How Autonomous Vehicles and Robots Navigate in the Real World with MATLAB Examples", 1st Edition, Springer, 2025.
2. Christoph Bartneck, Tony Belpaeme, Friederike Eyssel, Takayuki Kanda, Merel Keijsers & Selma Šabanović, "Human-Robot Interaction – An Introduction", 2nd Edition, Cambridge University Press, 2024.
3. Larry T. Ross, Stephen W. Fardo & Michael F. Walach, "Industrial Robotics Fundamentals", 4th Edition, Jones & Bartlett Learning, 2023.

Web Links:

1. https://swayam.gov.in/nc_details/NPTEL (Introduction to Robotics by IIT Madras and Robotics by IIT Kharagpur)
2. https://www.udemy.com/course/robotics-course/
3. https://www.coursera.org/courses?query=robotics

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Applied Game Theory (RCP23DCPE623)		
Applied Game Theory Laboratory (RCP23DLPE623)		

Prerequisite: Linear Algebra, Calculus, Probability, Statistics and Basic algorithm design and analysis.

Course Objective(s):

1. Introduce fundamental principles of strategic, zero-sum, non-zero-sum, and repeated games with computational simulation.
2. Develop the ability to model, analyse, and solve multi-agent interactions using algorithmic and Python-based approaches.
3. Familiarize students with evolutionary, cooperative, and Bayesian game-theoretic frameworks, including reinforcement learning and human-in-the-loop feedback.
4. Apply game-theoretic reasoning to real-world applications such as auctions, market design, bargaining, and resource allocation.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze and simulate strategic, zero-sum, and non-zero-sum games to identify Nash equilibria and optimal strategies.	L4	Analyze
CO2	Apply algorithmic techniques and reinforcement learning to compute equilibria and model multiagent interactions.	L3	Apply
CO3	Evaluate evolutionary, cooperative, and Bayesian game scenarios for fairness, stability, and decision-making efficiency.	L5	Evaluate
CO4	Design, implement, and assess real-world games and applications, including auctions, repeated games, market design, and RL-based strategy optimization.	L6	Create

Applied Game Theory (RCP23DCPE623)
Course Contents

Unit-I 08 Hrs.

Introduction to Game Theory:

Strategic games, players, strategies, payoffs; dominance, minimax, saddle points; pure & mixed strategy Nash equilibria; real-world examples: auctions, pricing, simple multi-agent interactions

Unit-II 08 Hrs.

Zero-Sum and Non-Zero-Sum Games:

Zero-sum games, saddle points, matrix games; mixed strategies; non-zero-sum games, iterated elimination of dominated strategies; Lemke–Howson algorithm.

Unit-III 10 Hrs.

Evolutionary and Cooperative Game Theory:

Evolutionarily Stable Strategies (ESS), replicator dynamics, fictitious play; cooperative games: transferable utility, core, Shapley value, nucleolus; correlated equilibria; Multi-Agent Reinforcement Learning (MARL) and reward shaping with human feedback.

Unit-IV 10 Hrs.

Bayesian and Algorithmic Game Theory:

Bayesian games, Bayes–Nash equilibrium, auctions, bilateral trading; complexity of equilibrium computation; mechanism design basics; Vickrey auction, incentive compatible resource allocation.

Unit-V 10 Hrs.

Repeated and Extensive Form Games:

Repeated games: Nash Folk Theorem, subgame perfect equilibrium, one-shot deviation principle; extensive form games: game trees, backward induction, sequential equilibria

Unit-VI 10 Hrs.

Game Design, Simulation, and Real-World Applications:

Game design principles: payoff engineering, fairness, multiplayer dynamics; applications: oligopoly models, voting games, matching markets, resource allocation, utility theory; RL-based strategy optimization and human-in-the-loop feedback.

Applied Game Theory Laboratory (RCP23DLPE623)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Strategic-Form Games and Payoff Matrix Construction: Construct and simulate matrix games; compute best responses and pure Nash equilibria.
2. Dominance Analysis and Mixed Strategy Nash Equilibria: Analyse dominance relations, compute mixed strategies, and visualize payoffs.
3. Zero-Sum Game Simulation and Minimax / Saddle Points: Implement zero-sum games and compute saddle points using Python.
4. Non-Zero-Sum Game Simulation and Iterated Elimination of Dominated Strategies: Solve nonzero-sum games computationally and identify NE.
5. Lemke–Howson Algorithm Implementation: Compute Nash equilibria of bimatrix games algorithmically.
6. Evolutionarily Stable Strategies (ESS) and Replicator Dynamics: Simulate population dynamics and ESS in multi-agent systems.
7. Fictitious Play and Multi-Agent Reinforcement Learning (MARL): Implement learning strategies for repeated interactions and observe convergence.
8. Cooperative Game Theory: Core, Shapley Value, Nucleolus Computation: Compute fair allocations in transferable utility games.
9. Bayesian Games and Bayes–Nash Equilibrium: Implement games with incomplete information and compute equilibria.
10. Auction Simulation: First-Price, Second-Price, Sealed-Bid, and Online Auctions; Analyse strategy and outcomes.
11. Repeated and Extensive Form Games: Simulate repeated strategies, subgame-perfect equilibrium,and backward induction in game trees.
12. Matching Market and Resource Allocation Applications: Implement market design, matching, and allocation scenarios computationally.
13. Custom Game Design with RL and Human-in-the-Loop Feedback: Design a multi-agent game,implement RL agents, incorporate human feedback, and analyse strategic outcomes.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performe

during laboratory sessions.

Text Books:

1. Game Theory: An Introduction, 3^{rd} Edition by E.N. Barron, Wiley, 2024.
2. Richard S. Sutton and Andrew G. Barto, "Reinforcement Learning: An Introduction",MIT Press, 2^{nd} Edition, 2022.
3. Binmore, K., Game Theory: A Very Short Introduction, OUP, 2010.

Reference Books:

1. Shoham Y., Leyton-Brown K., "Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations", Cambridge University Press, 2024.
2. Thomas Ferguson, "Game Theory", World Scientific, 2018.

Web Links:

1. NPTEL Course: https://nptel.ac.in/courses/106105237
2. IIT Bombay: Useful Lecture Notes on Game Theory — IEOR @ IIT Bombay

Program: Computer Science & Engineering (Data Science)	T. Y. B.Tech.	Semester: VI
Information Security (RCP23DCPE624)		
Information Security Laboratory (RCP23DLPE624)		

Prerequisite: Computer Communication and Networks

Course Objective(s):

1. To understand the fundamental principles of cryptography, network security, and secure communication mechanisms in modern computer systems.
2. To apply symmetric and asymmetric encryption techniques to ensure confidentiality, authentication, and data integrity.
3. To analyse and evaluate security threats, vulnerabilities, and countermeasures, including the application of machine learning techniques for intelligent threat detection.

Course Outcomes:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain the fundamental concepts of cyber-attacks, defence strategies, guiding principles of modern security practices, and apply number theory concepts such as modular arithmetic, Euclid's algorithm, and classical ciphers to illustrate basic cryptographic operations.	L2	Understand
CO2	Apply appropriate encryption, hashing, and authentication protocols to design and implement secure systems and data communication models.	L3	Apply
CO3	Analyze different network threats and attacks such as DDoS, spoofing, and phishing, and evaluate suitable defence mechanisms, including IDS, IPS, and firewalls.	L4	Analyze
CO4	Evaluate the role of machine learning models in cybersecurity, examining their effectiveness in detecting and mitigating cyber threats in real-world scenarios.	L5	Evaluate

Information Security (RCP23DCPE624)
Course Contents

Unit-I 10 Hrs.

Introduction:

Cyber Attacks, Defense, Strategies and Techniques, Guiding Principles of Modern Security Practices. OSI security model.

Number Theory: Modulo Arithmetic, Euclid's Algorithm, Fermat's and Euler's Theorem, Chinese Remainder Theorem, Cipher Properties, Substitution Ciphers – Mono-alphabetic Ciphers, Polyalphabetic Ciphers, Transposition Ciphers.

Unit-II 10 Hrs.

Symmetric Cryptography:

Block Cipher, Fiestel Structure, Block Cipher Modes of Operation, S-DES, Double DES, Triple DES, AES Algorithm.

Asymmetric Cryptography: Private Key and Public Key Cryptography, The RSA algorithm, Key Management, Diffie-Hellman Key Exchange, Key Exchange Algorithm.

Unit-III 10 Hrs.

Integrity and Authentication:

Cryptographic Hash Functions: Message Authentication, Secure Hash Algorithm(SHA-512),

Message authentication codes: Authentication requirements, HMAC, CMAC, Digital signatures, Elgamal Digital Signature Scheme.

Key Management and Distribution: Symmetric Key Distribution Using Symmetric & Asymmetric Encryption, Distribution of Public Keys, Kerberos, X.509 Authentication Service, Public – Key Infrastructure

Unit-IV 12 Hrs.

Network Security:

Network attacks, DoS and DDoS attack, Sniffing, Session hijacking, Spoofing, Phishing, Cross-site Scripting (XSS), IPSec Protocol, SSL Handshake Protocol, Firewalls, IDS Prevention and Detection.

Unit-V 05 Hrs.

Basics of Machine Learning in Cyber Security:

Cyber Threat Landscape, The Cyber Attackers Economy, why use machine learning in cybersecurity? Real-World Uses of Machine Learning in Security, Spam Fighting: An Iterative Approach, Limitations of Machine Learning in Security.

Unit-VI 09 Hrs.

Machine Learning in Cybersecurity:

Machine Learning: Problems and Approaches, Classification and Clustering, an ML approach for Security, Time Series Analysis and Ensemble Modeling: Analysis of time series in cyber security, Prediction of DDoS attack, Ensemble learning methods and voting ensemble methods to detect cyber attacks.

Information Security Laboratory (RCP23DLPE624)

List of Laboratory Experiments

Suggested Experiments (Any 08)

1. Implement Playfair Cipher with key entered by user.
2. Implement polyalphabetic Cipher
3. Implement Simple and Advanced Columner Transposition technique
4. Implement Simplified DES
5. Implement Simple RSA Algorithm with small numbers.
6. Implement Diffie-Hellman Key Exchange
7. Implement DoS and DDoS attack using Hping.
8. Implement phishing attack using HTTrack Website Cloning.
9. Implement static code analysis using Flawfinder Python Distribution.
10. Implement packet sniffing using Wireshark and TCP Dump.
11. Implement cross site request forgery in a controlled virtual environment using DVWA Web Server.
12. Implement firewalls using IP tables.
13. Implement Network Intrusion Detection System (NIDS).
14. Implement Host based Intrusion Detection System (HIDS).
15. Implementing and Evaluating an Email Spam Classifier Using Naive Bayes or Logistic Regression.
16. Detection of DDoS Attacks in Network Traffic using Random Forest and Ensemble Methods.

Any other experiment based on syllabus may be included which would help the learner to understand topic/concept.

Oral examination will be based on the entire syllabus including, the practicals performed during laboratory sessions.

Text Books:

1. William Stallings, "Cryptography and Network Security Principles and Practices", Pearson/PHI,8th Edition, 2023.
2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", McGrawHill, 3rd edition 2017.
3. Clarence Chio,David Freeman, "Machine Learning and Security: Protecting Systems with Data and Algorithms", O'REILLY Publications,2018.
4. Soma Halder, Sinan Ozdemir"Hands-On Machine Learning for Cybersecurity", Packt Publishing,2018.

Reference Books:

1. Atul Kahate, "Cryptography and Network Security", McGraw Hill, 3rd Edition, 2013.
2. Bernard Menezes, Network Security and Cryptography, Cengage Learning: 2nd Edition, 2011.
3. Wade Trappe, Lawrence C Washington, "Introduction to Cryptography with coding theory", Pearson: 2nd Edition, 2006.
4. W. Mao, "Modern Cryptography – Theory and Practice", Pearson Education: 1st Edition, 2003.
5. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing – Prentice Hall of India, 2015.

Web Links:

1. Damn Vulnerable Web Application (DVWA): https://dvwa.co.uk/
2. Open Web Application Security Project: https://owasp.org
3. Web penetration testing: https://pentesterlab.com
4. Penetration Testing: https://kali.org

Program: Computer Science & Engineering (Data Science)	T.Y. B.Tech.	Semester: VI
Project Stage-I (RCP23IPEL601)		

Course Objectives:

1. To understand the basic concepts and principles of project development.
2. To formulate/identify the problem statement.
3. To implement the solution as per the problem statement.
4. To develop the team building, writing, logical reasoning and management skills.
5. To provide the connections between the designs and concepts across different disciplinary boundaries.
6. To encourage students to become independent personnel, critical thinkers and lifelong learners.

Course Outcomes:

On completion of the course, the learner will be able to:

COs	Course Outcomes	Blooms Level	Blooms Description
CO1	Analyze the problem statement and produce solution of the problem considering cultural, social, environmental and economic factors using appropriate tool and method.	L4	Analyze
CO2	Interpret project based learning that allows students to transfer existing ideas into new applications.	L2	Understand
CO3	Apply the ability to work in teams and manage to conduct the project development activity.	L3	Apply
CO4	Use different perspectives from relevant disciplines which help them to get internships, jobs, and admission for higher studies.	L3	Apply
CO5	Explain the project development in the form of technical writing, and interpret what constitutes plagiarism and the use of proper referencing styles.	L2	Understand

Syllabus:

Domain knowledge (any beyond) needed from the areas of Computer Science & Engineering(Data Science)for the effective implementation of the project. The areas can be updated based on the technological innovations and development needed for specific project.

Guidelines: The main purpose of this activity is to improve the students' technical skills, communication skills by integrating writing, presentation and teamwork opportunities.

- Each group will be reviewed twice in a semester and marks will be allotted based on the various points mentioned in the evaluation scheme.
- In the first review of this semester, each group is expected to complete 30% of project stage-I.
- In the second review of this semester, each group is expected to complete 50% of project stage-I.
- Interaction with alumni mentor will also be appreciated for the improvement of project stage-I.

Assessment Criteria:

- At the end of the semester, after confirmation by the project guide, each project group will submit project completion report in prescribed format for assessment to the departmental committee.
- Assessment of the project (at the end of the semester) will be done by the departmental committee.
- Oral examination shall be conducted by Internal and External examiners. Students have to give presentation and demonstration based on their project stage-I.

Prescribed project report guidelines:

Size of report shall be of minimum 30 pages (excluding cover and front pages). Project stage-I report should include appropriate content for:

- **Abstract**
- **Introduction**
  - Background
  - Motivation
  - Problem Statement
  - Objectives
  - Scope
- **Literature Survey**
  - Review of Existing System(s)

- Limitations of Existing System(s)

- **Proposed System**
  - Analysis/Framework/ Algorithm
  - Details of H/W and S/W required
  - Design details
  - Methodology (your approach to solve problem)

- **Implementation Plan for Project Stage-II**

- **Conclusion**

- **References**

Assessment criteria for the departmental committee for Continuous Assessment:

Guide will monitor weekly progress and marks allocation will be as per Table 4.

Assessment criteria for the departmental committee for End Semester Exam:

Departmental committee will evaluate project as per Table 5.

Table 4: Log Book Format

Sr	Week (Start Date:End Date)	Work Done	Sign of Guide	Sign of Coordinator
1				
2				

Table 5: Continuous Assessment Sheet

Sr	P.R.N.	Name of Student	Student Attendance	Log Book Maintenance	Literature Review	Depth of Understanding	Report	Total (50)
			10	10	10	10	10	50

Table 6: Evaluation Sheet

Sr	P.R.N.	Name of Student	Project Stage - I Selection	Design /Methodology /Logic	Implementation	Result Verification	Presentation	Total (50)
			10	10	10	10	10	50

Program:Computer Science & Engineering (Data Science)	T.Y. B.Tech.	Semester: VI
Environmental Science Tutorial (RCP23ITHSX06)		

Prerequisite: Interest in Environment and its impact on Human.

Course Objective(s):

1. To familiarise students with environment related issues such as depleting resources, pollution, ecological problems and the renewable energy scenario.
2. To give overview of Green Technology options.

Course Outcomes:

On completion of the course, the learner will be able to:

CO	Course Outcomes	Blooms Level	Blooms Description
CO1	Explain how human activities affect environment.	L2	Understand
CO2	Describe the various technology options that can make a positive environmental difference.	L2	Understand

Environmental Science Tutorial (RCP23ITHSX06) Course Contents

Unit-I 02 Hrs.

Air Pollution: Sources of Air pollution. Definition of Air Quality Index and how it is measured.

Unit-II 02 Hrs.

Water Pollution: Sources of water pollution. Ground water pollution and eutrophication.

Unit-III 01 Hrs.

Noise Pollution : Noise pollution and sources. Decibel limits for hospital, library, silence zone.

Unit-IV 01 Hrs.

Biodiversity loss : Value of Biodiversity. Endangered species

Unit-V 02 Hrs.

Deforestation : Product and services provided by forests. Relationship between forests and climate change.

Unit-VI 02 Hrs.

Renewable Energy sources : Our energy needs and global energy crisis. Renewable energy sources.

Unit-VII 02 Hrs.

Climate change: Greenhouse gases and climate change.

Unit-VIII 02 Hrs.

Green Technology : Data Center Energy Efficiency, Thin-Client and Energy Efficiency.

Environmental Science Tutorial (RCP23ITHSX06)

List of Tutorial

1. Case study on Smog.
2. Qualitative and Quantitative methods for Air Pollution Monitoring.
3. Presentation on Water Pollution (Industrial, Sewage) explaining any specific case.

4. General Techniques in Water Quality Monitoring
5. List effects of noise pollution on human health. Measure decibel level in college library, canteen, classroom
6. Case study on effect of pollution on Biodiversity loss.
7. Radioactive and Hazardous Pollutants.
8. Debate for and against to promote Economic Growth Deforestation is required.
9. Presentation on different Renewable Energy Technologies.
10. Report on major impact of Global warming on Environment giving real examples.
11. Report on advantages and examples of Green Building for Sustainable development, Sustainable Software Design.
12. Green Hydrogen: The Energy of Future.
13. Sustainable Software Design: Reducing energy/carbon footprint (e.g., green coding, optimized AI/ML, efficient cloud usage)
14. Reducing AI's carbon footprint (efficient models, serverless) and applying AI for environmental good, like optimizing energy grids, smart buildings, precision agriculture (water/fertilizer use),waste management, and climate modeling.

Text Books:

1. R. Rajagopalan, "Environmental Studies From Crisis to Cure".
2. Erach Bharucha, "Textbook of Environmental Studies For Undergraduate Courses".
3. Narayanan, P., "Environmental Pollution: Principles, Analysis and Control", CBS Publishers Distributors, 2009.
4. Mohammad Dastbaz, Colin Pattinson, Babak Akhgar, Morgan and Kaufman, Elsevier., "Green Information Technology A Sustainable Approach".

Reference Books:

1. Paulina Golinska, Marek Fortsch, Jorge Marx-Gómez, "Information Technologies in Environmental Engineering", New Trends and Challenges, Springer, 2011.

Web Links:

1. CITES: https://cites.org/eng

2. Convention on Biological Diversity: www.biodiv.org

3. Kalpvriksh: www.kalpvriksh.org

4. Water pollution: http://en.wikipedia.org/wiki/Water_polution

5. Ecosan: www.eco-solutions.org